Food and Agriculture Organization of the United Nations

FIAF/C942 Rev.3 (En)

FAO Fisheries and Aquaculture Circular

ISSN 2070-6065

REVIEW OF THE STATE OF THE WORLD FISHERY RESOURCES: INLAND FISHERIES

Cover photo: Inland fishing traps and liftnet in Songkhla Lake, Thailand (Simon Funge-Smith)

REVIEW OF THE STATE OF THE WORLD FISHERY RESOURCES: INLAND FISHERIES

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 2018

ISBN 978-92-5-130793-9

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PREPARATION OF THIS DOCUMENT

As part of an ongoing commitment to improve global understanding of the role and value of inland fisheries, the FAO Fisheries Resources Branch (FIAF) produces the periodic FAO Fisheries and Aquaculture Circular No. 942 (C942) entitled *Review of the state of world fishery resources: inland fisheries*. The first publication of the circular (FAO, 1999) was issued in 1999 and the latest version (Welcomme, 2011) was published in 2011, it is therefore time to produce an update.

Previous versions of C942 (Rev. 1, Rev. 2) have focused on analysis of the FAO inland fishery statistics to derive national and regional trends. They also cover thematic issues relevant to inland fisheries. This third revision (C942 Rev. 3), the present publication, seeks to go beyond the analysis of trends in catch and provide a deeper analysis of the state of inland fishery resources and their importance/relevance to the achievement of the Sustainable Development Goals (SDGs), in particular, SDGs 2, 3, 6, 7 and 15.[1]

It aims to improve global understanding and appreciation of the contribution of inland fisheries to food security and human nutrition, ecosystems services and biodiversity resources and livelihoods, (also other services such as employment and inclusive growth). The C942 Rev. 3 therefore seeks to:

- quantify global inland fisheries resources in terms of food production, nutrition, employment and economic contribution with respect to those countries/regions or subnational areas where they are important;
- provide baseline values of what might be lost as a result of impacts, drivers and poor management and the potential replacement cost of this (in terms of dollars, other resources such as land and water, feeds, labour etc.); and
- provide updated discussion on ways to measure and assess inland fisheries, in particular, how to establish more accurately the inland fishery catch in the many situations where there are challenges to the collection of catch statistics.

The structure of the C942 Rev. 3 builds on the previous revisions of the circular (C942, C942 Rev. 1 and C942 Rev. 2) with the specific objectives to:

- update and expand the scope of previous reviews of the state of world fishery resources: inland fisheries, C942 Rev. 1 (FAO, 2003) and C942 Rev. 2 (Welcomme, 2011);
- review the status and trends of inland fisheries catch at global, continental and subcontinental levels;
- place inland capture fisheries in the context of overall global fish production, and call attention to the importance of inland capture fisheries with respect to food security and nutrition;
- develop an analysis of the economic value of inland fisheries;
- assess the contribution to employment and the gender differences related to this;
- assess the extent and value of recreational inland fisheries;
- examine the linkage between inland fisheries and biodiversity; and
- explore the approaches that may be used to develop improved estimates of inland capture fishery production.

These objectives of the C942 Rev. 3 are guided by the recommendations of the 2016 FAO Committee on Fisheries (COFI) that called for improved assessment of inland fisheries and their contributions to food security. They are also guided by the *Rome Declaration – 10 Steps* that emerged from the 2015 Global Conference on Inland Fisheries (see Taylor *et al*., 2016).

All maps in this document were generated using the QGIS Geographic Information System (QGIS Geographic Information System. Open Source Geospatial Foundation. URL http://qgis.osgeo.org) using the Database of Global Administrative Areas (GADM) shapefiles (https://gadm.org/).

[1] Arguably, this would also include SDG14 Life below water, as there are many common objectives to freshwater fisheries, however this SDG has been framed in an exclusively marine context.

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Funge-Smith, S.J. 2018.
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ABSTRACT

The FAO Fishery and Aquaculture Circular C942 Revision 3 (C942 Rev. 3) updates and expands the scope of previous revisions of the circular. C942 Rev. 3 is an important baseline document, intended to assist in the global understanding of inland fisheries and inform dialogue on their current and future role.

The third revision reviews the status and trends of inland fisheries catch at global, continental and subcontinental levels. It places inland capture fisheries in the context of overall global fish production, and calls attention to the importance of inland capture fisheries with respect to food security and nutrition and the Sustainable Development Goals. It quantifies global inland fisheries resources in terms of food production, nutrition, employment, economic contribution with respect to those countries/regions or subnational areas where they are important.

A characterization approach to distinguish large-scale and small-scale fishing operations and their relative contributions is provided. The review provides estimated economic values of inland fisheries, as well as a valuation of potential replacement cost of these (in terms of dollars, other resources such as land and water, feeds). There is also an analysis of the extent and economic value of recreational inland fisheries. The contribution to employment and the gender differences related to this are quantified. The linkages between inland fisheries and biodiversity are also explored. C942 Rev. 3 discusses ways to measure and assess inland fisheries, in particular, how to establish more accurately inland fishery catches in the many situations where there are challenges to collection of catch statistics.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

The production of this FAO Fisheries and Aquaculture Circular C942 Revision 3 has only been possible because to the work and commitment of a huge number of people over the past seven years. Their research and analysis have provided the rich base for collation of material found here in this review.

The following people have contributed substantively to this review:

Abigail Bennet developed the chapter one section on large-scale and commercial inland fisheries as part of an FAO fellowship funded by Michigan State University.

Andy Thorpe provided reviews of Central Asia (Chapter 2). Alexei Sharov kindly reviewed the information on the Russian Federation (Chapter 2). David Bunnell, Devin Kinney, Steve Cooke, Doug Beard and Bill Taylor provided input to the section on North America (Chapter 2). The bulk of the information about the South American countries and Mexico in Chapter 2 were derived from national reports compiled by Claudio Baigún and written by: Claudio Baigún (Argentina); Paul A. Van Damme (Bolivia); Mauro Luis Ruffino and Claudio Baigún (Colombia); Luz F. Jiménez-Segura, Francisco Gutiérrez, Rosa E. Ajiaco-Martínez and Carlos Lasso (Brazil); Ramiro Barriga S. (Ecuador); Carmen Pedroza-Gutiérrez (Mexico); Viviana Ríos Morinigo (Paraguay); Carlos Cañas, Max Hidalgo, Carla Muñoz, Lisveth Valenzuela and Hernán Ortega (Peru); Marcelo Crossa (Uruguay); Antonio Machado-Allison and Blanca Bottini (Venezuela). The full reports will be published separately. The information about the Central American countries (except Mexico) and the Dominican Republic were largely drawn from national reports compiled in collaboration with the Central America Fisheries and Aquaculture Organization (OSPESCA) and written by: Martha Zapata (Belize); Álvaro Segura (Costa Rica); Ricardo Colon Álvarez (Dominican Republic); Camila Amellalí Oquelí Otero (El Salvador); Manuel de Jesús Ixquiac Cabrera, Erick González, Julio Lemus, Luis Lopez, and Airam Lopez (Guatemala); Luis Morales Rodriguez (Honduras); Rodolfo Sanchez (Nicaragua); Jorge García Rangel (Panama). The full reports will be published separately.

The following authors drafted or contributed to the subsequent chapters and are acknowledged in the main document: Fiona Simmance (chapters three and four); Andy Thorpe and Carlos Zepeda (chapter five); Jennifer Gee, Fiona Simmance and Felix Marttin (chapter six); Fiona Simmance and Jennifer Gee (chapter 7); Doug Beard, Steve Cooke and Ian Cowx (chapter 8); Devin Bartley (chapter 9); Rachel Ainsworth, Ian Cowx, Etienne Fluet-Chouinard, Peter Mcintyre and David Bunnell (chapter 10).

We would like to further acknowledge the support of the following colleagues who assisted in providing essential country level data on prices and country details for various estimates and calculations used in the text of chapter 5: Angelito Gonzal, Pedro Bueno, David Bunnell, Mikhail Chebanov, Mark Ebener, Alaa Mahmoud Mohamed El Far, Walid Elsawy Aly, Abdolhay Hossein, Nick Innes-Taylor, Yumiko Kura, Abby Lynch, Seamus Murphy, Chikondi Pasani, Sui Chian Phang, Rohana Subasinghe, Shunji Sugiyama, Chanthaphone Thammavong, and Raymon VanAnrooy.

Robin Welcomme and John Jorgensen reviewed the entire document and made important suggestions that improved the text. The document was edited by Iljas Baker.

DEFINITIONS USED IN THIS REVIEW

Inland waters	This term refers to lakes, rivers, brooks, streams, ponds, inland canals, dams, and other landlocked waters (usually freshwater) such as the Caspian Sea and the Aral Sea.	FAO CWP Handbook
Inland capture fishery	The extraction of living aquatic organisms from natural or man-made inland waters, but excluding those from aquaculture facilities.	FAO (2011)
Stocking	The release of cultured or wild aquatic organisms at any life stage into an aquatic ecosystem for the purpose of enhancement, stock rebuilding or biological control.	FAO (2011)
Enhanced fisheries	Fisheries that are supported by activities aimed at supplementing or sustaining the recruitment of one or more aquatic organisms and raising the total production or the production of selected elements of a fishery beyond a level which is sustainable by natural processes. Enhancement may entail stocking with material originating from aquaculture installations, translocations from the wild and habitat modification.	FAO (2011)
Culture–based fisheries	Capture fisheries which are maintained solely by stocking with material originating from aquaculture installations.	FAO (2006)
Habitat enhancement	A fishery management tool with the sole purpose of providing better environmental conditions for desired species of fish, e.g. the construction of brush parks as found in tropical Africa and Asia.	FAO Term Portal
Naturally reproductive stock component	In fisheries enhanced through stocking, that component of the total stock that is maintained by natural reproduction. This component may include organisms derived from natural reproduction of stocked fish.	FAO (2011)
Recreational fishing	Any fishing for which the primary motive is leisure rather than profit, the provision of food or the conduct of scientific research and which does not involve the sale, barter, or trade of part or all of the catch.	FAO Term Portal
Introduced species *(alien species)*	Species (including associated races or strains) that are intentionally or accidentally transported and released by humans into an environment outside their natural range. (Adapted from Article 8(h) of the Convention on Biological Diversity)	FAO (2011)
Translocations (transfers)	Movement of individuals of a species or population, intentionally or accidentally transported and released within their natural range.	FAO (2011)

The determination of what constitutes “inland waters” for the purpose of fishery statistical reporting was considered by the FAO Coordinating Working Party on Fishery Statistics (CWP) at its Fourteenth Session in Paris, France (FAO, 1990). The important consideration was that salinity was an inadequate criterion for separating inland waters from marine waters. It concluded that FAO member countries should identify waterbodies or areas that might present problems of categorization and report these to FAO. The principle goal is to ensure that fish catch is not double counted. This does mean that brackishwater lagoons and low salinity inland seas might be considered marine or inland waters by different countries. In the case of separation by species, this is also an inadequate criterion when used alone, as some species are found in both marine and freshwaters.

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EXECUTIVE SUMMARY

The global population now stands at 7.6 billion and is projected to rise to 9.7 billion people by 2050. Inland capture fisheries have an important role to play in this global challenge to sustainably feed this growing population, as they deliver quality nutrition to some of the world's most vulnerable populations in a manner that is both accessible and affordable. These nutritional and food security benefits are an integral part of the agricultural landscape of these countries; they are also increasingly impacted and changed as countries develop their agricultural water and land resources. It is vital to recognize that in our efforts to irrigate water-hungry crops for cereals and feeds for livestock, or to provide hydropower energy for burgeoning cities, we are undermining the very basis of an existing and often important food production system. In some cases, it is possible to seek some co-existence or even capture synergies, but elsewhere decisions on trade-offs are necessary and this requires full awareness of who and what this will impact, in terms of livelihoods and food security.

The country distribution of inland fisheries catches is worldwide with catches concentrated around rich water resources such as lakes, rivers and floodplains, especially where there are higher population densities of rural people able to exploit these resources. The world's largest inland capture fisheries are particularly concentrated in the tropical and subtropical latitudes of the world. In regions that are economically more developed, the use of inland waters for capture fisheries tends to change to the use of these waters for recreational purposes

INLAND FISHERY CATCH, CATCH TREND AND HIDDEN CATCH

FAO reported an inland fisheries catch of 11.47 million tonnes in 2015, representing 12.2 percent of total global capture fishery production. Seventeen countries produce 80 percent of this global inland fishery catch and a further 10 percent of global catch is produced by a further 12 countries. The next 7 percent is produced by 26 countries and the remaining 3 percent comes from 96 other countries.

Inland fisheries are predominantly small-scale in nature, but large-scale and commercial inland fisheries do make a contribution to livelihoods and food security. Global catches from large-scale inland fisheries have an aggregate catch of between 1 140 000 and 1 340 000 tonnes, representing 11 to 13 percent of total global inland fisheries catch. Commercial inland fisheries produce 700 000 to 900 000 tonnes of catch destined for extended or specialized commercial value chains. Some of this is derived from small-scale fishing units, but between 540 000 to 740 000 tonnes are harvested by large-scale commercial units. The small pelagic inland fisheries of the African Lakes region contribute more than half of the global commercial inland fisheries catch, producing between 787 236 and 791 028 tonnes. These fisheries make an important contribution to African food security as part of an extensive and complex regional trade network across the continent.

The Asian region (excluding China) has the highest inland fishery catch representing 46 percent of the global total. China contributes an additional 20 percent to this. This high contribution is a function of the major inland fishery ecosystems and wetlands (including vast areas of managed ricefield ecosystems) that present extensive and productive habitats. It is also linked to high population densities capable of intensively exploiting these resources and a widespread, strong tradition of fish consumption. Africa is the second largest catch of inland fisheries, but just under half that of Asia. Importantly, the catch per capita (2.56 kg/capita/yr) is far higher than that of Asia (1.99) or China (1.63). This indicates the relative importance of inland fisheries to Africa, which does not yet have a major aquaculture industry. The American continent has a reported inland catch of 570 515 tonnes produced mainly in South and Central America. This low value might be considerably higher if the retained recreational catch of North American countries was included. The European catch is low at 150 017 tonnes, but might be considerably higher with the inclusion of the retained catch of recreational fishers and those that catch fish on an occasional basis for household consumption. The catch of Oceania is largely confined to Papua New Guinea, New Zealand, Australia and Fiji. The Arabian region has no reported inland fishery catch.

The growth in global inland fisheries catch over the past decade has been driven by 34 countries. The principal countries driving this trend were China PR, India, Cambodia, Indonesia, Nigeria, the Russian

Federation and Mexico. There are 37 countries that indicated an increasing production trend over the past decade representing 58.7 percent of global inland fish catch. There were 28 countries that indicated decreasing production but represent only 5.9 percent of global inland fish catch, (the trend in this group is driven by Brazil, Thailand, Viet Nam and Turkey). There are 27 countries that demonstrate stable catches (the major contributors to global catch in this group are Tanzania UR, Congo DR, Mali and Kazakhstan) and represent only 7.7 percent of global catch. The remaining 17 countries had no discernible trend of increase or decrease in their catch, these countries representing 12.6 percent of global catch (this group is driven by Bangladesh and Egypt, followed by Zambia). Even in countries that report declining catches, inland fisheries remain extremely important at the subnational level (e.g. the Mekong basin, the Amazon basin) and there is no case for complacency.

There are plausible reasons to consider that the total global inland fishery catch figure may be an underestimate. Based on the modelling of inland fisheries catch using household consumption surveys applied to the 2008 reported figures, total global inland fishery catch was estimated to be 64.8 percent higher (13.93 million tonnes) than the reported figure (10.3 million tonnes). The confidence interval for this study (11.82 to 16.12 million tonnes) is still in excess of the current globally reported 2015 reported catch (11.47 million tonnes).

CHARACTERIZATION OF INLAND FISHERY TYPES

An analytical method to support the objective characterization of the scale and nature of inland fisheries was developed for this review. This method uses a matrix approach across a number of characteristics related to scale, including vessel and fishing methods, labour and employment, the nature of fishing trips and area, and the disposal of the catch. The approach recognizes the multi-character nature of the scale of fishing operations and avoids inappropriate classifications that can emerge when relying on a single characteristic or a highly-constrained number of characteristics, such as gear and vessel length. The method therefore provides an approach to assess scale objectively without imposing a narrow definition based on a single or highly constrained number of quantitative metrics. This method allowed the disaggregation of small and large scale inland fishery catches and the distinction of catch from commercially organized fishing operations.

CONTRIBUTION TO SUSTAINABLE DEVELOPMENT, HUMAN NUTRITION AND FOOD SECURITY

Small-scale inland fisheries catch tends to be directed for local human consumption and plays an important direct role in food security (note the exception with the African, small, inland-pelagic fish). Ecosystem services from freshwater environments and inland capture fisheries influence human well-being by alleviating poverty and contributing to food and livelihood security. Inland capture fisheries and their ecosystem services provide a broad range of benefits for development and contribute directly to the Sustainable Development Goals (SDGs). Despite this, the inland fisheries sector is typically ignored or overlooked in policy and global debates on food security.

Global inland fishery production is reported at 11.47 million tonnes of fish in 2015. This is equivalent to the full dietary animal protein of 158 million people. At least 43 percent (4.9 million tonnes, 2015) of the world's inland fish capture harvest comes from 50 low-income food deficit countries (LIFDCs). At least 11 percent of global inland fishery production (1.3 million tonnes, 2015) comes from landlocked countries. Inland fish provides nutritional quality to countries where there are otherwise poor diets, due to poverty and limited access to other forms of quality food. Inland fisheries are efficient producer of food, with a far lower resource use footprint when compared with livestock or other protein dense foods. In low GDP countries with inland fisheries, the per capita supply of fish food produced from inland waters is greater than that of marine capture fisheries or aquaculture.

THE ECONOMIC VALUE OF INLAND FISHERIES

The economic value of inland freshwater fisheries catches (as reported to FAO) is estimated to be approximately USD 26 billion. The major contributions to this come from Asia (66.1 percent) and

Africa (22.2 percent). It is acknowledged that a significant proportion of the inland catch is "hidden" and therefore unreported, although this proportion has probably reduced over the past few years as a result of improved reporting. If this hidden component is included in the valuation, the estimated total use value of inland freshwater fisheries rises to USD 38.53 billion. This value is further increased to USD 43.53 billion if the value of freshwater molluscs and crustaceans is included. The value of capture fisheries is somewhat dwarfed by the use values generated by recreational fishing. With a 2015 non-market use value (NMUV) of recreational fishing estimated to lie somewhere between USD 64.55 billion and USD 78.55 billion. The United States of America and Canada account for almost 72 percent of this value. It is considered that the NMUV is almost certainly an underestimate because of the lack of data from Africa and limited data from Asia and Latin America, despite their burgeoning recreational fishing activity. Aggregating the NMUV of inland recreational fisheries and the UV of inland capture fisheries indicates that the total UV of the inland fishery sector is worth an estimated USD 108 billion to USD 122 billion annually. If the costs of capture (value added ratio:VAR) are discounted, the gross value added (GVA) of inland capture and freshwater recreational fisheries is still between USD 90 billion and USD 100 billion.

EMPLOYMENT IN INLAND FISHERIES

Inland capture fisheries employ between16.8 million and 20.7 million people employed in inland capture fisheries. Another 8 million to 38 million are employed in the post-harvest sector. This represents about 2.5 percent to 6 percent of the global agricultural workforce. Women represent more than 50 percent of the workforce in inland fisheries. Inland fisheries are predominantly rural, small-scale fisheries with limited commercial large-scale fisheries. Inland fisheries are generally less dangerous than marine capture fisheries but, because of the poverty of small-scale inland fishers, there are still problems with child labour and unsafe working conditions in some inland fisheries.

WOMEN'S INVOLVEMENT IN INLAND FISHERIES

Women's engagement in inland fisheries is often invisible although they play a significant role in many fisheries. Women are often narrowly associated with post-harvest processing and marketing activity, but they also engage in fishing. In 61 countries that report disaggregated data and where women a recognized as fishers, the ratio is 1 fisherwoman to every 7.3 fisherman. There are 44 countries which report that women do not engage in fishing. Women's access to income from fish processing and marketing may have a stronger and more beneficial impact on household incomes than income from fishing by men. Despite their dependence upon the fishery, this may be poorly reflected in fishery management decision-making processes. Vulnerable women engaged in post-harvest marketing of fish may be dependent upon male fishers for access to fish, relying on transactional sex for preferential supply of fish.

RECREATIONAL FISHERIES

Recreational fishing involves considerable numbers of people around the world in both developed and developing countries. There is an average of 6.7 percent of the population engaged in recreational fisheries in those countries where recreational fishing is a common activity (>174.5 million). Some estimates place this figure higher. A sense of the value of recreational fisheries can be derived from direct costs, which are estimated in excess of USD 44 billion per year. The indirect costs are estimated at over USD 100 billion per year. Indications from a number of countries suggest that the retained catch from inland recreational fisheries is likely to be substantial, about 5.4 percent of total global reported catch. This catch is reported rarely to FAO, therefore at least some of this catch explains under-reporting in countries such as those in Eastern Europe, the Russian Federation, Ukraine, Central Asia and North America. The introduction and establishment of non-indigenous fish for recreational fishing would benefit from more systematic reporting as their potential to become invasive often only becomes apparent a considerable time after the initial introduction.

INLAND FISHERIES LINKAGE TO AQUATIC BIODIVERSITY

Aquatic ecosystems (inland and marine) represent the most biodiverse sources of food consumed by humans. This includes vascular plants and algae, and animals such as crustaceans, molluscs, reptiles, amphibians and finfish. Freshwater ecosystems cover only about 1 percent of the earth's surface, but provide habitat for over 40 percent (13 000) of the world's freshwater fish species. Another 2 000 species of fish can also live in brackishwater. In general, the level of knowledge on freshwater biodiversity (i.e. species richness, endemism, production, level of endangerment and value), is poor or out of date for many areas. Freshwaters are one of the ecosystems most heavily impacted by humans. Major impacts on biodiversity include pollution, habitat loss and degradation, draining wetlands, river fragmentation and poor land-management. Biodiversity of fish can and does serve as indicators of ecosystem health. Freshwater biodiversity is threatened and has declined in many areas as a result of these impacts. According to the IUCN Red List, the highest number of threatened, endangered or extinct species is in Asia. The greatest freshwater diversity in inland fisheries is found in Asia, but South America has the greatest overall fish biodiversity (i.e. not limited to freshwater). The neotropical regions contain the highest amounts of fish biodiversity and the tropical and subtropical floodplain rivers and wetlands are the ecoregions with the highest levels of biodiversity. South America also has the highest levels of endemism. Rice fields are an important source of biodiversity and include over 200 species of fish, insects, crustaceans, molluscs, reptiles, amphibians and plants (in addition to rice) that are used by local communities. Many freshwater species are important to the aquaculture industry as sources of broodstock for spawning and early life history stages (e.g. eggs, larvae) for ongrowing. Non-native aquatic species can contribute significantly to the production and value in inland fisheries and aquaculture. The use of international guidelines on species introductions and a precautionary approach are advised when considering moving species into new areas.

METHODS FOR ASSESSMENT OF INLAND FISHERIES

The review concludes with the exploration of ways to improve the assessment of inland fisheries. The known limitations of inland fishery statistics and the assessment of inland fisheries are described and a series of methodologies to try to improve this situation are presented. The methods use innovative approaches such as household consumption surveys, habitat yield models and a basin approach to inland fishery characterization. Methods to estimate the intrinsic value of inland fisheries using a replacement methodology are also reported.

SUBREGIONAL COUNTRY GROUPS USED IN THIS REVIEW

One of the challenges of integrating information relevant to inland fisheries is that the delineation of boundaries varies according to the information source. This is linked to the purpose to which the information is being used. FAO fishery statistics are not recorded at fishery or basin/sub-basin level. They are reported to FAO as a national aggregate statistic that is compiled from a range of fisheries based on different habitats that are related to the size and geography of a country. This means that the national figure will represent the fisheries of a number of basins, and range of fisheries – spanning rivers, lakes, floodplains and wetlands. In many cases, inland fishery production areas are not wholly contained within a national boundary and are part of a transboundary river basin.

It is possible to group countries into subregional clusters that reflect common climatic characteristics, or even at a level that reflects their shared water resources (e.g. countries within a basin). The subregional groups that are used to present the inland fisheries statistics in this review comprise groups of countries that align more or less with identifiable regions and subregions, or in some cases (e.g. the African Sahel, African Great Lakes) a cluster of countries that have a particular common feature or climatic characteristic. The countries and their subregional groupings are presented below.

Region	Sub-region	Countries
Africa	North	Algeria, Libya, Morocco, Tunisia
	Sahel	Burkina Faso, Chad, the Gambia, Mali, Mauritania, the Niger, Senegal
	Nile Basin	Egypt, Ethiopia, South Sudan, the Sudan
	East Coast	Djibouti, Eritrea, Somalia
	West Coast	Benin, Cameroon, Côte d'Ivoire, Equatorial Guinea, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Togo
	Great Lakes	Burundi, Kenya, Malawi, Rwanda, the United Republic of Tanzania, Uganda
	Congo Basin	Central African Republic, the Congo, the Democratic Republic of the Congo, Gabon
	Southern	Angola, Botswana, Lesotho, Mozambique, Namibia, South Africa, the Kingdom of Eswatini, Zambia, Zimbabwe
	Islands	Madagascar
Asia	Southeast	Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Viet Nam
	South	Bangladesh, Bhutan, India, Nepal, Pakistan, Sri Lanka
	China	China, China, Hong Kong SAR, China, Macao SAR, Taiwan Province of China
	East	Japan, Democratic People's Republic of Korea, the Republic of Korea
	West	Iran (Islamic Republic of), Iraq, Israel, Jordan, Lebanon, Palestine, the Syrian Arab Republic, Turkey
	Central	Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Tajikistan, Turkmenistan, Uzbekistan
Russian Federation	-	Russian Federation
Europe	Eastern	Belarus, Bulgaria, Czechia, Hungary, Republic of Moldova, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, Ukraine
	Northern	Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden

Region	Sub-region	Countries
	Western	Andorra, Austria, Belgium, Channel Islands, Faroe Islands, France, Germany, Ireland, Liechtenstein, Luxembourg, Netherlands, Switzerland, United Kingdom
	Southern	Albania, Bosnia and Herzegovina, Croatia, Cyprus, Greece, Italy, Former Yugoslav Republic of Macedonia, Malta, Portugal, Spain
America	South	Argentina, Bolivia (Plurinational State of), Brazil, Chile, Colombia, Ecuador, French Guyana, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela (Bolivarian Republic of)
	Central	Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama
	North	Canada, United States of America
	Islands	Cuba, Dominican Republic, Falkland Islands (Malvinas), Haiti, Jamaica
Oceania	-	Australia, Fiji, French Polynesia, Micronesia (Federated States of), New Zealand, Papua New Guinea, Samoa, Solomon Islands
Arabia	-	Bahrain, Kuwait Oman, Qatar, Saudi Arabia, United Arab Emirates, Yemen

Not covered in this review

American Samoa, Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Bermuda, British Virgin Islands, Cabo Verde, Cayman Islands, Comoros, Cook Islands, Dominica, Greenland, Grenada, Guadeloupe, Guam, Kiribati, Maldives, Marshall Islands, Martinique, Mauritius, Montserrat, Nauru, Netherlands Antilles, New Caledonia, Niue, Northern Mariana Island, Palau, Pitcairn Islands, Puerto Rico, Reunion, Saint Helena, Saint Kitts and Nevis, Saint Lucia, Saint Vincent/Grenadines, San Marino, Sao Tome and Principe, Seychelles, Tokelau, Tonga, Trinidad and Tobago, Turks and Caicos Islands, Tuvalu, United States Virgin Islands, Vanuatu, Wallis and Futuna Island.

INFORMATION SOURCES

The sources of specific data used in this document are referenced in the tables where they appear and the full bibliographic reference is provided at the end of each chapter.

Large data sets for national and subnational levels have also been used to add context or supporting analysis to the review of fisheries and their respective basins. These data sets used are as follows:

Data set	Source
Global inland fishery production	**FAO FishStatJ database:** http://www.fao.org/fishery/statistics/software/fishstatj/en
Population data	**Total population:** FishStatJ (Dataset includes the Food Balance sheet workspace) http://www.fao.org/fishery/statistics/software/fishstatj/en
	Global labour force: International Labour Organization, using World Bank population estimates. http://data.worldbank.org/indicator/SL.TLF.TOTL.IN
	GIS population data GPW: for 2015 http://sedac.ciesin.columbia.edu/data/collection/gpw-v4/whatsnew
Administrative unit delineation *Hydrological/river basin and sub-basin delineation and descriptions*	**Global administrative unit layers (GAUL):** http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691 **Major hydrological basins of the world:** http://www.fao.org/geonetwork/srv/en/metadata.show?id=38047
	Major river basins of the world (2007): Global Runoff Data Centre (GRDC), Koblenz, Germany: Federal Institute of Hydrology (BfG) http://www.bafg.de/GRDC/EN/02_srvcs/22_gslrs/221_MRB/riverbasins_node.html
	Watersheds of the world: World Resources Institute http://multimedia.wri.org/watersheds_2003/
Surface water and water storage, dams, lakes and reservoirs	**HydroLAKES: global lakes 10 ha or larger** http://www.hydrosheds.org/page/hydrolakes
	The global reservoir and dam (GRanD) database provides the location and main specifications of large global reservoirs and dams with a storage capacity of more than 0.1 km^3 both in point and polygon format. http://atlas.gwsp.org/index.php?option=com_contentandtask=viewandid=208andItemid=52
Biodiversity-related	We are especially grateful to Michele Thieme (WWF), Carmen Ravenga (TNC), Paulo Petry (TNC) and Peter McIntyre (University of Wisconsin) for information on species richness and endemism.
	Information on ecoregions and major habitat types was from Abell (2008) Ecoregion data kindly provided by **WWF/TNC Freshwater Ecosystems of the World** http://www.feow.org/ GIS Shapefile (2013) http://www.feow.org/downloadlist
	A global database on freshwater fish species occurrence in drainage basins (Leprieur, F. *et al*., 2017) https://doi.org/10.6084/m9.figshare.c.3739145
	Ramsar sites information service https://rsis.ramsar.org/
National household expenditure and consumption surveys	**Adept database of household income and expenditure surveys** accessed by FAO Food and Nutrition Service (ESN), FAO, Rome.

1 SUMMARY OF GLOBAL INLAND FISHERIES

Simon Funge-Smith

The global population now stands at 7.6 billion and is projected to rise to 9.7 billion people by 2050 (FAO, 2017). Feeding this growing population is a recognized challenge and requires action across the agricultural sector to achieve this in a sustainable manner. Inland capture fisheries have an important role to play in this global challenge. They deliver quality food to some of the world's most vulnerable populations in a manner that is both accessible and affordable. These nutritional and food security benefits are an integral part of the agricultural landscape of these countries and as a result will be impacted and changed as countries increasingly develop their water and land resources to produce food for their growing populations. Recognizing the current contribution of inland fisheries is vital for their sustained contribution to food security, but it is also vital to recognize that in our push to irrigate water-hungry crops for cereals and feeds for livestock, or to provide hydropower energy for burgeoning cities, we are undermining the very basis of an existing and often important food production system. In some cases we can seek some co-existence or even capture synergies, but elsewhere we need to make decisions on trade-offs, fully aware of who and what this will impact in terms of livelihoods and food security.

1.1 GLOBAL INLAND FISHERIES CATCH

FAO reported an inland fisheries catch of 11.47 million tonnes in 2015, representing 12.2 percent of total global capture fishery production. Seventeen countries produce 80 percent of this inland fishery catch ranging between 151 000 and 2.3 million tonnes (Table 1-1). A further 10 percent of global catch is produced by another 12 countries with catches in the range of 50 000 to 150 000 tonnes. The next 7 percent is produced by 26 countries with catches in the range of 20 000 to 49 000 tonnes. The remaining 3 percent comes from 96 other countries ranging between 1 and 20 000 tonnes.

Table 1-1: Summary table of global inland fisheries catch (2015)

% of global total	Total inland fishery catch (tonnes) (2015)	Range of national catch (tonnes)	Countries
80	9 190 291	151 000 to 2 281 000	China, India, Bangladesh, Myanmar, Cambodia, Indonesia, Uganda, Nigeria, Tanzania UR , Russian Federation, Egypt, Congo DR, Brazil, Philippines, Thailand, Kenya, Mexico
10	1 186 401	50 000 to 150 000	Viet Nam, Malawi, Pakistan, Chad, Mozambique, Mali, Ghana, Iran IR, Zambia, Cameroon, Sri Lanka, Lao PDR
7	771 666	20 000 to 49 000	Ethiopia, Kazakhstan, Angola, Peru, the Congo, South Sudan, Niger, Turkey, Venezuela BR, Japan, the Sudan, Senegal, Finland, Rwanda, Central African Republic, Canada, Guinea, Madagascar, Uzbekistan, Iraq, Nepal, Germany, Benin, Burkina Faso, Burundi, Ukraine,
1.6	182 773	10 000 to 20 000	12 countries
1.1	123 482	1 000 to 10 000	36 countries
0.1	4 887	1 to 1 000	48 countries

The Asian region (excluding China) has the highest inland fishery catch representing 46 percent of the global total. China alone provides nearly 20 percent in addition to this (Table 1-2). This huge proportion of the global catch is a function of the major inland fishery ecosystems and wetlands (including vast areas of managed ricefield ecosystems) that present extensive and productive habitats. Coupled to this is a high population density that is capable of intensively exploiting these resources, and a widespread, strong tradition of fish consumption.

Table 1-2: Inland fishery catch by major region, per capita production and contribution to global total (for subregional details see table Annex 1)

Subregion	Inland capture fishery catch (tonnes) (2015)	Inland fishery production (kg/cap/year) (2013)	Total renewable surface water (km3/yr)	Fish production per unit of renewable surface water (tonnes/km3/yr)	Global inland fishery catch (%) (2015)	Global renewable surface water (%)
Asia	5 304 612	1.99	11 023	1 841	46.2	20.9
Africa	2 860 131	2.56	5 529	8 716	24.9	10.5
China	2 281 065	1.63	2 739	833	19.9	5.2
Americas	570 515	0.57	24 824	233	5	47.1
Russian Federation	285 090	1.84	4 249	67	2.5	8.1
Europe	150 017	0.24	3 042	194	1.3	5.8
Oceania	18 030	0.5	1 314	14	0.2	2.5
Arabia	0	0	5	0	0	0
GLOBAL	**11 469 460**	**1.64**	**52 726**	**11 898**	**100**	**100**
EXCLUDED COUNTRIES*	0	0.00	227	0	0.0	0.4

* These are countries that report no inland fisheries production to FAO.

Africa is the second largest catch of inland fisheries, but just under half that of Asia. Importantly, the contribution per capita (2.56 kg/capita/yr) is far higher than that of Asia (1.99) or China (1.63) (Figure 1-1, Table 1-2, details in Annex 1). This indicates the relative importance of inland fisheries to Africa, which does not yet have a major aquaculture industry (762 406 tonnes in 2015).

Conversely, Asia (14.8 million tonnes) and China (30.7 million tonnes) both have substantial freshwater aquaculture production, which makes an equal or higher contribution to the per capita consumption of freshwater fish.

The American continent has a reported inland catch of 570 515 tonnes produced mainly in South and Central America. This low value might be considerably higher if the retained recreational catch of North America (estimated at 419 000 tonnes for Canada and the United States of America, see Section 2.5.3) was accounted for in the statistics reported to FAO.

The European catch is lower still at 150 017 tonnes. This figure might be considerably higher with the inclusion of the retained catch of recreational fishers and those that catch fish on an occasional basis for household consumption, but that are not considered to be sport fishers/anglers (i.e. they are unlicensed or fishing illegally).

The catch of Oceania is largely confined to Papua New Guinea, New Zealand, Australia and Fiji. Arabia has no reported inland fishery catch.

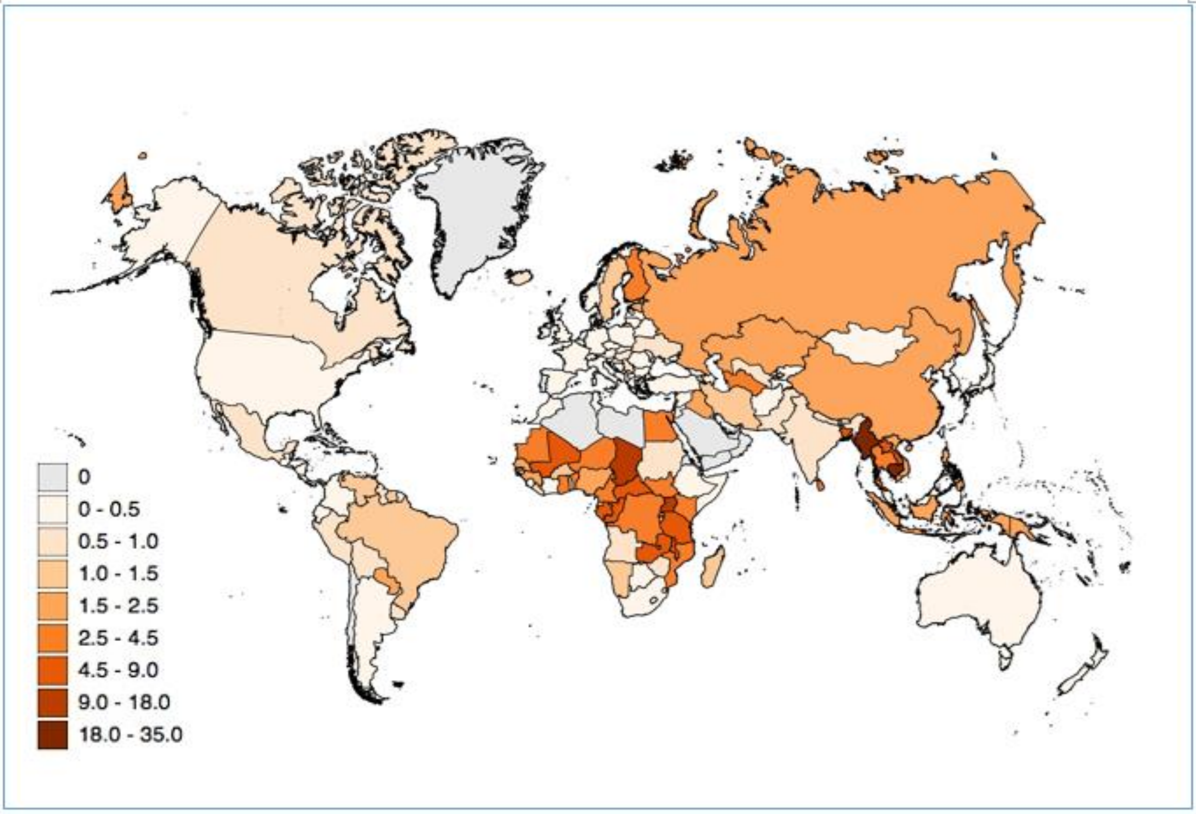

Figure 1-1: Global inland fishery catch, per capita of population (2013 data)

1.2 TRENDS IN NATIONAL CATCH 2007 TO 2016

Based on the FAO inland fishery catch statistics over the decade 2007 to 2016, the aggregated global trend is one of steady growth. This global trend of inland fisheries production may be misleading, as it shows a continuous increase over time. Some of this increase can be attributed to improved reporting and assessment at country level and may not be increased production. The improvement in reporting may also mask trends in individual countries where fisheries are declining.

To establish how this global inland fishery catch trend was composed, an analysis was made of individual country catch for the decade 2007 to 2016. Analysis at the national level (using the Mann–Kendall test for trend analysis, 90-percent confidence) can indicate the catch trend of individual countries and thus the influence this has on the global inland fishery catch trend. This allows the countries which are contributing positively to growth in inland fisheries to be identified, versus those countries for which inland fishery catch has no clear trend or is declining.

It was not possible to use all the 153 countries that have an inland fishery catch. This is because a number of countries do not report with sufficient regularity to FAO, requiring estimation of their national catch. In order to base the trend analysis on national reports (and not FAO estimates), the analysis excluded those countries which reported inland fishery catch to FAO seven or less times over the decade (43 countries in total). The 43 countries excluded from the analysis represented 15.1 percent (1 756 309 tonnes) of the global inland fishery catch for 2016 . Of the remaining 110 countries, a Mann–Kendall trend analysis (90-percent confidence level) was performed to establish the trend in reported production (Table 1-3).

Table 1-3: Production trends and the relative contribution to the global catch

Catch trend over decade 2006 to 2015	Number of countries	Aggregate catch (tonnes)	Percentage of global catch	Countries having a significant effect on the group (>1% of total catch of group)
Increasing catch	37	6 830 955	58.7	China (34%), India (21%), Cambodia (7%), Indonesia (6%), Nigeria, Russian Federation, Mexico, Philippines, Kenya, Malawi, Pakistan, Chad, Mozambique, Iran IR, Sri Lanka, Ethiopia, the Congo
Decreasing catch	28	691 672	5.9	Brazil (33%), Thailand (27%), Viet Nam (16%), Turkey, Madagascar, Japan, United States of America, Peru, Poland, Czechia
Stable catch	27	893 401	7.7	Tanzania UR (35%), Congo DR (26%), Mali (11%), Kazakhstan, Niger, Finland, Benin, Venezuela BR, Iraq, Nepal, Argentina, Togo, Romania
No clear trend	17	1 464 573	12.6	Bangladesh (72%), Egypt (16%), Zambia, Canada, Burundi, Germany, Korea RO
Excluded from analysis	43	1 756 309	15.1	Myanmar (50%), Uganda (22%), Ghana (5%), Lao PDR (4%), South Sudan, Senegal, the Sudan, Central African Republic, Guinea, Cameroon, Colombia, Paraguay, Zimbabwe, Mauritania, Turkmenistan, Papua New Guinea, Gabon

There are 37 countries that indicated an increasing production trend over the decade representing 58.7 percent of global inland fish catch (Figure 1-2). The major drivers of this trend were China PR, India, Cambodia, Indonesia, Nigeria, the Russian Federation and Mexico.

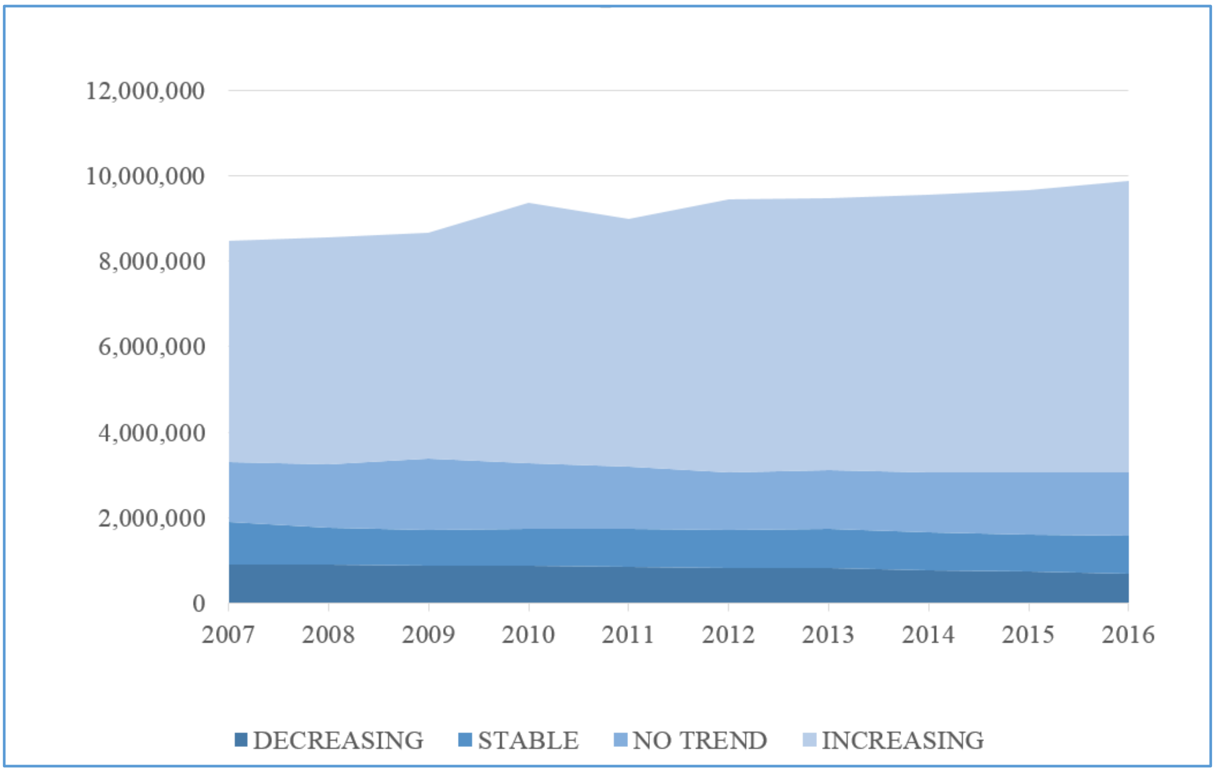

Figure 1-2: Global catch trend for the decade 2007 to 2016 (tonnes)

There were 28 countries that indicated decreasing production representing only 5.9 percent of global inland fish catch, and of this group the trend is driven by Brazil, Thailand, Viet Nam and Turkey.

There are 27 countries that demonstrate stable catches, indicating that there is little or no variation in their reported catch trend. The major contributors to global catch in this group are Tanzania UR, Congo DR, Mali and Kazakhstan. The group represents 7.7 percent of global catch. The remaining 17 countries had no discernible trend of increase or decrease in their catch. These countries represent 12.6 percent of global catch and the group is highly dominated by Bangladesh and Egypt, followed by Zambia.

The conclusion of this analysis is that growth in global inland fisheries is driven by 34 countries, and of these, about eight relatively large producers drive this trend. The 24 countries that are reporting declining catches represent a relatively low contribution to global production and all four have significant aquaculture production. Inland fisheries remain extremely important at the subnational level in these countries (e.g. the Mekong basin, the Amazon basin), hence this decline should not be a cause for complacency.

1.3 HIDDEN, UNDER-REPORTED CATCH

There are plausible reasons to consider that the total figure reported in FishStatJ may be an underestimate. Based on the modelling of inland fisheries catch using household consumption surveys (Fluet-Chouinard, Funge-Smith and McIntyre, 2018; Section 10.5 of this review), applied to the 2008 reported figures, the total global catch was estimated to be 64.8 percent higher (13.93 million tonnes) than the reported figure (10.3 million tonnes). The confidence range for 2008 (11.82 to 16.12 million tonnes) is still in excess of the 2015 reported catch (11.47 million tonnes).

Table 1-3: Summary of estimates of hidden, under-reported inland fish catch

Estimate of production	Year	Catch (million tonnes)	Confidence interval (million tonnes)	Source
FAO FishstatJ total annual catch	2008	10.3	-	FAO (2017)
Total catch including adjustments of 42 countries based on consumption model	2008	13.93	11.82 to 16.12	Fluet-Chouinard, Funge-Smith and McIntyre (2018)
Total catch including adjustments of 42 countries based on consumption model, applied to 83 percent of global catch	2008	17.1	-	Fluet-Chouinard, Funge-Smith and McIntyre (2018)
Total catch including estimated, unreported hidden catch	2009	15	-	World Bank (2012)

Source: FAO FishStatJ 2015, Fluet-Chouinard, Funge-Smith and McIntyre (2018); Section 10.5, this review; World Bank (2012)

Application of the adjustment to other countries using a modelling approach indicated that the global catch in 2008 was 17.1 million tonnes (Table 1-3). Using this approach to estimate a historic hidden catch, it is not possible to apply exactly the same proportion to the current reported catch. However it does indicate the potential for an underestimate and the issues of under-reporting that existed in 2008 and remain to this day.

1.4 LOCATIONS OF THE WORLD'S INLAND FISHERIES

1.4.1 INLAND CAPTURE FISHERIES

The world's inland capture fisheries are particularly concentrated in the tropical and subtropical latitudes of the world, with a few notable exceptions (e.g. Finland lakes, Russian large lakes, the Volga and Yenisei rivers, North American Great Lakes and salmon rivers, Paraguay/La Plata River in South America, Chinese large rivers (Figure 1-3).

The country distribution of inland fisheries catches is worldwide. However, these catches tend to be concentrated around rich water resources such as lakes, rivers and floodplains, especially where there are higher population densities of rural people able to exploit these resources.

The database developed by Lehner and Grill (2013) based on the hydrosheds database identifies 3 210 hydrological basins. Many of these basins are rather small and may not contain significant hydrological resources to support fisheries. The Global Runoff Data Centre (GRDC) database[2] identifies more than 405 major river basins in the world with an estimated 263 international/transboundary river basins. These tend to have large river basins and can encompass upland headwaters (some at high altitude), floodplains and deltas. They may be a combination of temperate/arctic and temperate/tropical environments.

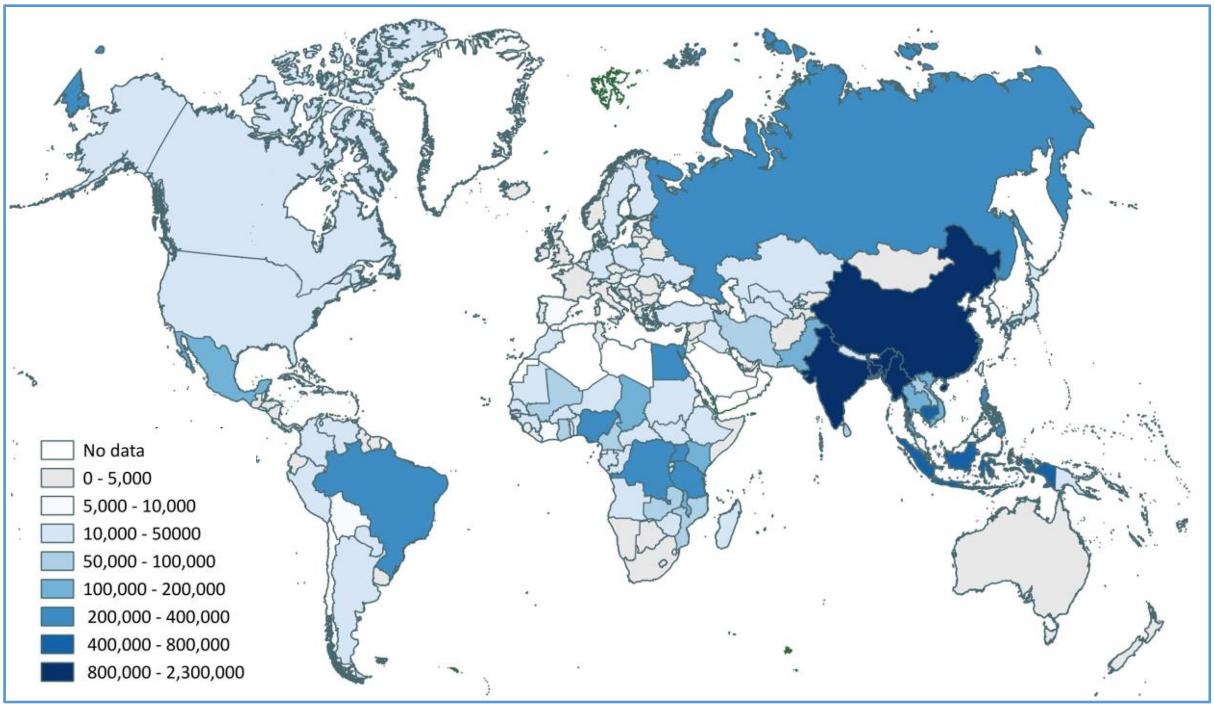

Figure 1-3: Map of the world's highest inland fishery producing countries (in tonnes; data from FAO FishStatJ)

In section 10.3 of this review more than 40 major hydrological basins that have significant inland fisheries are identified. There are many more smaller hydrological basins (typically in tropical areas) that have inland fisheries, but which are not individually large enough to attract international attention, though they may still contribute significantly to the national inland fishery catch.

[2] http://www.bafg.de/GRDC/

There is another group of basins that have very low inland fishery production. The basins in this group are often overlooked because they have limited freshwater resources, or are in cold regions and thus have low fish productivity. Some of these hydrological basins that have low fishery catches may still have relatively rich fish biomass; their limited inland fishery activity because of their remote location or inaccessibility (some of the North American and Siberian lakes and rivers). Despite their low reported production, they may still be important, especially in terms of valuable recreational fisheries, and should not be ignored.

1.4.2 ENHANCED FISHERIES

There is an interface between some aquaculture systems and inland fisheries. This is most evident in the case of stocked systems, especially when the fish have been cultured in aquaculture hatcheries and released to open waters. There are also systems where the parents are taken from the wild for reproduction and the fingerlings subsequently released back to the same waters. This activity is mainly directed at the enhancement of salmonid fisheries in rivers and lakes. There are similar systems for sturgeon to enhance fisheries (the enhancement stocking of the Caspian Sea with sturgeon juveniles raised from wilds adults in hatcheries is perhaps the largest-scale example) as well as for conservation purposes.

A further extension of enhanced fisheries towards full aquaculture systems is the introduction of fish to rice fields. Fisheries may also be enhanced through use of aggregation devices and habitat management and enhancement such as brush parks or management of the habitat in breeding grounds. Reporting of these enhanced fisheries may be problematic for statistical purposes and is often treated in aquaculture reporting. Strictly speaking, culture-based fisheries are aquaculture activities, but in this case the stocked fish in the system are the only source of fish that are captured. In reality, it is often a mixture of stocked and wild recruited fish that is harvested.

1.4.3 RECREATIONAL FISHERIES

In regions that are economically more developed, the use of inland waters for capture fisheries tends to change to the use of these waters for recreational purposes (Figure 1-4).

Regular capture fishing for food transforms to occasional recreational fishing for pleasure (although the consumption of catch is still widespread (see Chapter 8).

Participation rates in recreational fishing are high and this can also be an economic activity (Sections 5.8 and 8.4 cover the value of recreational fishing).

Recreational fishing is not always a function of the state of economic development as many Eastern European countries and the Russian Federation have a long tradition of recreational fishing that is undertaken with the particular purpose of catching food for the home. This is not classified as subsistence or artisanal fishing and where is occurs it has sometimes been officially referred to as “amateur fishing”.

Recreational fishing is also pursued in developing countries around the world and often with some intention of providing supplementary food in the home. This type of fishing is extremely hard to quantify and has a much smaller footprint than other forms of subsistence and artisanal fishing in these countries. As such, there is rarely any data available on participation rates and effort.

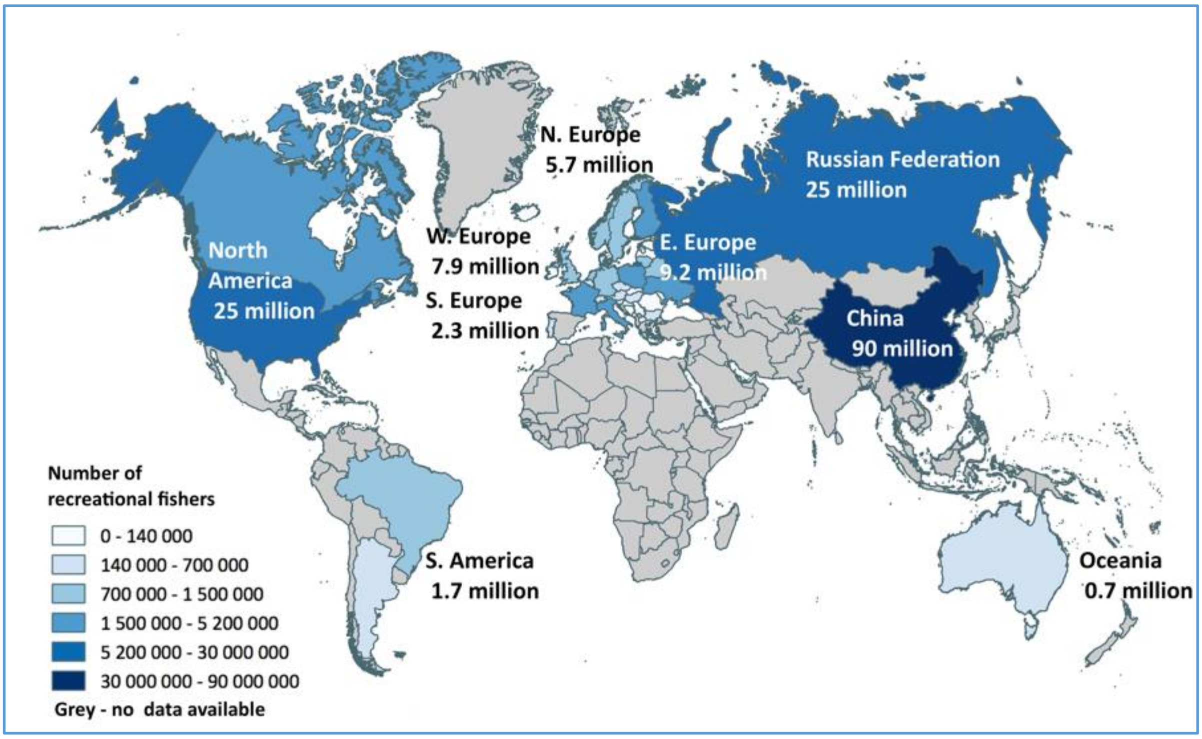

Figure 1-4: Map of the world's important recreational fisheries regions, in terms of numbers of participating fishers (Data sources in Table 8-2).

1.5 ESTIMATING THE CONTRIBUTION OF LARGE-SCALE AND COMMERCIAL INLAND FISHERIES

Simon Funge-Smith and Abigail Bennett

Large-scale and commercial inland fisheries make substantial livelihood and food security contributions. Based on the estimates which are described in the following sections, the global catch from large-scale inland fisheries, many of which are also commercial fisheries, is between 1 140 000 and 1 340 000 tonnes. This represent between 11 to 13 percent of global inland fisheries production (Figure 1-5).

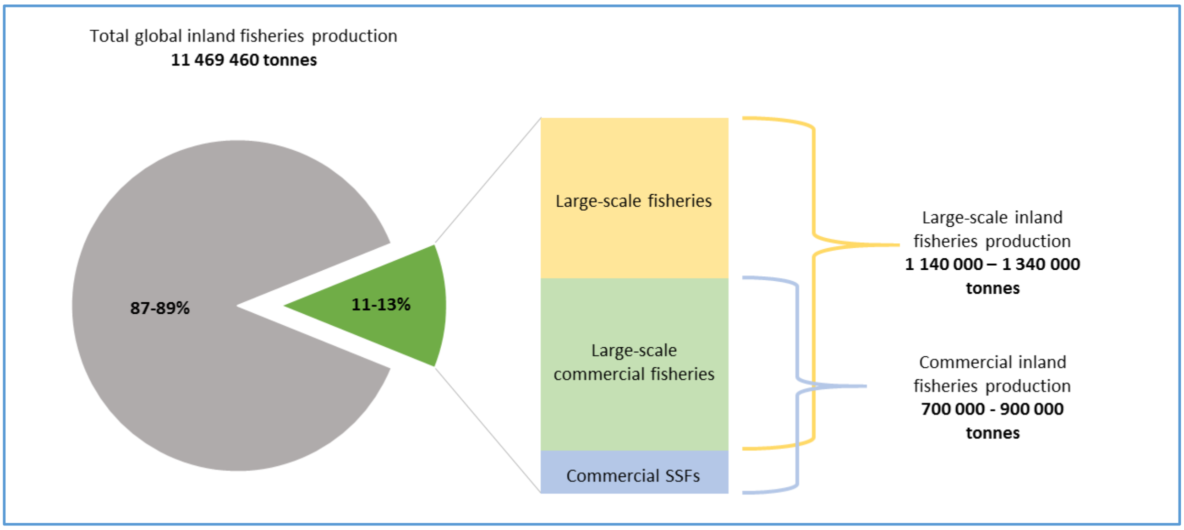

Figure 1-5: Total catch from large-scale and commercial inland fisheries

Between 700 000 and 900 000 tonnes of inland fish catch are destined for extended or specialized commercial value chains.Some of this is derived from small-scale fishing units. The set of large-scale inland fisheries and the set of commercial inland fisheries overlap, but not completely. In other words, many – but not all – large-scale inland fisheries are commercial fisheries and vice versa. The overlap between large-scale and commercial fisheries production falls between 40 and 50 percent, with 540 000 to 740 000 tonnes of inland fisheries catch harvested by large-scale commercial units.

Although the majority of inland fisheries are small-scale operations harvesting for household consumption and local trade or barter, recognizing that a non-trivial portion of inland fisheries catch originates from large-scale and commercial operations has important implications for both valuation and governance.

1.5.1 CHARACTERIZING THE SCALE OF INLAND FISHING OPERATIONS – A MATRIX APPROACH

Inland fisheries are generally characterized as small-scale operations that typically harvest for household consumption and local barter or trade (Bartley *et al*., 2015). A global study estimating the total catch, including "hidden" or unreported catch, from marine and inland capture fisheries estimated that inland fisheries produce 15 000 000 tonnes total annual catch, of which 1 000 000, or 6.7 percent, originates from large-scale fisheries with an estimated value of less than USD 1 billion. (World Bank, 2012). Despite representing a minority of inland fisheries, large-scale and commercial inland fisheries make substantial contributions to livelihoods and food security. Furthermore, the governance challenges and opportunities they face are distinct from those of smaller-scale fisheries. Therefore, this chapter provides an updated in-depth assessment of the contribution of large-scale and commercial inland fisheries and their characteritics.

There is increasing interest in trying to characterize small-scale and large-scale fisheries for a variety of reasons, spanning across governance (policy, legislation, access and tenure), economic (taxation, subsidies, special preference) and management (regulation, gears, zoning) considerations. For example, the FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries is part of an ongoing process to recognize small-scale fisheries as an identifiable segment of fisheries that is important enough to warrant special consideration. There have been various attempts to develop a characterization framework for small-scale versus large-scale fisheries (e.g. Thompson, 1980; Sumaila *et al.*, 2012; Berkes *et al*., 2001; Jacquet and Pauly, 2008; World Bank, 2012; Gibson and Sumaila, 2017), as well as distinct characterizations in various national fishery legislation around the world.

In reality, however, there is no simple cut-off for defining a small-scale or large-scale fishing activity. The FAO Working Group on Small-Scale Fisheries concluded that it was not possible or useful to formulate a universal definition for small-scale fisheries considering their diversity and dynamism. It therefore provided a broad characterization that was intended to capture this diversity (FAO/Advisory Committee on Fisheries Research 2004, p. 2). However, this does not resolve the need for an objective method to create a distinction between large-scale and small-scale fisheries to inform trade-offs in policy and legislation at national and regional levels and governance approaches more broadly.

Any such method must recognize that in reality, many fisheries have quantitative and qualitative characteristics that may be associated with either smaller-scale or larger-scale fisheries. This means that a fishery will rarely have a complete set of characteristics that are exclusively large-scale. It is this variety that makes defining large-scale and small-scale fisheries challenging. Existing broad definitions that are utilized are starting to account for the fact that the scale of a fishery must be measured using multiple characteristics. This recognizes that the use of narrowly defined metrics (such as vessel size, motorization or gear type) is counter-productive and can result in inequitable exclusion for some fishing operations and the inappropriate inclusion of others.

To this end, this analysis utilized a matrix that assesses fisheries across a number of characteristics related to scale, including vessel and fishing methods, labour and employment, the nature of fishing trips and area, and the disposal of the catch. This approach recognizes the multicharacter nature of the scale of fishing operations and avoids inappropriate classifications that can emerge when relying on a single characteristic or a highly-constrained number of characteristics, such as gear and vessel length.

The matrix presented here (Table 1-4) provides an approach to assess scale objectively without imposing a narrow definition based on a single or highly constrained number of quantitative metrics. It allows the general qualitative characteristics of fishing operations to be used as a scoring method to identify the scale of fishing operations. It is an adaptation of the table that is presented in the Hidden Harvest study (World, Bank 2012), which itself was adapted from a number of previous authors (Berkes *et al.,* 2001; Chuengpagdee *et al.,* 2006; Johnson, 2006).

The earlier tables had a similar range of characteristics, but differed in that there were absolute categorizations for each of the types of fishery (subsistence, small-scale, large-scale). In contrast, this matrix generates an aggregate score for any given fishery, which provides the basis for assessing scale.

When scores from all the categories are aggregated, an overall picture emerges that facilitates differentiation between larger-scale and smaller-scale fisheries. This allows a decision to be made based on an overall cut-off score to separate small-scale and large-scale operations. For inland fisheries, scores of 21 or higher tend to display more characteristics of large-scale fisheries, such as gear that aggregate large volumes of fish, larger and more powerful vessels, distinct forms of property rights and labour relations, and formal integration into the economy and governance institutions. The analysis presented below utilized this matrix to identify the set of large-scale inland fisheries. This method allowed the generation of a robust estimate of global inland fisheries production originating from large-scale fisheries.

The assessment in this section also includes estimates for commercial inland fisheries, both large-scale and small-scale. Many of the inland fishers in the world trade or barter at least part of their catch at the local level. However, the analysis below focuses on commercial inland fisheries that are associated with extended value chains (i.e. at the regional or international level), fisheries that harvest particularly high-value products, for example sturgeon cavier, or fisheries that sell products into specialized markets, for example for aquarium fish or niche markets utilizing ecolabels.

Table 1-4: Scoring matrix to inform the characterization of scale and complexity for different types of inland fisheries

Score	0	1	2	3
Indicative gears				
Passive/ no gear	Foraging by hand, traps, pots	Gill nets, baited longlines	Pumped trap ponds	Large fence traps, large river traps/bagnets
Active gear	Cast net, handheld lift net, scoop, spear, baited hook	Seine net, lift net	Large lift net	Actively hauled dredge/trawl net
Mechanization	No mechanization	Battery powered equipment / lanterns	Generator/ engine powered attracting lights	Small power winch/ hauler powered off engine
Vessel				
Size of fishing vessel	No vessel	<4m	>4 m to <8 m	>8 m
Motorized or not	n.a.	No engine	Outboard engine <25 hp	Inboard engine >40 hp
Operations				
Daily trip/multi-day	Occasional foraging	Seasonal fishing, short trips	Regular fishing trips, all-day	Multi-day fishing trip
Fishing area/waterbody type	Seasonal waterbodies, wetlands and small streams, ricefields	Less than ~5 km from shore in permanent rivers, medium waterbodies, wetlands	Large rivers, large waterbodies, reservoirs <500 km^2	Inland seas, large lakes and waterbodies >500 km^2
Storage / preservation				
Refrigeration/ storage	No storage	Insulated box / ice box	Ice hold	Refrigerated hold
Employment / labour				
Labour/ crew	Individual and/or family members	Cooperative group	<2 paid crew	>2 paid crew
Fishing unit/ ownership	Owner/operator	Leased arrangement	Owner	Corporate business
Time commitment	Part-time/occasional	Full-time, but seasonal	Part-time all year	Full-time
Use of catch				
Disposal of catch	Household consumption/barter	Local direct sale at landing site	Sale to local market traders	Sale for export
Utilization of catch, value adding/ preservation	For direct human consumption	Preserved: chilled, fermented, smoked , salted, dried	Frozen, filleted	Factory processed
Integration into economy and/or management system	Informal not integrated (occasional, no fees required)	Integrated (registered/ recognized fisher, untaxed)	Formal integrated (licensed fisher, payment of landing fees /personal taxes)	Formal, integrated (registered, licensed, taxed as a commercial concern)

1.5.2 CHARACTERISTICS OF LARGE-SCALE INLAND FISHERIES

Large-scale inland fisheries are estimated to produce between 1 140 335 and 1 343 928 tonnes (Table 1-5). Production volumes from individual fisheries ranged from a few thousand tonnes to a few hundred thousand tonnes. Annexes 2 and 3 provide details about the production estimates for each fishery.

Table 1-5: Catch from large-scale inland fisheries

Fishery	**Main species**	**Production (tonnes)**
Lake Victoria *dagaa* fishery	*Rastrineobola argentea*	457 000
Myanmar *inn* fishery	Various floodplain species	189 959 to 388 552
Lake Victoria Nile perch fishery	*Lates niloticus*	199 000
Lake Albert *muziri* and *ragoogi* light fishery	*Neobola bredoi* *Brycinus nurse*	129 000
Lake Tanganyika *kapenta* light fishery	*Stolothrissa tanganicae* *Limnothrissa moidon*	52 000
Caspian Sea *kilka* fishery	*Clupeonella spp.*	37 425
Lake Kariba *kapenta* fishery	*Stolothrissa tanganicae* *Limnothrissa moidon*	18 000 to 19 000
Tonle Sap *dai* fishery	Various species	13 950
Cahora Bassa *kapenta* fishery	*Limnothrissa moidon*	11 922
Brazilian Amazon estuary trawl fishery	*Brachyplatystoma vaillantii* *Bracyplatystoma flavicans* *Pseudoplatystoma fasciatum* *Brahyplatystoma filamentosum*	11 076
Lake Albert Nile perch fishery	*Lates niloticus*	8 619
Laurentian Great Lakes trawl fishery Laurentian Great Lakes gill net fishery	*Coregonus clupeaformis* *Perca flavescens* *Sander vitreus*	4 000 to 8 000
Lake Malawi stern trawl fishery Lake Malawi Maldeco stern trawl fishery Lake Malawi pair trawl fishery	*Lethrniops spp.* *Copadichromis spp.* *Oreochromis spp*.	5 600
Finland Vendace trawl fishery	*Coregonus albula*	1 373
Estonian Lake Peipus gill net and trap net fishery	*Perca fluviatilis*	1 231
Caspian Sea sturgeon fishery	*Acipenser gueldenstaedtii* *Acipenser persicus* *Acipenser stellatus*	180
Total		**1 140 335** to **1 343 928**

The matrix scores for large-scale inland fisheries ranged from 21 (the cutoff between large-scale and small-scale fisheries) to 34 (out of a total possible 39) (Table 1-6). Grouping the set of large-scale fisheries by score (e.g. <25, 25–30, and >30) clearly demonstrates that no single characteristic defines large-scale inland fisheries. For example, among the lower-scoring large-scale fisheries are fisheries utilizing both passive and active gears, motorized and non-motorized vessels (or no vessel), and disposing of catch in a variety of ways.

Although all of the fisheries scoring above 30 utilize active gears such as trawls, some of the highest scores were assigned to gill net (passive gear) fisheries from the United States and Europe. To improve comparison, Table 1-6 also includes a number of co-located small-scale inland fisheries operating in the same waterbodies. The detailed matrix scores for each fishery are included in Annex 2.

Table 1-6: Matrix scores for large-scale and selected small-scale inland fisheries

Fishery	**Matrix score**
Large-scale inland fisheries	
Caspian Sea kilka (*Clupeonella spp*.) fishery	34
Laurentian Great Lakes trawl fishery	31
Lake Malawi Maldeco stern trawl fishery	30.5
Brazilian Amazon estuary trawl fishery	30
Estonian Lake Peipus gill net and trap net perch and pike-perch fishery	28.5
Laurentian Great Lakes gill net fishery	28.5
Lake Malawi stern trawl fishery	27.5
Caspian Sea sturgeon fishery	26
Lake Kariba *kapenta* (*Limnothrissa miodon*) fishery	26
Cahora Bassa *kapenta* fishery	26
Lake Victoria Nile perch fishery	24
Lake Albert Nile perch fishery	24
Finland Vendace trawl fishery	23
Tonle sap stationary trawl (*dai*) fishery	22.5
Lake Tanganyika *kapenta* light fishery	22.5
Lake Malawi pair trawl fishery	22.5
Lake Turkana Nile perch fishery	22.5
Lake Albert *muziri* and *ragoogi* light fishery	21.5
Lake Victoria dagaa (*Rastrineobola argentea*) fishery	21
Myanmar leasable (*inn*) fishery	21
Selected co-located small-scale inland fisheries	
Lake Volta winch boat fishery	20.5
Lake Nasser trammel net and gill net fishery	19
Laurentian Great Lakes trap net fishery	17.5
Brazilian Amazon canoe and mothership fishery	17.5
Lake Kivu *kapenta* light fishery	17
Lake Tanganyika gill net and longline fishery	15
Lake Malawi small purse seine fishery	14
Lake Malawi gill net fishery	14

Table 1-6: Matrix scores for large-scale and selected small-scale inland fisheries

Fishery	**Matrix score**
Lower Parana sabalo (*Prochilodus lineatus*) fishery	13.5
Tonle Sap gillnet fishery	13
Lake Malawi beach seine fishery	11

Gear and vessel characteristics

Many of the large-scale inland fisheries utilize the types of large, motorized vessels that are typically associated with large-scale fishing activity. The Caspian Sea *kilka* fishery is the largest-scale inland fishery. In the Caspian Sea *kilka* fishery, large vessels utilize 500 to 1 000 watt electric "attracting lights" to aggregate large numbers of the small fish. These fish are harvested with mechanized fishing gear, most often large, cone-shaped nets and sometimes electric fish pumps that suction *kilka* from below the surface (Salmonov *et al.*, 2013; FAO, 1998). African lake fisheries for small pelagics (see Table 1-8) also utilize light attracting methods, some battery-operated and some kerosene type. Inland fisheries in Malawi, the Brazilian Amazon estuary, Europe, and the Laurentian Great Lakes utilize trawls and other mechanized fishing gear.

At the same time, many of the large-scale fisheries utilize gears and vessels more commonly associated with small-scale fisheries. For example, In the Lake Victoria Nile perch fishery, passive gillnets are the most-used gear followed by longlines, and less than one third of boats are motorized (Kolding *et al.*, 2014). Even fisheries that use stationary gear and no vessels may be large-scale operations. For example, the Tonle Sap *dai* fishery in Cambodia utilizes bag nets that are about 100 m in length (referred to as *dai*) to aggregate large volumes of migrating fish as they pass through channels (Lamberts, 2001).Although the *dai* is a passive gear, most use mechanized winches of nearly 2 500 hp (Halls *et al*., 2013). Similarly, the Myanmar *inn* fishery uses large fence traps. That these fisheries represent large-scale fishing operations often formally integrated into national economic and governance systems and capable of aggregating substantial volumes demonstrates the importance of assessing scale based on multiple characteristics beyond vessel length, gear and motorization or mechanization.

Operations

The character of a fishery's operations pertains to where, and for how long, a typical fishing trip or activity takes place. Among all the characteristics of the matrix, the scores for operations show the most consistency across the set of large-scale fisheries. The vast majority of large-scale inland fisheries take place in inland seas or in large lakes and waterbodies greater than 500 km^2. However a few take place on more moderately-sized waterbodies, for example the Finland Vendace trawl fishery, or on large rivers, for example the Brazilian Amazon estuary trawl fishery (although this is restricted to the estuary) and a segment of the Myanmar *inn* fishery. With few exceptions, such as some Caspian Sea sturgeon operations, large-scale fisheries generally involve regular all-day or all-night fishing trips.

Employment and labour

Characteristics related to employment and labour describe how property rights for fishing vessels, gear, and fishery access are organized and the type of labour relations in the activity. In most of the large-scale inland fisheries the vessels and gear are owned by an invidual or commercial enterprise that employs fishers and crew to undertake the fishing activities. The vast majority of large-scale inland fisheries employ more than two crew members on board each vessel. In some fisheries, individuals own multiple boats, such as the Lake Victoria Nile perch fishery where boat owners may manage large fleets (Modesta, 2015). The *dai* fishery, although utilizing stationary gear and no vessel, is a highly capitalized fishery in which gear owners pay the wages and other incidental costs for an average of 11 to 25 people per operation (Hap and Ngor, 2001). For large-scale inland fisheries, the most common fishing units are individual owners followed by corporate business, for example those found in Lake Malawi trawl fisheries or the Lake Kariba *kapenta* fishery.

Use of catch

The use of catch pertains to whether the catch is consumed within the household or sold at local, regional or export markets, whether it is consumed fresh, minimally processed, processed using traditional methods, or factory processed, and the extent to which a fishing operation is integrated into the formal economy and management systems, ranging from unregulated fishing operations to those formally licensed and taxed as commercial concerns. Some large-scale inland fisheries harvest for regional trade and export. For example, the Lake Victoria Nile perch fishery, despite utilizing passive gears and relatively small-scale vessels typically without motors, is an export-oriented fishery. Nile perch is processed as chilled and frozen fillets before being exported to Europe, Asia, and the United States. Although fish frames have, in the past, been primarily dried and consumed locally, now the majority of fish frames are factory processed into fishmeal. On the other hand, the Lake Victoria fisheries are not highly integrated into formal economic and governance structures. Although vessels are registered, they are not associated with any sort of landing fees or personal or commercial taxes (Eggert *et al*., 2015). In contrast, the Myanmar *inn* fishery represents a formally integrated fishery, with leases to fishing lots auctioned by the government at prices ranging from USD 97 to USD 5 726. (Tezzo *et al*., 2017).

1.5.3 COMMERCIAL INLAND FISHERIES

Commercial inland fisheries harvesting for extended value chains or specialized or high-value markets contribute 702 718 to 902 718 tonnes to total inland fisheries catch (Table 1-7). More than 80 percent of commercial inland fisheries are also large-scale fisheries.

Table 1-7: Catch from commercial inland fisheries

Fishery	**Main species**	**Production (tonnes)**
African lakes small pelagics fisheries (see Table 4)	*Rastrineobola argentea* *Neobola bredoi* *Brycinus nures* *Limnothrissa moidon* *Stolothrissa tanganicae* *Engraulicypris sardella* *Barbus paludinosus*	400 000 to 600 000
Lake Victoria Nile perch fishery	*Lates niloticus*	199 000
Caspian Sea *kilka* fishery	*Clupeonella spp.*	37 425
Brazilian Amazon estuary trawl fishery and Brazilian Amazon canoe and mothership fishery	*Brachyplatystoma vaillantii* *Brachyplatystoma flavicans* *Pseudoplatystoma fasciatum* *Brahyplatystoma filamentosum*	32 957
Lower Paraná *sábalo* fishery	*Prochilodus lineatus*	17 191
Lake Albert Nile perch fishery	*Lates niloticus*	8 619
Lake Erie multi-species commercial fishery	*Perca flavescens* *Sander vitreus*	2 565
Global eel fisheries	*Anguilla anguilla* *Anguilla rostrata*	1 924
Estonian Lake Peipus gill net and trap net perch and pike-perch fishery	*Perca fluviatilis*	1 231
Bratsk Reservoir perch fishery	*Perca fluviatilis*	921

Table 1-7: Catch from commercial inland fisheries

Fishery	**Main species**	**Production (tonnes)**
Lake Malaren and Lake Vanern pike-perch fishery	*Sander lucioperca*	261
Lake Hjalmaren pike-perch fish trap and gill net fishery	*Sander lucioperca*	201
Caspian Sea sturgeon fishery	*Acipenser gueldenstaedtii* *Acipenser persicus* *Acipenser stellatus*	180
Irikla Reservoir perch fishery	*Perca fluviatilis*	180
Waterhen Lake walleye and northern pike gill net fishery	-	50
Lake Malawi aquarium fish fishery	Various cichlids	12
Total		**702 718** to **902 718**

Characteristics of commercial inland fisheries

Many of the commercial inland fisheries harvest products for export to distant markets. However, some products consumed domestically move through extended value chains to different regions within large countries such as Brazil, and represent a particularly high-value or luxury good, or employ specialized marketing strategies such as ecolabels.

Typically, commercial fisheries products will undergo some form of processing or preservation, although some specialized products are marketed fresh. Commercial inland fisheries often make substantial contributions to income, for example, the Lake Victoria Nile perch fishery, whose production is largely destined for export to the European Union. Since 2010, the total value of Nile perch exports has ranged from USD 250 million to USD 310 million per year (IOC, 2015).

Advanced storage and preservation techniques are typical of commercial inland fisheries. For example, the *sábalo* fishery in Argentina contributes more than half of the catch for the Lower Parana Basin, the second largest basin in South America (Baigun *et al.*, 2013). The advent of cold plants and export markets in the early 2000s drove rapid increases in *sábalo* landings, which peaked at about 40 000 tonnes in 2004 (Baigun *et al*., 2013). Argentina exported 17 191 tonnes of *sábalo* in 2016 to Colombia, Bolivia and Brazil, with small amounts destined for the United States of America and Paraguay (Ministerio de Agroindustria, 2016). The transition to export markets for Nile perch in the early 1990s also corresponded with a shift away from traditional processing methods such as smoking fish in traditional kilns near the lakeshore to industrial processing plants (Abila, 2003).

High-demand and luxury food products are an important segment of commercial inland fisheries, and are often associated with vulnerability of target species to overexploitation. For example, high demand for caviar from wild caught sturgeon has promoted heavy fisheries exploitation in the Caspian Sea (Pikitch *et al*., 2005). Officially, sturgeon fishing in the Caspian Sea is now banned and trade of all wild caviar products is regulated under CITES, however illegal fishing and trade persists (Uhm and Siegal, 2016).

Some highly commercialized inland fisheries are for non-food products. A number of inland fisheries target ornamental fish for the export trade. In the Brazilian Amazon, the ornamental fish trade focuses primarily on the cardinal tetra (*Paracheirodon axelrodi*) for export to the United States of America, Europe, and Asia, generates millions of dollars and employs thousands of people (Ruffino, 2014). Lake Malawi, with hundreds of endemic species, also has fisheries harvesting for the international aquarium trade. In 2010, 11.78 tonnes in aquarium trade exports generated a revenue of USD 113 025 (Phiri *et al*., 2013).

Highly commercialized inland fisheries are not always under risk for overexploitation. In fact, a few inland fisheries in the world engage in specialized marketing techniques, most notably ecolabels and local branding, that ostensibly support sustainable fisheries governance. For example, multiple fisheries in Europe (e.g. Waterhen Lake walleye and northern pike gill net fishery, the Lake Hjalmaren pikeperch fish trap and gill net fishery, and Lake Malaren and Lake Vanern pike-perch fishery) and in the United States of America (the Lake Erie multispecies commercial fishery) have all obtained certification by the Marine Stewardship Council, a market-based sustainable seafood certification scheme.

1.5.4 THE UNIQUE CASE OF SMALL-PELAGIC FISHERIES IN THE AFRICAN LAKES REGION

The African Lakes region's small pelagics fisheries contribute more than half of the global commercial inland fisheries catch, producing between 787 236 and 791 028 tonnes of small pelagic fish such as *dagaa*, *kapenta*, and *usipa* (Table 1-8).

Through extensive and complex regional export trade, these fisheries make an important contribution to food security across a large region that includes the Democratic Republic of the Congo, Uganda, Kenya, the United Republic of Tanzania, Rwanda, Burundi, Zambia, Malawi, Mozambique, Zimbabwe and beyond.

Estimating the commercial catch from the African Lakes region's small pelagics fisheries presents a challenge because there is a general lack of data on the extent to which these species are traded. It is clear that trade in these species is substantial and that they are linked with extended value chains (Smartfish, 2013). Nonetheless, some proportion of these fish is consumed locally. The presence of large-scale informal and unreported fish trade complicates estimations but also underscores the magnitude of trade in these species. For example, Mussa (2017) estimates that between 2015 and 2016, informal fish exports from Malawi to neighbouring countries totalled 24 116 tonnes. Of this, 20 924 tonnes (86.7 percent) was *usipa*. Taking into consideration that all or nearly all of traded *usipa* is dried, the equivalent fresh weight volume is nearly threefold. This suggests that more than half of *usipa* production in Malawi is traded informally outside the country.

Table 1-8: Catch and trade patterns of African Lakes region small pelagics fisheries

Fishery	Production (tonnes)	Trade patterns
Lake Victoria *dagaa* fishery *Rastrineobola argentea*	457 000	Tanzania UR and Uganda are the biggest exporters, supplying Kenya, Congo DR, Malawi, Mozambique, the Sudan, Rwanda, Zambia, Zimbabwe, and South Africa. About 80% of production processed for animal feed in major cities of Tanzania UR and Kenya (e.g. Dar Es Salaam, Nairobi)
Lake Albert *muziri* and *ragoogi* light fishery *Neobola bredoi* (*muziri*) *Brycinus nurse* (*ragoogi*)	129 000	Consumed in Uganda and exported to DRC and Southern Sudan
Lake Kivu *kapenta* light fishery *Limnothrissa moidon*	17 714	
Lake Tanganyika *kapenta* light fishery *Stolothrissa tanganicae* *Limnothrissa moidon*	52 000	Tanzania UR is a net exporter of *kapenta* from Lake Tanganyika; Burundi, the Congo DR and Zambia are net importers
Lake Mweru *chisense* fishery *Poecilothrissa mweruensis*	No data	Zambia exports chisense from Lake Mweru to Congo DR and other markets along railway lines, in addition to local consumption

Lake Malawi *usipa* fishery *Engraulicypris sardella*	99 370	Nearly 21 000 tonnes of *usipa* (dry weight) exported from Malawi through informal trade routes alone
Lake Kariba *kapenta* fishery *Stolothrissa tanganicae* *Limnothrissa moidon*	18 000 to 19 000	Zambia exports *kapenta* from Lake Kariba to Zimbabwe, Botswana, Namibia, and South Africa
Cahora Bassa *kapenta* fishery *Limnothrissa moidon*	11 992	
Lake Chilwa *matemba* seine fishery *Barbus paludinosus*	2 230 to 6 022	Exports destined to Zambia and Zimbabwe
Total production	**787 236** to **791 028**	
Estimated range of total production destined for extended value chains	**400 000** to **600 000**	

Informal fish trade between Zambia and neighbouring countries is even more substantial than that of Malawi. From Zambia, 102 264 tonnes of fish is exported, of which 97 119 tonnes (nearly 95 percent) goes to the Congo DR. This informal trade data contrasts starkly with official statistics that indicate Zambia as a net importer of fish commodities, with fish exports totalling only 334.3 tonnes. *Dagaa* is the most-traded species in the Zambian informal fish trade, which also includes *kapenta* (Mussa, 2017). It is also worth noting that at an estimated 80 percent of *dagaa* production is processed as animal feed in major cities of the United Republic of Tanzania and Kenya (Legros and Luomba, 2011), representing a separate value chain that also extends beyond direct consumption and local markets.

The United Republic of Tanzania and Uganda are the first and second biggest exporters of *dagaa*, supplying Kenya, the Democratic Republic of the Congo, Malawi, Mozambique, the Sudan, Rwanda, Zambia, Zimbabwe, and South Africa (Smartfish, 2013). However, the *dagaa* value chain seems to be continuing to expand, with traders near Lake Victoria reporting sales in Cambodia and Viet Nam (Legros and Luomba, 2011). Around Lake Tanganyika, the United Republic of Tanzania is a net exporter of *kapenta* and Burundi, the Democratic Republic of the Congo and Zambia are net importers, however Zambia also exports *kapenta* from Lake Kariba to Zimbabwe, Botswana, Namibia, and South Africa.

Two other small fish, *muziri* and *ragoogi*, are exported to the Democratic Republic of the Congo and Southern Sudan in addition to being consumed locally in Uganda. Taken together, these trading routes indicate that the Democratic Republic of the Congo is a major importer of these small dried fish products, a phenomenon which may be at least partially driven by civil conflict undermining the country’s domestic food production systems and increasing reliance on relatively affordable imported foods.

Although it is currently not possible to assess accurately the proportion of the African Lakes region’s small pelagics fisheries production that feeds extended value chains rather than local consumption, the fisheries clearly supply a complex international supply chain making important contributions to food security in the region.

1.5.5 CONCLUSIONS

Not all inland fisheries are small-scale operations harvesting for household consumption. In fact, over 10 percent of the global inland fisheries catch originates from large-scale and commercial fisheries and the contributions of these fisheries is significant in terms of livelihoods, food security, and development.

Furthermore, it is important to attend to the distinct governance challenges and opportunities they face. For example, large-scale fisheries involving high capital investment and concentrated operations may be more amenable to particular forms of management than more dispersed small-scale fisheries. At the same time, large-scale operations capable of aggregating large volumes of fish may need tighter regulatory institutions because of their ability to impact the status of the fishery and the overall health of the ecosystem.

High-value fisheries can face higher risks for overexploitation and stakeholder conflicts. For example, the export market for *sábalo* that emerged rapidly in Argentina after the establishment of cold storage plants is correlated with the decreased size of fish, an increased prevalence of smaller mesh sizes and heightened conflicts among resource users (Barletta *et al*., 2016).

Challenges generating reliable statistics on highly commercialized fisheries can hinder the development and implementation of appropriate governance institutions, for example when high-value markets produce incentives for illegal harvests and concomitant disincentives to report the catch fully.

For some specialized non-food products, in particular ornamental fish, data may go unreported because trade occurs outside of established food value chains.

The application of the matrix (Table 1-4) allows for a more nuanced analysis of these kinds of governance and policy implications that is not possible when following narrower definitions that equate scale with attributes such as vessel length. The matrix approach to characterization, thus provides a method to more fully account for large-scale and commercial inland fisheries in the global context.

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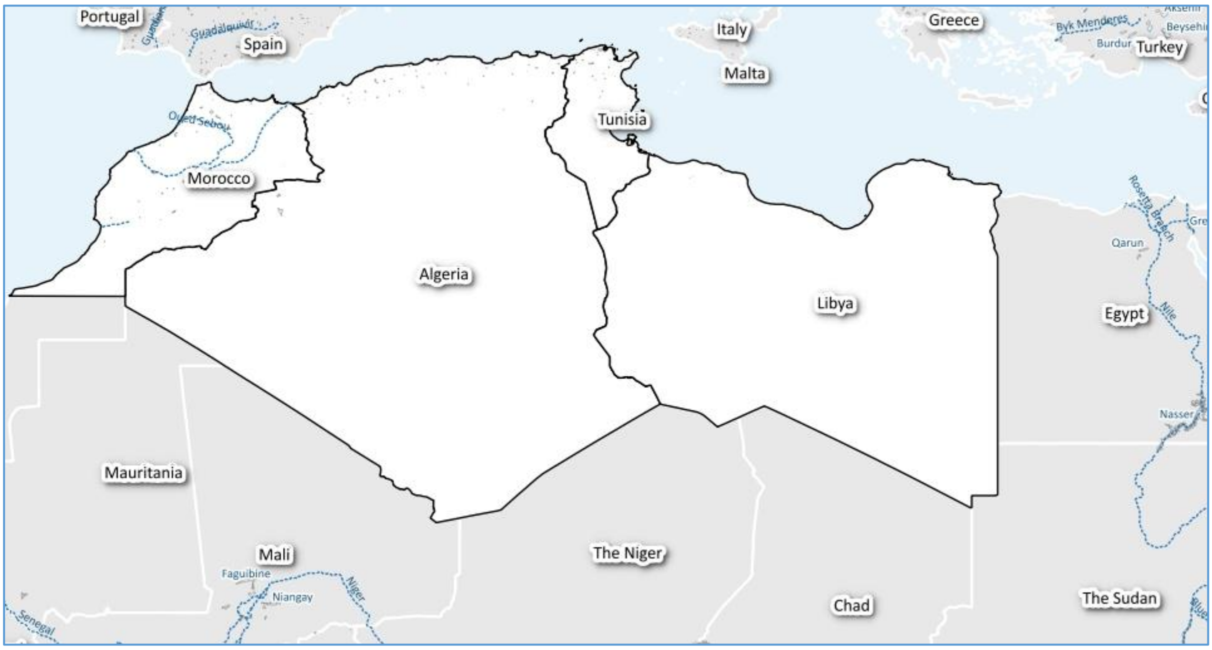
2 INLAND FISHERIES OF THE WORLD BY MAJOR SUBREGIONS

2.1 AFRICA

Subregion	Inland capture fishery catch (tonnes) (2015)	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)	Percentage of global inland fishery catch	Per capita inland fishery production (kg/cap/yr)	Number of inland fishers	Number of post-harvest workers
Great Lakes	1 053 694	226	4 669	9.2	6.11	536 555	290 699
West Coast	568 094	1 394	408	5.0	4.08	759 699	1 499 906
Nile River basin	354 949	261	1 358	3.1	3.85	212 390	77 520
Sahel	307 385	251	1 226	2.7	2.01	695 857	12 194
Congo basin	304 020	2 419	126	2.7	1.57	306 346	217 881
South	229 651	589	390	2.0	1.40	208 180	23 824
Islands	25 940	332	78	0.2	1.01	17 325	816
North	16 198	36	453	0.1	0.18	3 233	0
East Coast	200	22	9	0.0	0.01	390	0
TOTAL	**2 860 131**	**5 530**	**517**	**25**	**2.25**	**2 739 975**	**2 122 840**

2.1.1 NORTH AFRICA



FAO map disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Morocco	15 006	33 008 000	0.46	0.13	22	682
Tunisia	1 192	10 997 000	0.09	0.01	3	349
Algeria	0	39 208 000	0	0	10	0
Libya	0	6 202 000	0	0	0	0

The North African subregion is extremely arid with few permanent rivers and freshwater lakes. There are reservoirs and coastal lagoons where inland fishing activities take place. Total reported production for this subregion is 16 198 tonnes (2015), representing 0.1 percent of global inland fish production.

Morocco

There are several river basins, including Dra, Moulouya, Rbia, Tensift and Sous. There are several coastal lagoons, including Merja Zerga and Nador. There are more than 30 impoundments in Morocco, with a total reservoir area of over 500 km^2. These support small fisheries (Vanden Bossche and Bernacsek, 1991). Reported catches in Morocco started rising in 2002 from less than 1 000 tonnes to over 15 000 tonnes by 2014. The growth is largely from increased production of cyprinids in reservoirs and some lagoon fisheries. Eel catches have declined from 200 to 400 tonnes in the late 1990s to only 2 tonnes in 2014 (Juffe-Bignoli and Darwall, 2012). The inland fish production as a function of renewable surface water (682 tonnes/km^3/yr) is relatively high.

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Tunisia

Four small river systems discharge into the Mediterranean Sea. There are 14 large dams/reservoirs with a combined area of over 176 km^2. There are seven important coastal lagoons with a combined surface area of 550 km^2; the largest are Bibane (230 km^2), Bizerte (150 km^2) and Ichekeul (100 km^2) (Vanden Bossche and Bernacsek, 1991). The reservoirs support small fisheries. Inland fishery production started increasing in the early 1990s reaching 1 000 tonnes, but has remained stable since then. This supports 450 fishermen with 232 boats. The fishery is based around stocking of reservoirs with mullets and subsequently introduced species: common carp (*Cyprinus carpio*), pike-perch (*Stizostedion lucioperca*), mullet (*Mugil cephalus* and *Liza ramada*), eel (*Anguilla anguilla*), European catfish (*Silurus glanis*), roach (*Rutilus rutilus*), barbel (*Barbus setivimensis*), and tilapia (*Oreochromis niloticus*) (Mili *et al*., 2016). The inland fish production as a function of renewable surface water is about half of that of Morocco (302 tonnes/km^3/yr).

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Algeria

There are eleven river (*oued*) basins that discharge into the Mediterranean Sea. There are no important freshwater lakes. Several internal drainage basins possess salt lakes and marshes. There are 21 large dams constructed mainly for irrigation (Vanden Bossche and Bernacsek, 1991). Some intermittent inland catches were reported by Algeria before 1968. There are eel fisheries in Algeria that are considered highly threatened (Juffe-Bignoli and Darwall, 2012). In 2015, it was reported that there had been some stocking of dams and lakes of Algeria's northern provinces of Mila, Biskra and Laghoua (58 lakes and dams in 25 provinces) with Nile tilapia and common carp.

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The State of Libya

The State of Libya does not report an inland fishery production, and has extremely limited renewable surface freshwater resources. There are two small reservoirs and no true inland lagoon of significant size. There are short seasonal rivers (Vanden Bossche and Bernacsek, 1991). Inland fisheries in the State of Libya are negligible. Historical stocking (common carp and some tilapia) was carried out in the past at Wadi Kaam (Khoms/Zliten area) and Wadi Mjinine (Tripoli area) reservoirs, and more recently carp have been stocked in Abou Dzira Lake near Benghazi.

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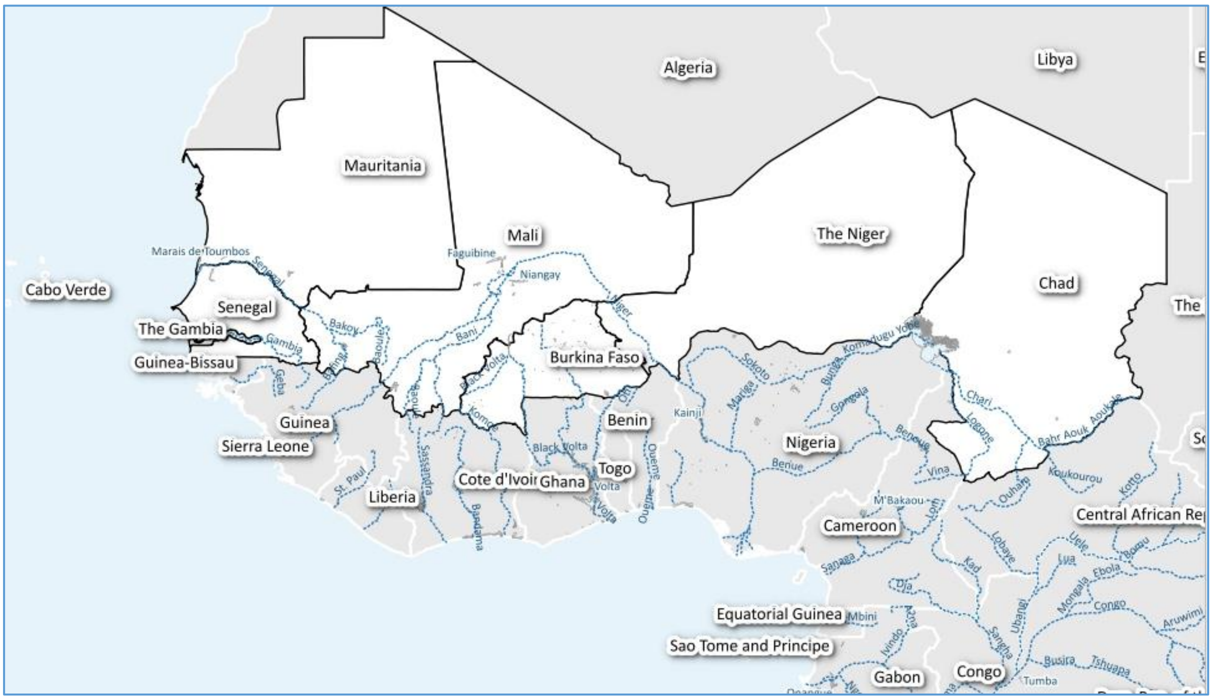
2.1.2 THE SAHEL



FAO map disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita Inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water ($tonnes/km^3/yr$)
Chad	110 000	12 825 000	9.36	0.96	44	2 489
Mali	92 480	15 302 000	6.49	0.81	110	841
Niger	35 252	17 831 000	2.52	0.31	32	1 117
Senegal	30 003	14 133 000	2.36	0.26	37	812
Burkina Faso	20 750	16 935 000	1.21	0.18	9	2 306
Mauritania	15 000	3 890 000	3.86	0.13	11	1 351
Gambia	3 900	1 849 000	2.47	0.03	8	488

The Sahel is a climatically unstable region that experiences high variable rainfall, flooding and consequently inland fishery production. Despite this, the Sahel includes some of the richest fishery resources of the continent, including the Niger, Senegal, Chari and Logone rivers, as well as parts of Volta and Gambia systems and the Lake Chad basin. The accuracy of the reporting for this important region remains a challenge as reported in C942 Rev. 2 (FAO, 2011; Welcomme and Lymer, 2012). The summary total reported production from these countries is 307 385 tonnes (2015) and is 2.7 percent of the global total.

This subregional total production is 26 percent less than the aggregated figure of 412 900 tonnes, estimated by Neiland and Béné (2008) for rivers and large lakes in the subregion (Table 2-1).

Table 2-1. Production and value of river fisheries in West and Central Africa*

River basins and lakes	Employment	Fishery river basins production (tonnes/yr)	Value of production (USD million/yr)	Potential production (tonnes/yr)	Potential value of production (USD million/yr)
River basins					
Senegal-Gambia	25 500	30 500	17	112 000	62
Volta (rivers)	7 000	13 700	7	16 000	8
Niger-Benue	64 700	236 500	95	205 610	82
Chad (rivers)	6 800	32 200	18	130 250	72
Sub-total	**104 000**	**312 900**	**137**	**463 860**	**224**
Lakes					
Chad	15 000	60 000	33	165 000	44
Volta	20 000	40 000	28	62 000	44
Regional total	**139 000**	**412 900**	**198**	**690 860**	**312**

* Where possible reservoir catches have been excluded from these figures.
Source: Modified from Neiland and Béné, 2008

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Chad

Chad has experienced steadily increasing production since 2002 (70 000 tonnes) reaching 120 020 tonnes in 2014. The artisanal fishery is focused on Lake Chad, internal rivers, small lakes, and seasonal flood plains. Thirty percent of fish are harvested from Lake Chad, and sixty percent from the basins of the Logone River and the Chari River. The whole of southern Chad is dominated by the Chari system, which with its main tributaries, the Salamat and Azoum Rivers, extends over about 1 200 km. There are extensive swamps over most of the Chari River basin and have been estimated as covering about 80 000 km^2. Lake Chad fluctuates in area in a pronounced cycle thought to be some 25 years long. This lake exists in two phases: the Greater Chad in pluvial periods, and the Lesser Chad in drought periods (Welcomme, 1979).

The dry state of the lake has continued beyond 2007 and this suggests that the level of fish production currently reported may be overestimated. These later reports for Chad (120 020 tonnes) are considered to be in need of validation although it is possible that the highly productive floodplains of the Logone River and the Chari River are making up some of the reported catch. A shift to “privatization” of the fisheries and impoverishment of certain sections of the fisher community have led to an intensification of the draw-down fishery by extensive creation of fish canals that enable fish to be trapped as they leave the floodplain (Laborde *et al*., 2016).

The survey model production indicates that inland fish production may be as high as 215 000 tonnes in Chad, which is double the current estimate of FAO (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). A possible reason for this elevated figure is that there might be a substantial amount of fish imported from neighbouring countries, although it is reported that much of the Lake Chad production used to be exported to Nigeria (Jolley *et al*., 2001).

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Mali

Most of the country is arid or desert and is only sparsely inhabited. The Niger River and its tributaries (the Baoulè and Bagoye, which unite to form the Bani) are the major arteries of Mali. There are twenty-three main lakes (surface area: ~2 450 to 3 500 km^2) and several hundred smaller ones in the central delta/floodplain of the Niger River. The Central Delta of the Niger has several floodplain lakes and the total area flooded at high water is about 20 000 to 30 000 km^2, and some 3 500 to 3 877 km^2 remain at low water. There are three reservoirs for hydroelectric generation. Fishery yield is affected by the Sahelian drought.

The inland fishery production of Mali has been reported as 80 000 tonnes in 2014 and has been estimated by FAO for preceding years. Although an earlier higher level of production (100 000 tonnes) was considered to be overestimated in the previous C942 (FAO, 2011), the household survey estimates for Mali indicate that inland fish availability in the country is about 127 735 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Vanden Bossche and Bernacsek *(*1991) estimated that for normal years maximum yield of the fishery would be 175 000 tonnes rising to 200 000 tonnes in a high flood year. Consequently the survey model value could be indicative of likely catch.

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The Niger

The Niger has a large land area, but is largely hot and arid. Lake Chad lies partly in the Niger and this rises to 2 774 km^2, during the “Large Chad” phase (17 percent of the total lake area). There are no large reservoirs although the Kandaji Dam on the Niger River is currently being constructed. The reported catch for the Niger has varied widely in the last decade after a massive increase from just over 2 000 tonnes in the early 1990s to 50 000 tonnes in 2005. The explanation for this considerable increase is not given, but may reflect an expansion of the fishery.

The fisheries have contracted since then and this is not unusual, as the tendency for the Sahelian fisheries is to undergo considerable fluctuation. The 2014 inland production is now estimated by FAO at 47 000 tonnes. Welcomme (1979) suggested that the Niger's inland fishery production was probably about 10 000 to 12 000 tonnes. Potential annual yield has been estimated between 4 000 tonnes in drought years and up to 40 000 tonnes in flood years (Vanden Bossche, 1991). According to Fluet-Chouinard, Funge-Smith & McIntyre (2018), the household survey model estimate for the Niger of 16 355 tonnes indicates that this reported catch may too high and perhaps should be closer to the 2007 figure of 27 000 tonnes.

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Senegal

Senegal has productive river fisheries and used to have an extensive floodplain fishery linked to its rivers. The Senegal River covers an area of 340 000 km², the Saloum River, covers an area of 29 700 km², and the Casamance River covers an area of 16 300 km². There is also part of the Gambia River which covers an area of 77 100 km² and Lake Guiers, which covers an area of 350 km². The Casamance River has an estuarine zone that extends far inland. There are also estuarine lagoons around the mouth of the Saloum River, and the Senegal River has an extensive delta that is deeply penetrated by salt water. There are a few small lagoons to the north of Dakar (Vanden Bossche and Bernacsek, 1990). There is a salinity barrage/flood-control dam in the Senegal River delta at Diama and the Manantali dam on the Bafing River.

In 1999, the estimate of fish production in Senegal was 30 540 tonnes in the Senegal River and 15 370 tonnes in the Sine-Saloum River (Ba *et al*., 2006). Women fishers are reported to account for half of the catch in the Sine-Saloum River. The inland fish catch by women is considered to have been excluded from previous estimates of the fishery and resulted in under-reporting of the production (Ba *et al*., 2006). Inland fisheries have been recorded as declining since 1999 (58 747 tonnes) to the present level of 30 045 tonnes, however this trend is based on only two reports from the country, with the intervening years being estimated by FAO.

The potential annual yield was estimated as 37 000 to 60 000 tonnes. The high variability is linked to the Sahelian drought and this has resulted in historic declines in the fishery and subsequent recovery. Typically, drought years result in a 50 percent decline in the fishery (Vanden Bossche and Bernacsek, 1990). Reports from Senegal indicate that inland fishery catches are currently declining. The construction of the Diama dam (on the border with Mauritania) and the Manantali dam (in Mali) in the Senegal River basin has been implicated in reduced fishery resources in part because of the failure to implement intended mitigation measures to ensure ecological flows for flooding and inundation of habitat to sustain inland fisheries (Degeorges and Reilly, 2006). The estimated flooded area of the Senegal River floodplain is less than 50 percent prior to construction of the Manantali dam.

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Burkina Faso

Burkina Faso has substantial river resources, forming the watershed between the Volta and the Niger systems (Vanden Bossche and Bernacsek, 1990). Burkina Faso holds 43 percent of the Volta basin, together with the Comoe basin and the Niger. There are two main types of fisheries in the country, namely riverine fisheries and seasonal, small waterbodies (typically used for water storage). These seasonal waterbodies together with lakes, floodplains, and reservoirs comprise a total area of 94 500 ha, equivalent to 77.5 percent of the total waterbody surface area (Béné, 2007). There are about 1 000 small reservoirs that are important for capture fisheries. Catches consist of species such as tilapia species and the African catfish (*Clarias gariepinus*) and vary between 60 and 120 kg/ha, which is consistent with larger artificial lakes in Africa (Kolding, 2016, citing Baijot *et al*., 2012). Rivers and their primary and secondary tributaries have a total area estimated about 27 500 ha, (i.e. 22.5 percent of the 122 000 ha of the country's total waterbody surface area).

The figure reported to FAO of 20 300 tonnes was recently re-estimated and increased from the earlier reported production of 7 000 to 9 000 tonnes (1990–2005). This is a considerable increase over earlier estimates of maximum potential yield and is attributed partly to the creation of additional reservoirs. The inland fish production as a function of renewable surface water (2 300 tonnes/km^3/yr) is second only to that of Chad in this region and comparatively high overall. The fish consumption model estimate for inland fishery production is three times higher at 77 740 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This does not account for possible unreported imports, although large-scale imports do not appear to be documented. If this estimate is correct, it would indicate that inland fish consumption (4.4 kg/capita/yr) is in the same order as other neighbouring Sahelian countries. The productivity estimates for Burkina Faso including stocked waterbodies is only in the range of 16 000 to 18 000 tonnes (Vanden Bossche and Bernacsek, 1990).

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Mauritania

Mauritania has very limited freshwater resources: along the Senegal River and some lakes associated with the floodplain and one major reservoir (Foum-Gleita). Inland capture production was estimated to reach 13 000 tonnes in the later 1970s but declined until 1993. FAO has been estimating inland fishery production for the past 26 years and after increasing between 1989 and 2005, is now fixed at 15 000 tonnes (2006–2015). The maximum national production is considered to be 15 000 tonnes with a minimum of 6 000 tonnes depending upon the state of drought in the country (Vanden Bossche, and Bernacsek, 1991). As the majority of inland fish in in the country come from the Senegal River and associated floodplain, declines in catches from this river are likely to affect both Mauritania and Senegal equally. The catches in Senegal are reported to have declined in recent years.

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The Gambia

The inland fisheries of the Gambia are confined to the Gambia River, which runs the length of this narrow country, entering from Senegal. The country is low lying and has an extensive floodplain, which floods in the rainy season covering 40 percent of the country (VanDen Bossche and Bernascek, 1990). There are no lakes or reservoirs. The inland fish production is relatively low at 3 900 tonnes estimated in 2015. The highest production estimated was nearly 5 000 tonnes. The maximum potential yield estimated by Welcomme (cited in VanDen Bossche and Bernascek, 1990) was 8 000 tonnes.

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2.1.3 NILE RIVER

FAO map disclaimer: The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area has not yet been determined.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Egypt	241 179	82 056 000	3.05	2.0	56	4 307
Ethiopia	45 519	94 101 000	0.41	0.4	120	379
South Sudan	37 000	11 296 000	3.28	0.3	50	747
Sudan	31 251	37 964 000	0.76	0.2	36	873

This region includes most of the Nile River basin, including tributary rivers, except for the headwaters in Uganda. It contains the Blue Nile, White Nile, Sudd, Lake Nasser/Lake Nubia, minor reservoirs, the Egyptian coastal lagoons, Lake Tana and the Ethiopian Rift Valley lakes. Nile tilapia is the most important species in catches in Egypt and Ethiopia. Total inland fish production for the subregion is 354 949 tonnes (2015) representing 3.1 percent of the global total.

Egypt

The Nile is the only river in Egypt and has a course of 1 300 km through the country. Catches from this subregion are dominated by Egypt with 67 percent of the total in 2014. Egyptian catches reported to

FAO have declined form a peak in 2003 (mainly because of a large drop in reported tilapia production), and have been more or less stable since then. Lake Nasser landings increased from 751 tonnes in 1966 reaching a peak of 34 200 tonnes in 1981. Since then, there has been a dramatic decrease to just 12 500 tonnes in 2005. These statistics may be flawed (underestimated) by the appearance of a significant black market as a response to fixed prices by the government for fresh fish, as well as to fishers own consumption, poaching, catch of undersized fish, illegal trade to avoid taxation, and discarded spoilt fish. This means that a large proportion of actual catch was not recorded, resulting in an estimated under-reporting of 50 percent (Van Zwieten *et al.*, 2011).

Tilapia (114 093 tonnes) dominates Egyptian catches, followed by catfish (30 459 tonnes) and mullet (29 368 tonnes). There is a significant amount of brackishwater inland catch from the Egyptian coastal lagoons (mullet). These species are collected both for consumption but also as fry for aquaculture (Saleh, 2008). The grass carp is the fourth largest product (15 371 tonnes). The fish consumption model estimate for inland fishery production (96 915 tonnes in 1997) is 38 percent of the reported production (261 167 tonnes) for the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This may be an indication of over-reporting.

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Ethiopia

Ethiopia has a number of natural lakes with Lake Tana being the largest (3 500 km^2), representing 52 percent of the total lake area. A small part of Lake Turkana and over half of Lake Abbe also lie within the country. Approximately 14 percent of the country is wetland swamp, rivers and floodplain (Vanden Bossche and Bernacsek, 1991). Much of the country is at higher altitude so the fish production is concentrated in the lowland areas. In the central Oromia region, the main fish species harvested are Bagrid catfish, eel (*Anguilla bengalensis labiata*) and *Barbus* species. The predominant fishing gears are handline and/or longlines. Fishers indicate increasing catches, but requiring greater effort to do so (Abelti *et al.*, 2014).

The fish consumption model estimate for inland fishery production (10 027 tonnes in 1999/2000) is lower than the reported production (15 858 tonnes) for the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This higher reported level decreased back to the 10 000 tonnes level in the following years (and is consistent with the consumption model figure), but starting in 2007 reported production increased steadily until it reached 50 119 tonnes in 2014. The estimated potential yield for all the water resources in the country ranges from 21 300 to 70 000 tonnes per year (Vanden Bossche and Bernacsek, 1991). On the basis of the surveyed fish consumption it is difficult to accept the high figure reported and no explanation can be given for the steady increase in production over the past decade. Even at a consistent fish consumption rate (since 1999) and accounting for population increase to the present, this would only give a total production in the region of 13 400 tonnes by 2013.

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South Sudan

The climate of South Sudan is equatorial, with more or less daily rainfall. The main river system is that of the White Nile. The Albert Nile enters South Sudan from Uganda through a narrow gorge in a series of rapids at Nimule. Northward, it becomes known as the Bahr El Jebel. The flat clay plains that lie between the Bahr El Jebel, Bahr El Zerat and the confluence of the White Nile are known as El Sudd (The Sudd). These are covered with papyrus marsh and seasonal grasslands. The Sudd area includes 8 300 km^2 of permanent swamps and over 80 000 km^2 of inundated area during the flood seasons (Krishnamurthy cited in Vanden Bossche and Bernacsek, 1991). The shallow floodplains (referred to locally as *touch*) flood during July to September. From November the waters recede, isolating the floodplain, which then drains through river channels and by February is dry, leaving a number of lagoons and deep pools that make up a major fishery. There have been historic proposals to divert water past the Sudd through the Jonglei canal to increase the agricultural area. This project has commenced, but has never been completed. Nevertheless, it has already had a serious adverse effect on the Sudd and its fisheries. The function of the Sudd swamplands to regulate the floodwaters in the Nile system is also seen to be potentially undervalued.

Fishery production of the Sudd swamp was estimated as 11 000 tonnes with a potential yield in the range of 75 000 to 100 000 tonnes (Vanden Bossche and Bernacsek, 1991). Current production is estimated by FAO at 55 percent of the total inland capture fishery production of the former Sudan (i.e. before its separation into the Sudan and South Sudan in 2011). The fish consumption model estimate for inland fishery production for the former Sudan (212 083 tonnes in 2009) is more than three times the FAO estimate for the former Sudan in the same year (66 000 tonnes) (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This consumption model estimate is more than double the maximum potential yield estimated by Vanden Bossche and Bernacsek (1991), however it seems plausible as the survey figures returned very high figures for fresh fish consumption in the main river and swamp areas, and this could only have been freshwater fish. This survey was conducted in 2009, prior to the unrest affecting the Sudan and before the creation of South Sudan, and it is quite possible these production figures are currently much lower as a result. Assuming that 55 percent of the catch prior to the creation of South Sudan came from the Sudd, then the survey model estimate for South Sudan would be about 114 000 tonnes.

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The Sudan

The Sudan has a desert climate with little rainfall throughout the year. Towards the south of the country it has an unstable climate, with a pronounced rainy season of variable duration. The Blue Nile, with a catchment of 325 000 km^2, originates in Ethiopia and extends 2 000 km into Sudan, until it joins the White Nile to become the River Nile. Within Sudan the Blue Nile is joined by the Dinder and Rabad tributaries. The Nile leaves Sudan at Lake Nubia and thereafter to Lake Nasser to enter Egypt. There are a number (>800) of small water storage bodies (*hafirs*) in the floodplains of the Sudan as well as floodplain lakes. These small waterbodies and the reservoirs in the country are estimated to have a potential yield in the order of 22 000 tonnes (Vanden Bossche and Bernacsek, 1991). As discussed above, the fish consumption model estimate for inland fishery production for the former Sudan (212 083 tonnes in 2009) is more than three times the FAO estimate for the same year (66 000 tonnes) (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Based on a crude division of the 2009 figure between South Sudan and the Sudan, this is perhaps shared 55:45, which indicates the Sudan's proportion is about 93 500 tonnes. The subnational consumption of freshwater fish in the surveys indicated high figures across most of the country containing the main rivers and floodplains. Further work on the subnational results in the model may give a better resolution of this figure.

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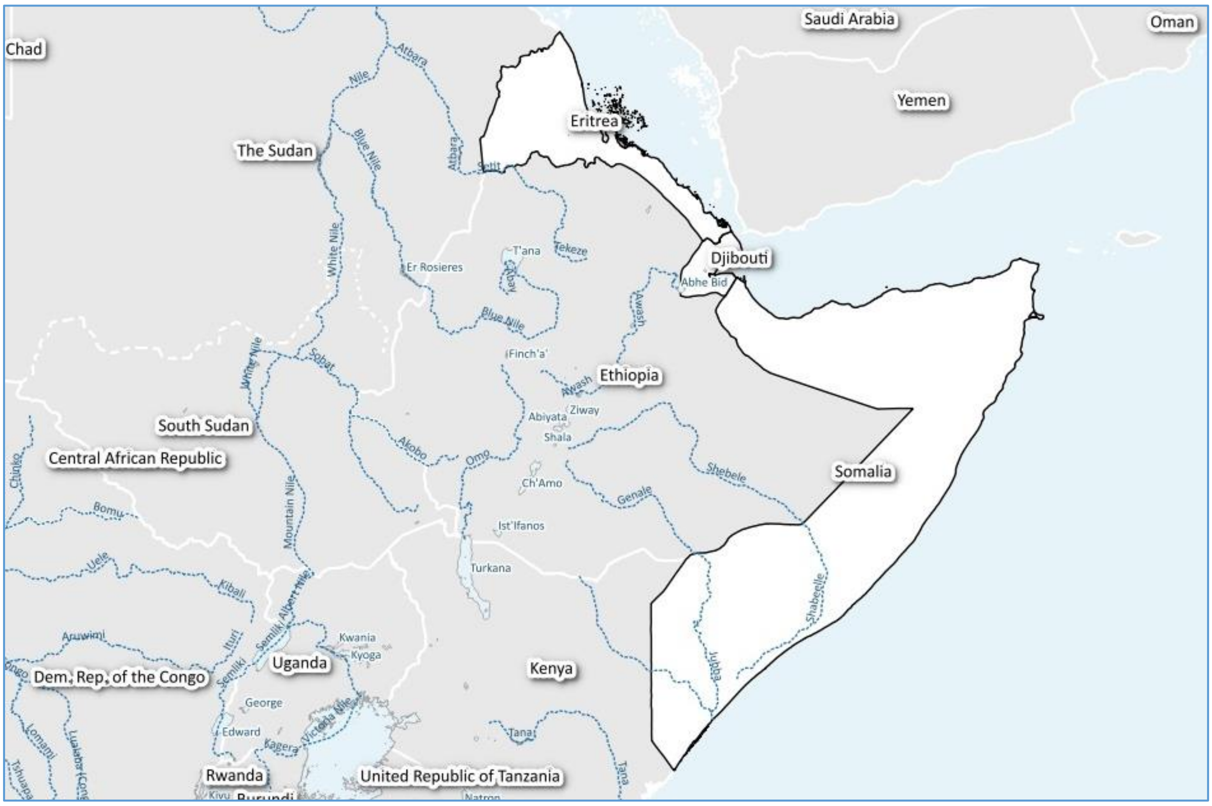
2.1.4 AFRICA EAST COAST



FAO map disclaimer: The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area has not yet been determined.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Somalia	200	10 496 000	0.02	0.0	14	14
Djibouti	0	873 000	0	0.0	0	0
Eritrea	0	6 333 000	0	0.0	7	0

The main basin in this subregion is the Jubba-Shebelle. This is an arid zone with few rivers and lakes and minimal inland fisheries, the subregional total being 200 tonnes only.

The Federal Republic of Somalia

The only major systems are the Juba and Webe-Shebelle that originate in Ethiopia and flow through Somalia to the sea. Fisheries resources are concentrated in the Juba and Shabelle Rivers and their associated swamps and floodplain areas. The two rivers have two peak flows during the *deyr* (October to December) and *gu* (long rains March to June) flood seasons. The Shabelle River flow is decreased at the downstream runoff stations during the two peak flow seasons, but there is only a very small flow reduction in the Juba River. During the *hagaa* (July to September) and *jilaal* (January to March) seasons the daily flow for the two rivers are very low and even close to zero.

The Shabelle River is a large but seasonal river that sustains a fishery, but this fishery had not been studied by 1991 (Vanden Bossche and Bernacsek, 1991). There was some potential for commercial-scale fishing, which was carried out by at least one fishing co-operative prior to the civil war (UNEP, 2005). Freshwater fisheries are primarily a subsistence activity practised by Bantu people along the rivers in southern Somalia.

Freshwater fish catches were estimated at 400 tonnes in 1990 (IUCN cited in UNEP, 2005), but more recent figures suggest that this catch had halved by 2000 (WRI cited in UNEP, 2005). Somalia has not reported any catches to FAO, and the present (conservative) estimate of 200 tonnes per year have been made by FAO since 1986.

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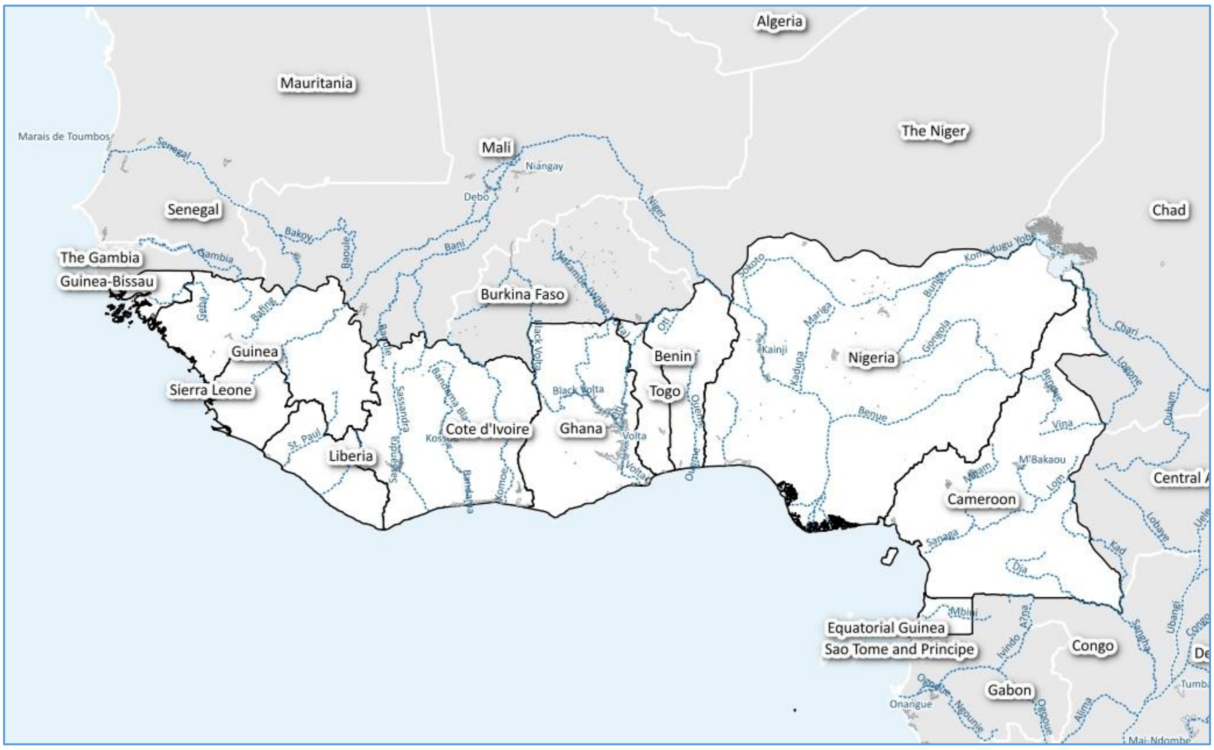
Djibouti

Djibouti consists largely of volcanic plateau and desert. There is one medium-sized lagoon, the Ghoubet Kharab. Minor streams flow into two lakes (Abbe and Asal). The country has no significant inland fishery outside of the Ghoubet Kharab and Djibouti does not report any inland fishery catch.

Eritrea

Eritrea is characterized by an arid and semi-arid climate and possesses limited water resources. Rainfall is torrential and unpredictable, occurring irregularly in high intensity short periods. Water harvesting structures such as dams, ponds, and wells have been constructed for domestic and irrigation uses. Some large, medium and small water storage structures (e.g. Gherset, Ghergera, Fanco and Kerkebet) have been constructed. Endemic fish fauna are limited, and Eritrea does not report any inland fishery catch.

2.1.5 AFRICA WEST COAST



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water ($tonnes/km^3/yr$)
Nigeria	337 874	173 615 000	1.96	2.95	279	1 210
Ghana	90 000	25 905 000	3.47	0.78	55	1 639
Cameroon	75 000	22 254 000	3.37	0.65	278	270
Guinea	26 000	11 745 000	1.87	0.23	226	115
Benin	20 770	10 323 000	2.53	0.18	26	796
Côte d'Ivoire	8 000	20 316 000	0.37	0.07	81	98
Togo	5 000	6 817 000	0.73	0.04	14	357
Liberia	2 200	4 294 000	0.51	0.02	232	9
Sierra Leone	2 100	6 092 000	0.49	0.02	150	14
Equatorial Guinea	1 000	757 000	1.32	0.01	25	40
Guinea-Bissau	150	1 704 000	0.09	<0.01	27	5

The West African coastal region groups those countries lying along the West African coast. This subregion includes a large number of rivers, the largest basins are the Volta, Sanaga, Benue and the Niger that all drain into the Atlantic Ocean. Many of the rivers have been impounded, and the Volta system includes the largest reservoir (Lake Volta) in the world by area. Many rivers also terminate in coastal lagoon complexes. Many countries in the West African coastal region are heavily influenced by the Sahelian climate as they extend northwards into the arid zone; this is especially the case with Ghana, Guinea and Nigeria. All of these water resources have rich inland fisheries, although the impacts of damming and impoundments have impacted connectivity and the extent of seasonal flooding. The summary total reported production from these countries is 568 094 tonnes (2015) and is 5.0 percent of the global total.

Nigeria

The Niger River drainage covers most of the hinterland of Nigeria. Two main arms, the Niger itself (which flows for about 1 300 km through the country) and the Benue (1 440 km long), are joined by several major tributaries such as the Sokoto, the Gongola, the Kaduna and the Anambra Rivers. The main channels of the Niger and Benue Rivers and main Nigerian tributaries to these rivers all have extensive floodplain systems. Total inland floodplain area in Nigeria reaches 5 150 km^2 (Vanden Bossche and Bernacsek, 1990). The southern coastal part of Nigeria is drained by a series of shorter rivers, principal among which are the Ogun, the Oshun (267 km) and the Cross Rivers. One major reservoir has been formed on the Niger River behind Kainji dam. Kainji reservoir covers a maximum area of 1 270 km^2. Lake Kainji fishery is reported to yield between 4 500 and 6 000 tonnes/yr. The productivity of these reservoirs ranges from 24 to 55 kg/ha/yr (Crul and Roest, 1995). There is a large reservoir at Tiga on the Kano River. There are numerous small reservoirs and some small lakes (100), totalling about 2 840 km^2 surface area. There are also extensive coastal lagoons and swampland in the coastal delta region of the country. Nigeria's inland fishery production (354 466 tonnes in 2015) represents 60 percent of the subregional catch.

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Ghana

Ghana has extensive rivers and is drained principally by the Black, White and Red Volta Rivers and the Oti River. There are several smaller rivers (including the Pra, Tano and Bia), which drain the forested southwestern area of the country. Ghana contains the largest man-made reservoir in Africa, the Volta reservoir, which is 8 482 km^2. It is over 400 km long and has drowned much of the lower courses of the various rivers of the Volta system. Flooding on the lower Volta River is now controlled by the Akosombo dam and this affects the riverine production below the dam. The only natural freshwater lake of any size in the country is Lake Bosumtwi, a crater lake situated in Ashanti region. This supports some commercial fishing activity. There are about 50 brackishwater lagoons situated along the coast of Ghana, the largest of which (Keta lagoon) has become more saline with the controlled release of water from the Volta reservoir. Maximum estimates of yield for the country range between 40 000 and 69 000 tonnes (1988), but these have been greatly exceeded in both the reported production and estimates based on stock assessment (Vanden Bossche and Bernacsek, 1990).

Ghana provided 20 percent of the subregional production, although FAO has estimated production for the last four years. Ghana's inland waters are dominated by Lake Volta (8 000 km^2). Ghana has reported a rising inland fishery catch from 65 000 tonnes (2000) to 90 000 tonnes 2015. Lake Volta provided about 90 percent of the inland catch of 86 772 metric tonnes in 2011 (Béné, 2007).

Stock assessment studies have shown considerable discrepancy with officially reported production. In some cases, inland waterbodies may produce over three times the national figure reported (de Graaf and Ofori-Danson 1997; Braimah, 2000). A number of estimates for Lake Volta (based on stock assessments) range between 150 000 and 200 000 tonnes (de Graaf and Ofori-Danson, 1997), with other reports indicating as much as 251 000 tonnes in 2000 (Béné, 2007).

The fish consumption model estimate for inland fishery production for Ghana (116 819 tonnes in 1998-1999) exceeds the officially reported production of 74 500 tonnes, for the same period (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This is equivalent to a per capita consumption of freshwater fish of 6.3 kg/capita/year for the period. Per capita fish consumption in stratum VII of the reservoir is 44 kg/year, (De Graaf and Ofori-Danson, 1997; van Zwieten *et al*., 2011).

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Cameroon

Cameroon is characterized by an extremely dry north region and a very wet, high-altitude western region. There are numerous perennial rivers in the south with extensive floodplains. There are a number of natural lakes in Cameroon. Northern Cameroon contains part of the Yaéré floodplain, which is part of the Lake Chad Basin and 8 to 40 percent of the lake area is contained in the country depending on the flooded extent of Lake Chad (Welcomme, 1979). There are more than 16 man-made reservoirs. There are no significant coastal lagoons. Although the country has relatively high amounts of surface water, the productivity of this is relatively low. Total annual production was estimated to be in the range of 40 000 to 50 000 tonnes before the Sahelian drought, dropping to 20 000 tonnes in the drought years. The potential production was estimated by Balarin as between 45 000 and 80 000 tonnes (Balarin, 1985, cited in Vanden Bossche and Bernascek, 1990). Cameroon's inland fish production is regularly estimated by FAO in between reporting years from Cameroon. This is rather static at 75 000 tonnes, which is at the upper end of the estimate of total potential yield.

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Benin

Benin has a relatively narrow marine coastline and a significant interior, thus inland fisheries are more important than marine capture fisheries in terms of employment and food production. Inland waters include coastal lagoons and lakes. The country has limited surface waters and no major river systems.

Despite this, Benin reported an inland fishery production of 32 991 tonnes in 2014 and has a fishery productivity of 1 265 tonnes/km^3/yr, which is comparable with Nigeria and Ghana. The inland fisheries of the country provide 69 percent of the national fish production and employ the majority of the country's fishers, estimated at 125 000 fishers and total employment in the subsector is estimated at over 200 000 (DeGraaf and Garibaldi, 2014). It is possible that the natural levels of productivity are exceeded by extensive (and growing) numbers of brush parks and *whedos* (ponds that retain trapped fish that are fed and harvested later in the season). Such structures occur along the West African coast in Ghana, Togo and Nigeria, but are nowhere as developed as in Benin, and they represent a shift towards enclosure of previously traditionally regulated free access fisheries (Welcomme, R. pers. comm.).

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Guinea

Several large rivers have headwaters in Guinea and the upper stretch of the Niger has 580 km of its length within Guinea. Together with its major tributaries this probably totals over 3 400 km of waterways. Other important rivers are the Gambia (210 km), the Bafing headwater of the Senegal (130 km) along with many others (including Konkoure and Kolente). There are no large natural lakes or coastal lagoons in Guinea. There are five reservoirs with a combined area of 31 km^2. The number of fishers employed is over 15 000 and total employment in the inland fishery subsector is estimated at just under 27 000. Welcomme (1979) estimated the total potential yield at 5 000 tonnes (prior to construction of at least one dam) and the inland capture production of Guinea is currently estimated by FAO at 26 000 tonnes (2015). FAO has estimated inland capture fishery production since 2002, therefore revisiting the estimated production may be worthwhile.

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Côte D'Ivoire

Côte d'Ivoire contains two main basins that lie wholly within the country and these are the basins of the Sassandra River (650 km), and the Bandama River (1 050 km). It also contains two very short headwater tributaries of the Niger River and several small rivers (Komoe, Cavally, Tano, Bia and Black Volta). There are no extensive swamps or floodplains. There are more than five reservoirs, but only one of any size (Kosoou). There are several large lagoon complexes along the coast (Aby-Tend-Ehy, Tagba-Maki-Tdio/Grand-Lahou, Ebrie) (Vanden Bossche and Bernacsek, 1990).

Estimates of production in 1982 were 24 000 tonnes (with another 11 500 tonnes from lagoon fisheries). FAO estimates for the same year are lower (22 000). Catches reported to FAO peaked in 1989 (30 500 tonnes) and have been declining ever since, with one outlier year. FAO estimates 2015 production as 8 000 tonnes. The fish consumption model estimate for inland fishery production for Côte D'Ivoire (155 328 tonnes in 2002) greatly exceeds the officially reported production of 22 000 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). It also exceeded the highest estimate of potential yield for the country (62 000 tonnes) in Lazard (cited in Vanden Bossche and Bernacsek, 1990). Early, low production estimates were attributed to limited numbers of fishers and a degree of unreported illegal, unreported and unregulated fishing. There are accounts of exports to neighbouring countries, e.g. Burkina Faso (Béné, 2007). However, these do not account for such a large production as that estimated in the consumption model. A partial explanation is that there are imports of smoked fish from elsewhere boosting the figure, but this seems unlikely to account for the entire difference. The high population of the country drives this high figure, as inland fish consumption rates in Côte D'Ivoire are relatively high for the region and it may simply be that these inland fisheries have been greatly underestimated in the past.

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Togo

There are three main river basins in Togo: that of the Oti River, which flows (210 km) to form a border with Ghana; that of the Mono River, which flows south (360 km) although part of its lower course is in Benin; and there are three small coastal rivers in the south which form a third small basin. The total estimated length of rivers is 1 500 km (Aubray cited in Vanden Bossche and Bernacsek, 1990). There are no natural freshwater lakes of any size in Togo, but several small coastal lagoons. There are a 70 small reservoirs and the larger Nangbeto reservoir is 180 km^2. Fishing activities are carried out in the Togolese lagoon system of 64 km² composed of Lake Togo, Togoville and Vogan lagoons, which has an estimated total production of 1 000 tonnes per year (FAO, 2007). Other inland fisheries in rivers and reservoirs occur throughout the territory (Mono and Oti Rivers, Nangbeto hydroelectric dam) with an estimated production of between 4 000 and 5 000 tonnes per year. The main species caught in inland waters are: Tilapia spp., *Clarias gariepinus*, *Labeo* spp., *Chrysichtys auratus*, *Lates niloticus*, *Alestes*, *Hemichromis*, Citharinidae, and Synodontis. Shellfish are rare and crustaceans (crabs and crayfish) are relatively abundant.

The total production reported to FAO is 5 000 tonnes (2014), a figure that has not changed since 1996. This is obviously an estimate, as the inland fishery is not monitored (FAO, 2007). The fish consumption model estimate for inland fishery production for Togo is 20 124 tonnes (2006), which is four times higher than the officially reported production of 5 000 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This is based on an estimated consumption figure of 3.4 kg/capita/yr. The estimate from the consumption model is also considerably higher than the estimate of total potential yield for the country of 6 000 tonnes (Aubrey, 1977 and Patasse cited in Vanden Bossche and Bernacsek, 1990). However these earlier estimates were before the construction of the Nongbeto reservoir, which has increased production somewhat. According to the African Development Bank, the original expectation of the developers was 1 000 to 1 500 tonnes of fish annually. Even accounting for additional production from the Nongbeto reservoir, it seems that there is more inland fish availability than accounted for in reported statistics.

More than half of all fishers work in the inland fishery, most often seasonal workers not from Ghana.

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Liberia

Freshwater bodies cover 15 050 km² (14 percent) of the total area of Liberia (Ministry of Agriculture). There are six main rivers in Liberia that flow from Guinea into and across Liberia (Loffa, Saint Paul, Saint John, Cestos, Moa and Mano Rivers). The Cavalla river forms the border with Côte d'Ivoire. There are smaller rivers and the total length for the country is estimated at 3 000 km (Aubray cited in Vanden Bossche and Bernsascek, 1990). The flat, low lying coastal plains are susceptible to flooding during the rains, in particular where a sandbar blocks the river mouth. Most rivers exhibit floodplains along their course, but the extent of these is not known. There are no important natural lakes in Liberia. There are two types of coastal lagoons: marine and freshwater. The freshwater lagoons occur where a river outlet is blocked by a beach sandbar, creating a reservoir. This is a common feature of a large number of the coastal rivers, especially those with a slow flow. It is also a characteristic feature of the strong offshore currents. Lake Piso in the north (170 km^2) and the swamps around Monrovia are examples of this and the total area is estimated between 500 and 800 km^2 (Aubray cited in Vanden Bossche and Bernsascek, 1990).

FAO has estimated inland fish production for the past seven years, which is currently 2 200 tonnes. Total potential yield based on assumed productivity of waters (25 to 50kg/ha/yr) is estimated at between 2 000 and 4 000 tonnes (Aubray cited in Vanden Bossche and Bernsascek, 1990). During the 1980s to the 1990s the upper level of 4 000 tonnes was reported, but this has now declined. With reasonably abundant renewable water resources (232 km^3/yr), comparable with those of Nigeria and Cameroon, it may be reasonable to suppose that production should be higher, although Liberia's population is relatively low.

The importance of the lagoon catches should not be underestimated. However, it is possible that these are included in the marine fishery statistics and thus not reported as inland fisheries, despite the fact that the species caught (tilapia and catfish) are essentially freshwater species. The lagoon catches have been estimated to range between 3 970 tonnes/year and 7 100 tonnes per year (Belhabib *et al.*, 2013).

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Sierra Leone

Sierra Leone has many small rivers that drain the northern highlands and discharge into the Atlantic. The largest are the Sewa River (340 km), Jong River (230 km), Little Scarcies River (260 km), Rokel River (260 km) and Moa River (190 km). The rivers are all rocky and torrential in their upper courses, but open into wide estuaries that penetrate far inland and are bordered by mangrove swamps (over 10 000 km^2 in area) and floodplains. There is one small lake in the country (Sonfon). The lower courses of these rivers have extensive saline intrusion and are surrounded by extensive marshes (Little Scarcies and Sewa Rivers). There are two large coastal lagoons (Mabegi and Mape) and many smaller ones. There are no major reservoirs in the country and only small dams on the Congo river (Musaja, Sefadu, Jaiama, Loma Valley, Regent) (Vanden Bossche and Bernacsek, 1990).

Estimated potential yield for inland fisheries is 3 000 to 6 000 tonnes (Welcomme, 1979). FAO has estimated inland fishery production since 2000 with one exception (2014). In the mid-1970s production leapt from about 1 000 tonnes to 16 500 tonnes. This declined gradually, according to FAO estimates, until 2006, whereupon it dropped rapidly to its present figure of only 2 100 tonnes. As these figures are largely FAO estimates, there is little conclusive analysis to be drawn. It should be noted though that during the period, 1990 to 2001, when production ranged between 14 000 and 15 000 tonnes the figures were national reports.

Sierra Leone has relatively abundant renewable water resources (151 km^3/yr), and is similar to Liberia. It may be reasonable to suppose that inland fishery production might be higher than that reported. Use of household consumption and expenditure surveys might reveal more as to the true extent of inland fishery production.

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Equatorial Guinea

There are no large rivers in the country and the riverine resources are all of relatively low productivity. The largest river (Rio Benito) is about 230 km long and has an average width of only 150 m. Other rivers are all typically clean, “black” acidic waters that are low in nutrient salts, dissolved oxygen and high in humic acids. There are no significant impoundments (Vanden Bossche and Bernsascek, 1990). Potential annual yield is estimated at 1 000 tonnes (Matthes cited in Vanden Bossche and Bernacsek, 1990). FAO has estimated production since 2001 with one exception and is currently estimated as 1 000 tonnes.

The importance of freshwater and estuarine fish has been identified as playing a major role in supplying the population of Equatorial Guinea with protein. This is caught mostly by women and children (Perpina Grau, 1945, Matthes, 1980 and Keylock, 2002; all cited by Balhabib *et al*., 2016). There have been attempts to estimate production using consumption estimates (Balhabib *et al*., 2016), however, these estimates did not distinguish between the fish supply from inland and marine waters. These authors indicate that catches from rivers and inland/estuarine waters might be considerably greater than the current 1 000 tonnes estimate.

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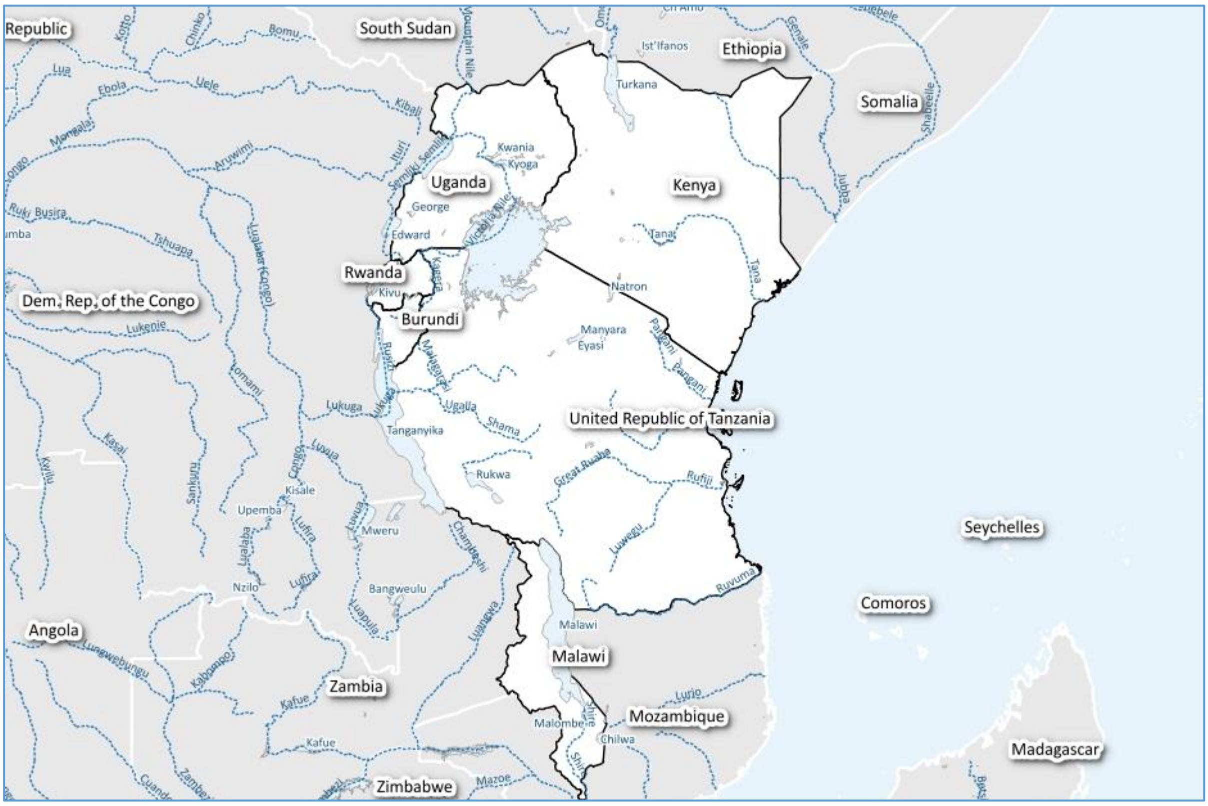
Guinea Bissau

Guinea Bissau has three main river systems, the largest being the Corubal. The Cacheu has a lower floodplain. There is one minor lake (Lake Cufada) and no reservoirs or coastal lagoons. FAO has estimated production for Guinea Bissau since records began and the current estimate is 150 tonnes (2015). The limited total renewable surface water resources and relatively low population indicate that the inland fishery catch is unlikely to be very high.

2.1.6 AFRICAN GREAT LAKES



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Uganda	396 205	37 579 000	11.16	3.9	60	6 592
United Republic of Tanzania	309 924	49 253 000	6.4	2.3	92	3 359
Kenya	156 468	44 354 000	3.48	1.3	30	5 181
Malawi	141 643	16 363 000	6.86	1.0	17	8 197
Rwanda	29 334	11 777 000	1.9	0.2	13	2 206
Burundi	20 120	10 163 000	1.3	0.1	13	1 604

The Great Lakes subregion of Africa includes some of the largest lakes in the world (Lake Turkana, Lake Victoria, Lake Kivu, Lake Tanganyika and Lake Malawi) and several lesser lakes. Catches increased in all the subregion’s countries until the 1990s and thereafter remained stable or declined slightly. There have been dramatic increases in *dagaa* (small pelagic cyprinid) catches in Lake Victoria over the last few years, possibly owing to increased productivity through eutrophication, and these are now appearing in the Ugandan and Kenyan and Tanzanian statistics. The summary total reported production from these countries is 1 053 694 tonnes (2015) representing 9.2 percent of the global total. Outside of the Great Lakes there are a number of floodplain fisheries, which also lie within the borders of the countries in this subregion.

Uganda

Uganda has an extensive lake system covering over 38 500 km^2, comprising Lake Victoria, Lake Kyoga and the Rift Valley Lakes (Edward, George and Albert). Lake Kyoga is, in essence, an extension of the Victoria Nile, being relatively shallow with numerous estuaries and swamps. In addition to its lakes, Uganda has about 5 100 km^2 of swamps, and over 2 000 km of main rivers (Vanden Bossche and Bernacsek, 1990).

The bulk of Uganda's inland fish production (396 205 tonnes) is derived from the Lake Kyoga complex and its Lake Victoria fisheries. Production has fluctuated between 367 000 to 461 000 tonnes since 2004. This was driven mainly by reported production of tilapia (*Oreochromis niloticus*) (49 464 tonnes) and Nile perch (*Lates niloticus*) (71 891 tonnes). Both of these species have declined in reported catches in recent years and the small pelagic species, the Lake Victoria sardine (*Rastrineobola argentea*) or *mukene* (73 767 tonnes), and the small, but carnivorous nurse tetra (*Brycinus nurse*) (68 887 tonnes) now make up a substantial proportion of the catch. Other reports of catches indicate Nile perch production as relatively stable. *Rastrineobola argentea* provides an important and affordable source of fish for poor communities living around the lake and in eastern, central and southern Africa. Lake Victoria's fisheries provide protein for the eight million people along the lake's shore and support over 100 000 fishermen (Darwall *et al.*, 2005; Geheb *et al.*, 2008).

The fish consumption model estimate for inland fishery catch (269 710 tonnes in 2005/2006) is 38 percent lower than the reported production (416 758 tonnes) for the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This is very consistent with the national catch figures reported prior to 2005 and may indicate that catch was subsequently overestimated, as the reported catch jumped 172 percent between 2003 and 2005 (from 241 810 tonnes to 416 758 tonnes). The lower figure may also reflect the fish consumed in the country rather than total catch, as exports from Uganda to surrounding countries may not be fully reflected in the national export data.

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United Republic of Tanzania

The total water area in the United Republic of Tanzania covers nearly 61 500 km^2 or about 6.5 percent of the total land area, 88 percent of which is made up by its three major lakes (Lake Tanganyika, Lake Nyasa and Lake Victoria), which are shared with neighbouring countries. Lake Victoria is a broad shallow lake with very high productivity. Other large lakes include Lake Rukwa and Lake Kitangiri. Over one million people are dependent upon the fisheries from Lake Tanganyika (Darwall *et al*., 2005).

There are a group of Rift Valley soda lakes (Lakes Natron, Eyasi and Manyara), which are very shallow and liable to dry up in low rainfall periods. There are comparatively few river systems within Tanzania as the main central plateau is arid. There are four distinct river basins (the Rufiji basin, which is the largest basin, and the smaller Pangani, Ruwami, Ruvu basins) and the Lake Nyasa (Lake Malawi) basin.

Total production is reported as 309 924 tonnes (2015). This is dominated by small pelagic species namely *Ratrineobola argentea* (*mukene/dagaa*) (136 906 tonnes) and *kapenta* (*Stolothrissa* and *Limnothrissa* spp., 20 967 tonnes) captured in both Lake Tanganyika and Lake Victoria. Nile perch (73 052 tonnes) and tilapia (28 577 tonnes) are also important lake catches. The rapid rise in *Ratrineobola argentea* after 2007 coincided with the reported decline of the Nile perch production and some declines in tilapia and *kapenta*. The Rufiji floodplain and delta and the Kilombero floodplains in Tanzania have inland fisheries and were estimated to produce about 11 000 tonnes (Turpie, 2000) with a further 2 000 to 7 000 tonnes from the Kilombero floodplain. It is assumed that these are a mixture of floodplain species and their contribution to the total production is relatively modest compared with the production from the Great Lakes.

The fish consumption model estimate for inland fishery production (368 678 tonnes in 2007) is in close agreement with the reported production (380 625 tonnes) for the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This indicates that per capita consumption of inland fish is 8.8 kg/capita/yr in 2007. Reported production generally fluctuates between 250 000 tonnes and 325 000 tonnes and it is worth noting that 2007 was an extreme outlying year.

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Kenya

The freshwaters of Kenya are estimated to cover 10 000 km^2 and these are largely influenced by the Great Rift Valley containing five drainage basins. The fisheries are dominated by the large lakes of the country. Six percent of Lake Victoria lies within Kenya's border and a considerable portion of this is located in the shallow and productive Kavirondo Gulf. The Lake Victoria basin contains eight rivers of significant size. These rivers (Nzoia, Yala and Sio Rivers are the most important) drain about 47 percent of the total of Kenya's runoff into Lake Victoria. The larger Rift Valley lakes are Lakes Turkana, Baringo, Bogoria, Nakuru, Elementeita, Naivasha and Magadi. There are many other smaller lakes in the country. There are extensive seasonal floodplains and swamps in Kenya that are filled with water during the rainy season for three to four months of the year. Several of these are the lower floodplains of the Tana and Sabaki Rivers. The Tana River is a coastal river and is the longest river in the country. The Sabaki-Athi-Galana River is the second longest, and has a broad floodplain in its lower reaches. There are also several small seasonal lagoons in coastal areas at the mouths of the Tana and Galana Rivers (Vanden Bossche and Bernacsek 1990).

Inland fishery production rose dramatically with the development of the Nile perch (*Lates niloticus*) fishery in Lake Victoria and then afterwards with the development of the silver cyprinid (*Rastrineobola argenta*) fishery. The Nile perch fishery reached its peak in 2000 (108 915 tonnes) but has declined continuously since then until the present (38 656 tonnes in 2015). The *Rastrineobola* (*dagaa*) fishery has increased to reach its current level of 76 134 tonnes (2015), but does fluctuate considerably between years (which is rather typical of small pelagic fisheries such as this). Tilapia species are another important component of the fishery although considerably less so than the top two species. Lake Turkana also has some potential as an important fishery but it has fluctuating productivity depending upon water levels and a low population of fishers. This lake, together with other sources, are considered to account for only 3 percent of the fish production of the country (Abila, 2007).

The fish consumption model estimate for inland fishery production (84 912 tonnes in 2005/6) is 40 percent lower than the reported production (140 199 tonnes) for the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This significant discrepancy may point to unreported fish exports (and thus less availability in the country), but also may indicate the extent to which *Rastrineobola* (*dagaa*) are converted to fishmeal. A survey conducted from 1997 to 1999 indicated that about 40 to 60 percent of *dagaa* was processed into fishmeal. This was estimated to be about 18 000 tonnes of (fresh/wet weight) *dagaa* and 8 000 tonnes of Nile perch by-products a year. At the same ratio in 2005/2006, the use of *dagaa* as fishmeal would be approximately 21 000 tonnes. This is still not enough of the production to explain the discrepancy, but is indicative of how unaccounted non-food uses may distort calculations of production based on household consumption.

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Malawi

Lake Malawi with an area of 30 800 km^2 covers 20 percent of the country and over half of the lake is effectively controlled by Malawi. Lake Malawi is a deep Rift Valley lake (maximum depth 758 m) and the richer fishing grounds of the shallow southern areas of the lake lie within Malawi. Lake Malombe (390 km^2) to the south of Lake Malawi, is a shallow lateral expansion of the Shire River. The lake regime has been stabilized by a flood-control dam downstream. Lake Chilwa is an endorheic lake showing extreme variations in level. It dries out almost completely in some years, but may extend over 2 590 km^2 at highest water when it is surrounded by 1 000 km^2 of marshland. Its mean area is about 750 km^2. Lake Chiuta is a smaller lake of the same type as Lake Chilwa and covers about 200 km^2 when full. The Shire River (520 km) is the principal river in the country and flows from Lake Malawi into the Zambezi and most of its length is in Malawi. The river floods over large areas to form the Elephant and Ndinde marshes and the total system covers about 1 030 km^2 at peak floods, but reduces in area to 480 km^2 at low water. There are ten large reservoirs for municipal water supply and limited irrigation capacity.

Lake Malawi supports a highly diverse capture fishery that can be grouped into large-scale commercial, small-scale commercial and subsistence, which are characterized by various fishing methods ranging from stern to hook and line fishing. The number of fishing vessels on Lake Malawi is estimated at 15 961. The subsector is largely artisanal in nature: the small-scale sector produces 90 percent of the annual fish production. The large-scale mechanized commercial fishery is confined to the southern part of Lake Malawi and is largely carried out by medium stern and pair trawlers. This sector contributes about 8 percent of the capture fishery landings.

Reported catches rose through to the late 1980s exceeding 88 000 tonnes, and then declined until early 2000. Following that, production has increased steadily to reach 141 613 tonnes (2015). This rise was initially driven by reports of cichlid catches until 2006 when these were replaced by a massive surge in catches of Lake Malawi sardine, locally known as *usipa* (*Engraulicypris sardella*), which had previously been a minor (or unidentified) part of the total catch.

Lake Malawi is the source of 50 to 60 percent of the total animal protein supply in the country, with over 70 percent of Malawi's population depending on Lake Malawi and its catchment for their daily survival needs and livelihoods (Chafota *et al*., 2005). The contribution of dried fish to increased blood iron content was noted by Aberman *et al.,* 2015. The fishery sector directly employs nearly 59 873 fishers and indirectly over 500 000 people who are involved in fish processing, fish marketing, boat building and engine repair. Furthermore, nearly 1.6 million people in lakeside communities derive their livelihood from the fishing industry (Singini, 2013).

The fish consumption model estimate for inland fishery production (392 902 tonnes in 2010/2011) is nearly 400 percent higher than the reported production (98 298 tonnes) for the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018) and still more than double the current reported production. This huge catch seems quite unlikely from Malawi's inland water resources and indicates that this production figure derived from the survey is unreliable. It is possible that there are hidden imports of fish to the country supplementing the national production, however published studies indicate that Malawi actually exports more fish than it imports. Crossborder fish exports (mainly dried *usipa*, *Engraulicypris sardella*) from Malawi into Mozambique and Zambia, were estimated at 24 116 tonnes (2015-2016) (Mussa *et al*., 2017). The fact that the majority of the fish reported in the household survey is dried fish, indicates that a potential source of this large error is the estimation of dried fish volume in survey responses and its subsequent conversion to fresh weight equivalents in the model. Both these factors would tend to drive the estimate up. Possible errors in the survey are explored by Aberman *et al.,* 2015. Despite these errors, the importance of fish in the Malawian diet is undeniable and indicates the role of inland fisheries in the national nutrition of both Malawi and its neighbouring countries.

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Rwanda

Rwanda has two main river basins of the Zaire and Akagera Rivers. The country is dominated by the Akanyaru-Nyabarongo-Akagera River, which drains the majority of the country. The river is encased in narrow valleys for much of its upper course, but forms broad papyrus-filled swamps in its middle reaches. The Upper Akagera Lakes Complex is warm, shallow and fertile and is interspaced among the flooded papyrus plain of the Akanyaru and the Nyabarongo Valleys. Its area is 167 km^2 and comprises Birira, Cyohoha South, Gaharwa, Gashanga, Kidogo, Kirimbi, Mirayi, Mugesera, Muhazi, Murago, Rugwero, and Sake Lakes. The Lower Akagera Lakes Complex is warm, shallow and fertile and is spread over the lateral floodplain of the Akagera River below the Rusumo Falls. Its area is 178 km^2 and comprises Chuju, Hago, Ihema, Iwapibali (also known as Rwakibale), Kishanja, Kivumba, Mihindi, Nasho, Ngerenke, Muhari, Rwampanga, Rwanyakizinga, and Rwehikama Lakes. Lake Kivu, in the Congo River basin is very deep and rich in nutrients. A short, but important, river is the Ruzizi, which flows out of Lake Kivu toward Lake Tanganyika. There are high altitude lakes in the north (Luhondo and Bulera), which are cold, deep and rather infertile. A higher altitude swamp occurs in the north of the country: Rugezi Swamp, which is 80 km^2 and is a tributary of Lake Bulera. Two reservoirs have been built, but are not used for fish production.

Total inland fisheries production for Rwanda was estimated at between 2 500 and 4 000 tonnes, which included the developing fishery for catch of *Limnothrissa*, which was introduced into Lake Kivu. This was the production reported until 1995, after which it started to increase exponentially until it reached 29 334 tonnes (2015). This is a testament to the development of the fishery for *Limonthrissa miodon* (Lake Tanganyika sardine), which dominates production at 61 percent of the total catch (17 920 tonnes in 2015).

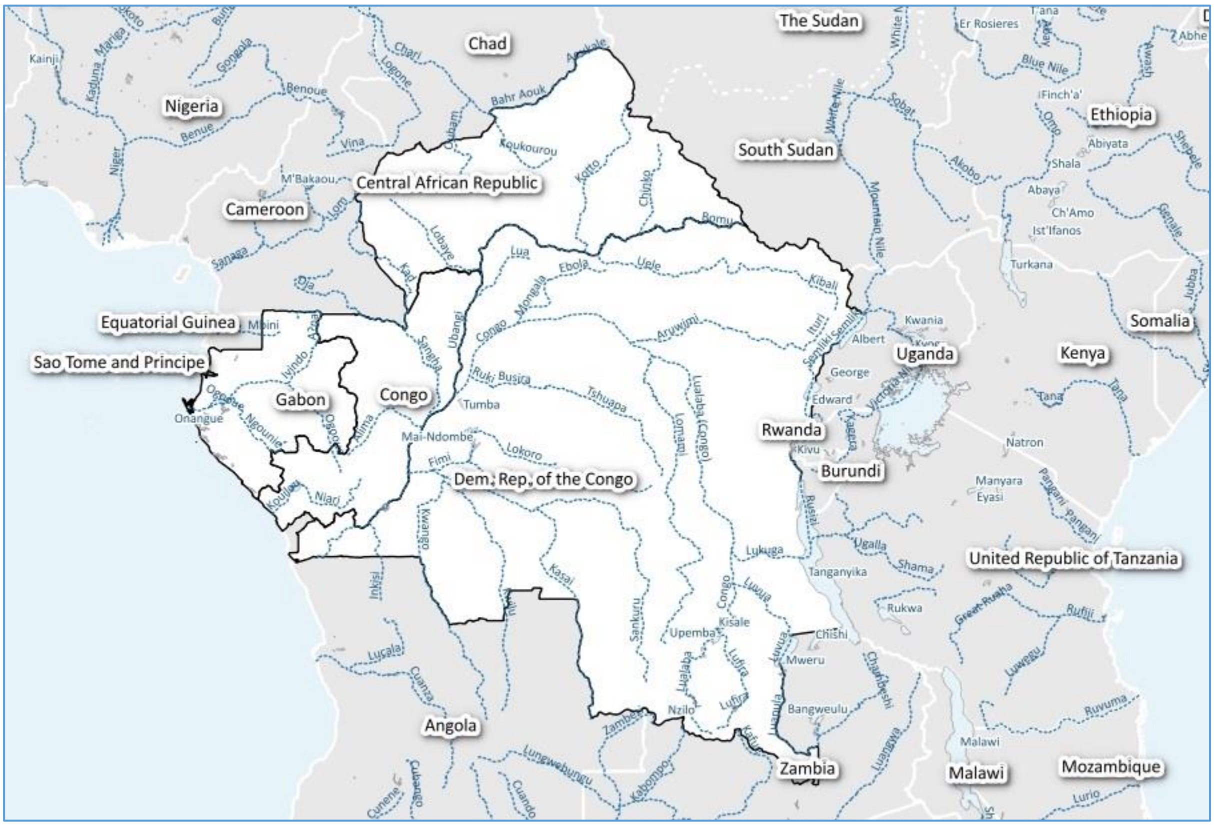
Burundi

The northeastern corner of Lake Tanganyika is the largest body of water in Burundi, comprising 2 600 km^2 of the lake area (8 percent). The lake is very deep (1 470 m) and the shoreline plunges steeply downward. There are some small lakes in the Upper Kagera Lakes Complex, associated with the Akanyaru River in the north. The largest are Lakes Cyohoha South and Rugwero, which are situated between Burundi and Rwanda. There are three smaller lakes (Kazigiri, Lirwihindi and Kakamurindi). There are no rivers in Burundi of major importance to fisheries. The main rivers are the Ruvubu (130 km in Burundi) and the Ruzizi River, which flows from Lake Kivu toward Lake Tanganyika. This is a relatively small and fast flowing river. In the north of Burundi there are tributaries of the Akanyaru River that drain toward the Kagera in Rwanda (and eventually Lake Victoria in Tanzania). There are a number of small floodplains and swamps in the north and southeast.

There are three important reservoirs: Mugere (Bujumbura Province), Rwegura (Kayanza Province), and Ruhoha (Muyinga Province). Ruhoha reservoir has been stocked with fish.

The principle species produced in Burundi are the small pelagic *Stolothrissa tanganicase* (Lake Tanganyika sprat), *Lates stappersii* (sleek lates) and other small pelagic *Limonthrissa/Stolothrissa* species (*dagaa/kapenta*). It is assumed that the bulk of the catch is derived from Lake Tanganyika and that this is the principle driver of national production. The *Limonthrissa/Stolothrissa* species dominated catches until 2004 when they collapsed to be replaced by the *Stolothrissa tanganicae*. The species had previously collapsed for a number of years between 1980 and 1987. During this time unspecific species production rose, but they were eventually replaced as the stock recovered.

2.1.7 CONGO BASIN



FAO map disclaimer: The final boundary between the Republic of the Sudan and the Republic of South Sudan has not yet been determined. Final status of the Abyei area has not yet been determined.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Democratic Republic of the Congo	227 700	67 514 000	3.31	1.99	1282	178
Congo	37 320	4 448 000	8.09	0.33	832	45
Central African Republic	28 000	4 616 000	6.5	0.24	141	199
Gabon	11 000	1 672 000	0.1	0.10	164	67

The Congo basin consists of the central African rivers system consisting of the Congo and Ubangi Rivers and the associated tributary river basins. Rivers of part of the Central African Republic are tributaries of the Chari system. Statistical reporting of inland capture production from the Congo basin and its rivers is very poor, and FAO has estimated catches for the Central African Republic and the Democratic Republic of Congo and Gabon regularly over the past ten years. Catches from most of the Congo basin countries are not reported by taxonomic grouping. Fish is generally considered to be important in the diet of the region, this is apparent from the per capita fishery production (in the case of the Congo and Central African Republic) and there is clear evidence of its importance in the household consumption figures for Democratic Republic of Congo (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Fish trade evidence points to considerable imports from neighbouring subregions (IOC, 2012).

The Democratic Republic of the Congo

The Democratic Republic of the Congo covers the major part of the basin and dominates the catches from the Congo River system accounting for 74 percent of the total inland capture production of the three countries. FAO has estimated catches from this basin for the last ten years at a stable level. The large size and relatively low population densities of the Democratic Republic of the Congo almost certainly limit the level of exploitation of the inland fisheries of the basin. However, the FAO 2014 estimate of 232 000 tonnes (2004) is only 24 percent of the estimate derived from the household survey model of 964 636 tonnes in 2004-2005 (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This indicates that there is potentially significantly more inland capture fishery production than is currently estimated. The general rising trend provided by the production estimates is consistent with the increasing populations of the basin. The important message from the survey information is that inland fish consumption is potentially far higher than officially recognized and is probably about 18 kg/capita/year, far higher than the apparent consumption indicated from the production figures.

The extensive nature of the Congo River resources and the ability of large tropical river basins to sustain high levels of production under increasing fishing pressure indicate that the higher estimate of production is quite reasonable. The current surface water productivity figure of 172 tonnes/km^3/yr for the Democratic Republic of the Congo is quite low, but in a similar order to other African countries. Equivalent surface water productivities in Asian tropical river basins can range from 500 to 1 000 tonnes/km^3/yr, indicating that inland capture production in the Democratic Republic of the Congo could easily be double the current estimate. However, this is still only half of the figure indicated by the consumption model. The Democratic Republic of the Congo is a recognized importer of inland fish from Uganda, namely Nile perch processing frames from Lake Victoria and dried Brycinus nurse from Lake Albert (IOC, 2012) and 97 119 tonnes of marine and inland fish from Zambia (Mussa *et al*., 2017).

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The Republic of the Congo

The inland fisheries resources of the Congo are located in the Cuvette Congolaise marshlands (45 000 km^2), which are shared with the Democratic Republic of the Congo. There are numerous large rivers associated with the swamp system including the reaches of the Congo, Ubangui, Sangha, Likouala and Likouala Aux Herbes. There are also numerous small lakes and the Conkouati, Loubi and Malonda coastal lagoons. Considering the resources, inland capture fishery production from the Congo is relatively low, but has increased to 37 320 tonnes in 2015. FAO surveyed the fisheries of Congo in the early 1990s mainly by market surveys in Brazzaville. The fisheries resources of the Cuvette Congolaise are very poorly studied, so their potential is unknown (Welcomme and Lymer, 2012). Population densities in the Congo are low (12 to 17 persons/km^2) relative to the neighbouring Democratic Republic of the Congo (29 to 135 persons /km^2), which may limit exploitation. The surface water productivity figure of 46 tonnes/km^3/yr for the Congo is the lowest in the region.

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Central African Republic

Central African Republic lies within two regions. To the north it forms part of the Sahelian Chad basin. To the south it lies in the extensive headwater basin of the largest tributary of the Congo River system, the Ubangi, which covers the majority of the country. FAO estimates the catch of Central African Republic on a regular basis. Estimated catch was relatively stable at about 15 000 tonnes during the 1980s and 1990s before increasing substantially to the present day. A single official report to FAO in 2012 of 32 000 tonnes effectively doubled this earlier figure. Vanden Bossche and Bernacsek (1990) provide a range of potential production figures between 23 000 and 35 000 tonnes, so the current 2015 FAO estimated figure of 28 000 tonnes is in the middle of the estimated potential production. Although population densities are low (4 to 9 persons/km^2), the surface water productivity figure of 199 tonnes/km^3/yr is the highest in the region.

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Gabon

The Ogooue River basin lies almost entirely within the borders of Gabon and forms the principal fishery of the country. The majority of the production is centred on the middle stretch of the Ogooue River. FAO has estimated the inland capture production of Gabon since 2007. In 1991, a major revision of the fisheries production resulted in an increase from previous estimates of about 2 000 tonnes to 9 466 tonnes (reported by Gabon) in 1996. The FAO estimate is currently 9 700 tonnes. The fishery production per unit of renewable surface water is quite low (67 tonnes/km^3/yr). The fish consumption model estimate for inland fishery production (2 507 tonnes in 2005) is only 25 percent of the estimated production (9 700 tonnes) for the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Considering the major revision of catch and the subsequent estimates of FAO, it may be time to re-assess the inland fishery catch of Gabon.

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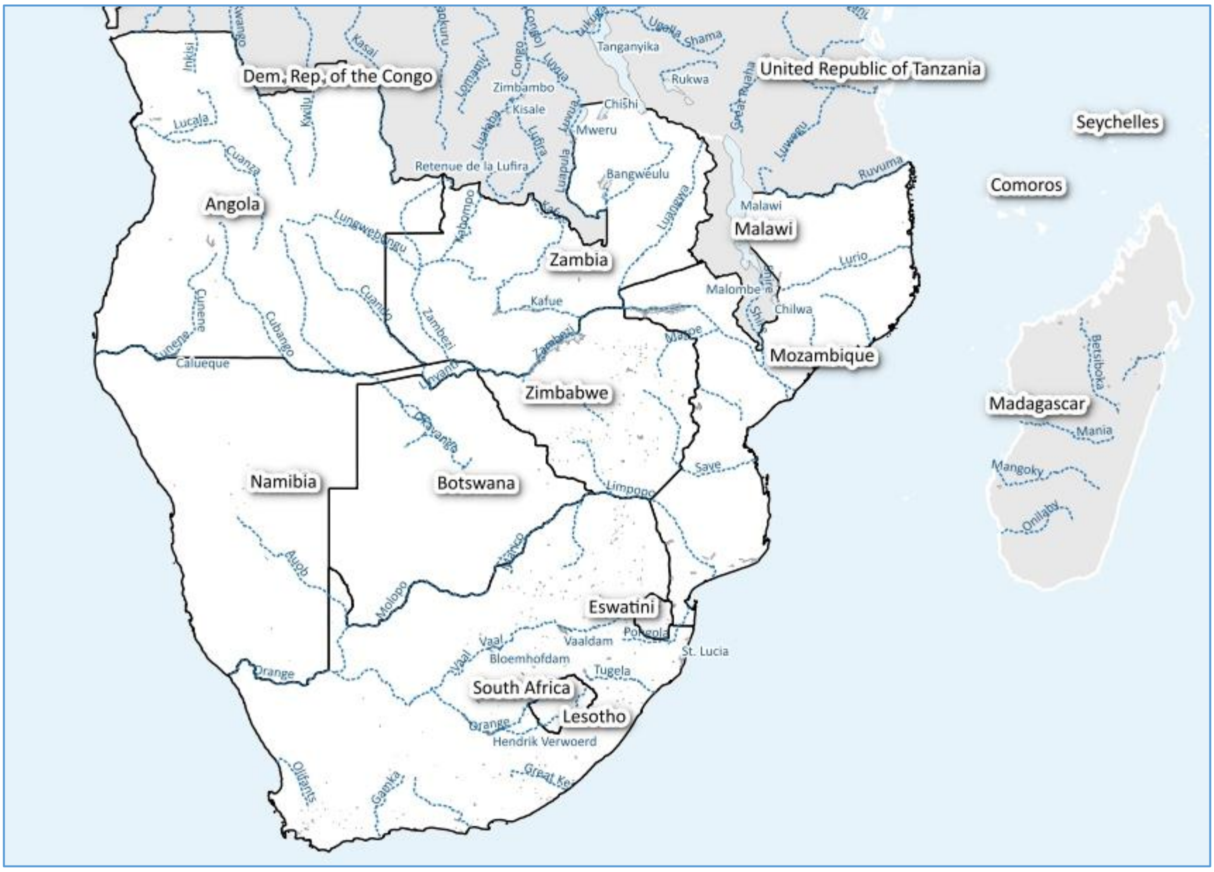
2.1.8 SOUTHERN AFRICA



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water ($tonnes/km^3/yr$)
Mozambique	93 020	25 834 000	3.28	0.81	214.1	434
Zambia	83 719	14 539 000	5.17	0.73	104.8	799
Angola	38 514	21 472 000	0.75	0.34	145.4	265
Zimbabwe	10 500	14 150 000	0.74	0.09	19	553
Namibia	2 800	2 303 000	1.22	0.02	37.85	74
South Africa	900	52 776 000	0.02	0.01	49.55	18
Botswana	81	2 021 000	0.21	0	10.64	8
Eswatini	65	1 250 000	0.05	0	4.51	14
Lesotho	52	2 074 000	0.02	0	3.022	17

Southern Africa is rich in river and lake resources and these are centred on the Zambezi system comprising the Zambesi River, Zambezi and Barotse floodplain (Zambia), the Zambezi-Chobe floodplain (Namibia) and the Zambezi delta (Mozambique). Catches from most of the Southern African countries are not reported by taxonomic grouping.

Mozambique

Inland fisheries catches, reported to FAO, amounted to less than 4 000 tonnes until 1992, after which they increased almost consistently until the present day level of 93 020 tonnes, the highest for this subregion. The estimate of fisheries in Mozambique (DeGraaf and Garibaldi, 2014) is 83 174 tonnes and this equates to about one tonne per inland fisher per year. The productivity of surface water (432 tonnes/km^3/yr) is one of the highest for the subregion.

The source of this production is principally attributable to the Cahora Bassa reservoir, where estimates of the combined yield is 26 000 tonnes per year. Of this, a total of about 10 000 tonnes of *kapenta* (*Limnothrissa miodon*), which has spread downstream from Lake Kariba, are caught, processed and marketed from Lake Cahora Bassa each year. Approximately 4 000 tonnes are caught by artisanal and small-scale fishers. Nile tilapia *Oreochromis niloticus*, has rapidly spread from Lake Kariba and has displaced the indigenous *O. mortimeri*, which is now in the IUCN red list (Marshall and Tweddle, 2007). The Mozambique portion of Lake Malawi/Lake Nyassa also contributed an estimated 9 100 tonnes in 1983 (Massinga and Contreras, 1983). The Zambesi delta fishery is variously estimated to be able to produce between 15 000 and 19 000 tonnes (Turpie *et al.*, 1999; Welcomme cited in Turpie, 2008). Additional inland fishery resources are derived from the Limpopo and Save estuaries.

The fish consumption model estimate for inland fishery catch (63 411 tonnes in 2002-2003) is 362 percent greater than the reported catch (17 500 tonnes) for the same year, clearly indicating that the catch was higher than estimated at the time. This is equivalent to a consumption of inland fish of 3.2 kg/capita/year in 2003. Based on current reported inland fish catch, the inland fish consumption is 3.3 kg/capita/year, indicating very close agreement with the earlier figure (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

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Zambia

Zambia ranks alongside Mozambique for inland capture fishery production in this region, reaching 80 820 tonnes in 2014. The Zambezi and Barotse floodplain (Zambia) in the main wetland area is 550 000 ha with approximately 224 000 inhabitants. The estimated total catch from this area is 10 500 tonnes.

The principal man-made large waterbodies are Lake Kariba (shared between Zimbabwe and Zambia) and the Itezhi-tezhi reservoir. Lake Kariba has a substantial *kapenta* (*Limnothrissa miodon*) fishery, which was introduced into the reservoir in the late 1960s. The fishery expanded from approximately 600 rigs allowed on the lake in 1999 to 1 098 in 2012 with a 40 percent increase in fishing effort over the same period. Catches have been declining since the 1990s, and are now estimated at 18 000 tonnes (Kinadjian, 2012).

Natural lakes that support inland fisheries are Mweru, Mweru wa Ntipa, and Bangweulu in Zambia. Bangweulu fishery supports a seasonal fishing industry and the population may increase markedly during the season. In 1989 the average annual catch was estimated at 11 900 tonnes, caught by 10 300 people using 5 305 dugout canoes, 114 plank and fibreglass boats, and only 54 outboard motors. In 2000 the catch was 13 500 tonnes (Jul-Larsen *et al*., 2003). The long-term average reported by Zambia is for a total catch of 8 350 tonnes for its part of Lake Mweru, but this does not include the important light fishery for the clupeid Lake Mweru sprat (*Microthrissa moeruensis*). This is estimated to produce between 25 000 and 40 000 tonnes (van Zwieten *et al*., 2003).

The estimated total inland fishery production based on household surveys was 764 573 tonnes in 2002/2003, and was considerably higher than the 63 000 tonnes production reported to FAO in the same year (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). However, this is equivalent to a consumption of inland fish of 67 kg/capita/year, which is extraordinarily high for the region. Based on current reported inland fish catch, the inland fish consumption is 5.2 kg/capita/year, which is more in line with other countries in the region (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). However, the national figure may well be an underestimate and there is evidence of imports of inland fish from neighbouring countries. The import of dried fish from Malawi alone (24 000 tonnes) is equivalent to an additional 90 000 tonnes of fresh fish. There are a number of reasons why these two catch estimates are so divergent, including non-inclusion of floodplain fisheries in official statistics and under-reported imports. There may also be some effects of the survey methodology, over-estimating actual fish in the households. The conclusion of this is that the survey figure may be somehow over-estimated (as has been suggested for Malawi) and warrants more detailed study of fish consumption. Furthermore, the productivity of Zambian inland fisheries may be greater than previously considered.

According to the Zambia Household Survey, fish provides 23 to 43 percent of women's dietary protein (and 24 to 26 percent of dietary fat) and is by the far the predominant source of animal protein in the Zambian diet (Alaofe *et al*., 2014).

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Angola

Reported inland capture fishery production rose to 10 000 tonnes in 2003, consistent with the magnitude of the aquatic resources in the country. Inland fishing areas include small to medium size artificial and natural lakes, rivers and extensive floodplains; there are no major waterbodies. FAO has estimated production for Angola since this time. In 2014, Angola reported an 80 percent increase in production (18 817 tonnes) above the previous estimated levels. The country remains challenged in the production of inland capture fishery statistics and there are few other sources to draw upon to validate estimates and reported production. As no census exists for the subsector there is no reliable estimate of the numbers of fishers and boats (IFAD, 2014). Angola's inland fishing activities are exclusively small-scale fisheries with no semi-industrial fisheries. The majority of the catch is made up of a few species, mainly tilapia and catfish (IFAD, 2014). Vanden Bossche and Bernacsek (1990) estimated a potential yield from all of Angola's inland fishery resources of between 50 000 and 55 000 tonnes per year. There is probably a quantity of hidden, unreported production in Angola through dispersed fishing activities, but it is unlikely that any real estimate can be derived unless a census or household survey is undertaken that specifically includes the inland capture fishery or its products.

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Zimbabwe

Zimbabwe shares part of the Zambesi basin and has several other rivers. There are a small number of floodplain areas. It has no large natural lakes. It shares Lake Kariba with Zambia. Total possible potential yield for Zimbabwe was estimated at between 21 000 and 44 000 tonnes per year (Vanden Bossche and Bernacsek, 1990). Catches from Zimbabwe have fallen from a peak of 25 607 tonnes in 1990 to a current estimated level of 10 500 tonnes. This is attributed in part to reduced capacity to manage fisheries and collect statistics. FAO has estimated inland capture fishery production since 2001, with one single report in the intervening period (2005). The Zimbabwe portion of Lake Kariba was estimated to produce 5 000 tonnes in 1995 (Mhlanga and Mhlanga, 2013), but more recent statistics are unavailable. It is unlikely to be increasing based on the decline in the catches in the Zambian side of the reservoir.

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Namibia

Namibian inland capture fishery production reported to FAO was negligible until 1983 whereupon a rapid increase marked improved estimates of the fishery. FAO has been estimating the production since 1998, with one exception (2 800 tonnes in 2007). Principle resources are the Chobe river (on the border with Botswana) and the Lake Liambezi fishery in the Caprivi area. The Lake Liambezi fishery developed from almost nothing in 2008, based on subsistence catches dominated by *Clarias gariepinus*, and a few tilapia (cichlid) species. In 2010, a rapid increase in large cichlid species encouraged fishermen to enter the fishery. The lake fishery is driven by water levels that vary considerably (the lake dried up in the 1980s). Estimates (Turpie, 2008) for the various fishery resources of Namibia are somewhat higher than the FAO estimate (2 800 tonnes), and are as follows:

- Caprivi region, which includes the rest of the Chobe and the Kwando-Linyanti system – 1 500 tonnes;
- Chobe River and Lake Liambezi – 600 to 800 tonnes per year; and
- Zambezi-Chobe floodplain – 1 279 tonnes.

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Botswana

Total inland capture production was estimated to have reached 1 800 tonnes in 1988, but underwent a spectacular decline after that period. Largely based on FAO estimates, by 1995 catches were less than 100 tonnes. The main large river and associated waterbody is the Okavango River (headwaters in Angola) and its endorheic delta. This fishery was estimated to have 35 000 residents fishing 40 days per year catching 840 tonnes. Another estimate is 56 000 residents fishing 60 days, yielding 1 045 tonnes (Tvedten *et al*., 1994). Estimates of the MSY range from 840 to 3 000 tonnes (Turpie, 2008). The reported fishery production of Botswana recovered from its low level in 2009 increasing to 1 186 tonnes in 2014. This is attributed to a significant increase of fishing effort at Lake Ngami (a lake outside the Okavango delta), where most fishing activities take place. A sharp decline in 2015 is a result of a fishing ban imposed on Lake Ngami.

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South Africa

The traditional fisheries on the Pongola floodplain in northern Kwazulu-Natal and the Orange River in the Northern Cape were the only inland fisheries until dams were constructed to meet urban and agricultural demand for water and energy in the early twentieth century. There are currently 3 150 waterbodies larger than 1.2 ha with a total surface area of 3 000 km^2 (McCafferty *et al.,* 2012).

The last year for which South Africa reported any catches was in 1990 with 900 tonnes. This figure has been maintained as an estimate by FAO since then. The highest catches were obtained during the 1970s and in the beginning of the 1980s when 1 150 tonnes were landed. Apart from 100 tonnes of unidentified species the entire catch was North African catfish (*Clarias gariepinus*). However, Vanden Bossche and Bernacsek (1990) reported that in 1987 catches were 2 300 tonnes, possibly including 695 tonnes estimated from recreational fishers in Hartebeespoort dam in the 1980s (Cochrane cited in McCafferty *et al*., 2012). Other quantitative data on catches are few and scattered: (Whitehead cited in McCafferty *et al*., 2012) reported that catches from Darlington Dam were 1 tonne per day for 100 days, and Batchelor (cited in McCafferty *et al*., 2012) reported a catch from various dams in 1984 of 469 tonnes. Andrew, Rouhani and Seti (cited in McCafferty *et al*., 2012) reported 3.6 tonnes in 120 days in Tyefu

Dam in the Eastern Cape, and Potts, Weyl, and Andrew (cited in McCafferty *et al.*, 2012) recorded 10.3 tonnes from Lake Gariep in 2000.

During the colonial period a large number of non-native species were introduced for recreational purposes, and recreational fishers continue to be the main users of inland fisheries resources, although subsistence angling is increasing and may contribute significantly to fishing effort. There have been attempts to develop commercially-oriented fisheries but these appear to have failed as they were not economically viable (McCafferty *et al*., 2012).

Based on an assessment of 425 dams, Britz *et al*. (2015) estimated the fisheries potential at about 15 000 tonnes annually. Of these dams, only 52 are large enough to yield more than 100 tonnes of fish per year. Most of the potential is found in the warmer areas of the country such as Limpopo, Mpumalanga, the north, and in KwaZulu-Natal.

The authors warn of the consequences for subsistence fishing and the impact on the more valuable recreational fisheries should commercial operations be developed. Brand *et al*. (2009) valued recreational fisheries for yellowfish in the Vaal River at USD 19 million (ZAR 133 million) per season whereas Du Preez and Lee (cited in Britz *et al*., 2015) showed that trout fishing generated USD 1.8 million (ZAR 13.5 million) (and employed 85 people in Rhodes Village in the Eastern Cape with a population of 600 people, of which only 15 percent were formally employed. The average expenditure was USD 690 (ZAR 5 052) per angler per trip.

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Lesotho

Lesotho is a small, landlocked mountainous country in which there are three main rivers: the Senqu, the Makhaleng and the Mohokare (all part of the Orange River basin). The total river length is 2 160 km with a drainage area of 31 000 km^2 (FAO Fisheries country profile). All rivers are highland streams without any floodplains (Vanden Bossche and Bernacsek, 1990). There are several hydropower dams of which the Katse dam (36 km^2) is the largest. However, construction of several new dams for hydroelectric purposes is ongoing. The area of surface waterbodies is estimated to be 80 km^2 (FAO Fisheries country profile 2008).

Lesotho has reported inland fisheries catches every year since 2000, however data for 2015 have been estimated by FAO at 52 tonnes (repeating the data for 2014). Common carp dominates catches with 27 percent of the catches, followed by Northern African Catfish (19 percent). The remaining landings are not identified and are reported as "not elsewhere included" (nei) (FAO FishStatJ). There is little monitoring of catches from rivers and reservoirs, with the gillnet fishery in Katse dam being the exception. This fishery yields an annual catch of 14 to 20 tonnes and is used to produce the estimate of national catches that are reported to FAO (FAO Fisheries country profile 2008).

Maar (cited in Vanden Bossche and Bernacsek, 1990) estimated a potential yield of 120 tonnes from riverine fisheries alone. Tilquin and Lechela (1995) made an inventory of lowland reservoirs and estimated about 400 functional reservoirs in the country all of them being smaller than 100 ha and with a total area of 430 ha. Only four of them with an area of 147 ha would be able to sustain an extensive gillnet fishery with a fisheries potential between 1.5 and 10 tonnes. Several hydropower dams have been constructed since the survey and the current potential may be somewhat higher than these earlier estimates.

In Lesotho, fishing is mostly for subsistence, only 15 percent of the estimated 150 fishers (2007) are full-time fishers. The fishery is directed towards both indigenous and exotic species. Lesotho has nine indigenous fish species among which smallmouth yellowfish (*Barbus aeneus*), largemouth yellowfish (*B. kimberleyensis*), Orange River labeo or mudfish (*Labeo capensis*), mud mullet or moggel (L. umbratus) and Northern African catfish potentially could be commercially exploited. However, an additional eight species have been introduced for fish farming and to enhance capture and recreational fisheries, including rainbow trout (Oncorhynchus mykiss), brown trout (Salmo trutta), common carp (Cyprinus carpio), largemouth bass (Micropterus salmoides) and bluegill sunfish (Lepomis macrochirus) (FAO Fisheries country profile 2008).

Some sportfishing for rainbow trout and yellowfish takes place in mountain streams mainly by tourists from South Africa (FAO Fisheries country profile 2008).

Fisheries are strongly affected by the erratic precipitation pattern (Vanden Bossche and Bernacsek, 1990).

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The Kingdom of Eswatini

The Kingdom of Eswatini has three significant river basins: the Nkomati, Mbuluzi and Usuthu. There are no natural lakes, swamps or floodplains, and the total surface water area is 160 km^2, mainly dams constructed for hydropower and irrigation purposes including the Hendrick Van Eck (0.4 km^2), the Luphohlo (8 km^2), the Maguga, the Mkimkomo, the Mjoli (84 km^2) and the Sand River dams (7.1 km^2). The Jozini dam, in the south of the country, is shared with South Africa, however, more than 98 percent of it is in South Africa (Breuil and Grima, 2014). Smaller dams for storing water for domestic uses and livestock are found throughout the country, but are mostly concentrated in the driest area (Lowveld) (Vanden Bossche and Bernacsek, 1990; Breuil and Grima, 2014).

The Kingdom of Eswatini has only reported fish landings to FAO on three occasions since 1950, the last time in 1988 with 90 tonnes. Since then, FAO has estimated the captures and the current estimate is 65 tonnes for 2015. The composition of the catches is not indicated as everything is recorded as nei (FishStatJ).

Vanden Bossche and Bernacsek (1990) estimated the potential yield to 215 to 280 tonnes per year for the major dams (mostly Mjoli reservoir).

A fish and fisheries survey conducted by the Fisheries Administration in 2002/2003 identified approximately 60 species of fish throughout the country. The main fish species that are exploited are tilapias (*O. mossambicus* and *Coptodon rendalli*) and Northern African catfish. Species targeted for sport fishing include the largemouth bass (*Micropterus salmoides*), rainbow trout and tiger fish (*Hydrocynus vittatus*). Smaller dams are often stocked with tilapias for food security at the local level (Breuil and Grima, 2014).

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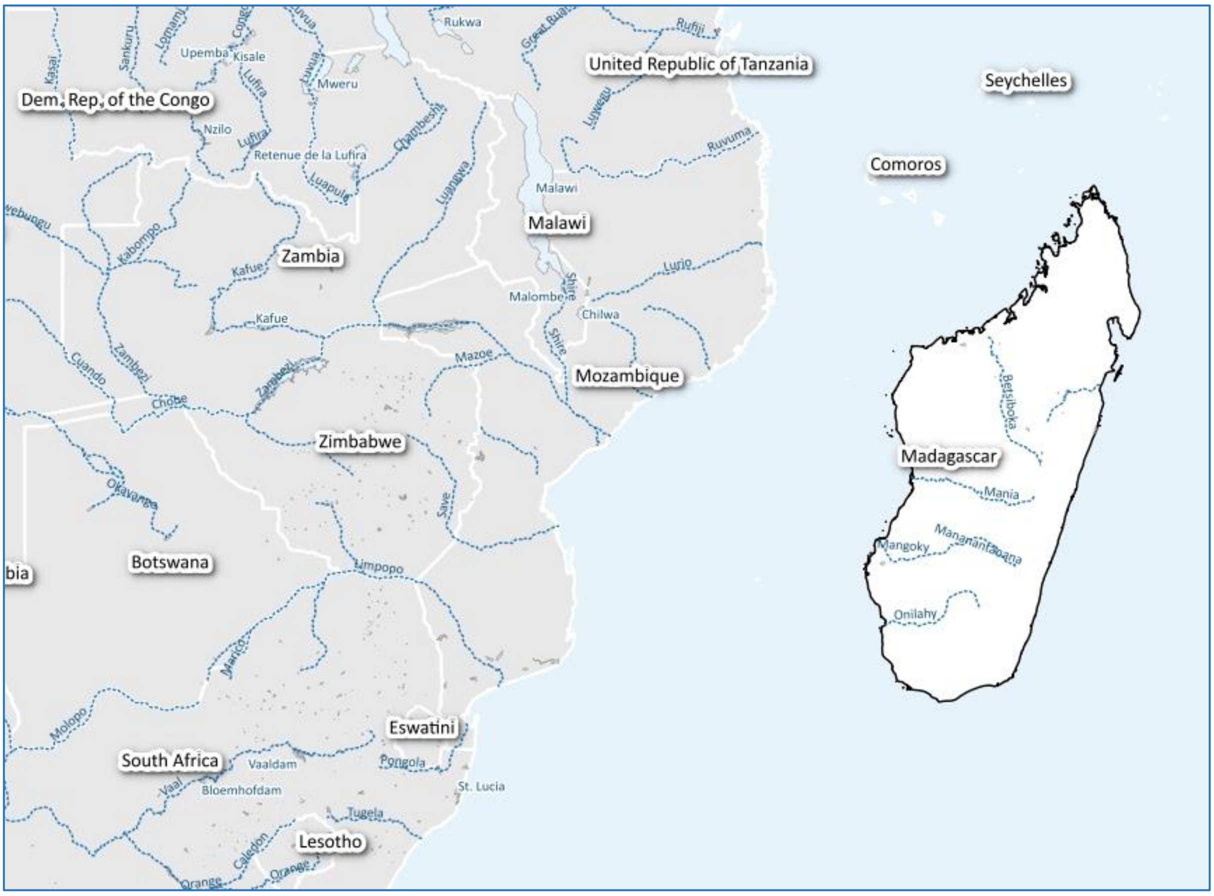
2.1.9 AFRICAN ISLANDS



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Madagascar	25 940	22 925 000	1.01	0.23	332	78

Of the African islands (Madagascar, Cabo Verde, Comoros), only Madgascar has a substantive inland fishery. Madagascar has hundreds of small and medium-sized lakes. Many are associated with the floodplains of westward flowing rivers. There are also many small mountain and crater lakes. Totalling the lakes, reservoirs and coastal lagoons, there are some 530 lacustrine waterbodies with surface areas over 0.20 km^2 in Madagascar. The largest lakes are: the Alaotra, the Kinkony, the Ihotry, the Itasy, the Tsimanampetsotsa, the Komanaomby, the Bemamba, the Hima, the Mandrozo, and the Amparihibe-South.

There are also coastal lagoons. The inland fisheries exploit various streams and lakes and are aimed mainly at local consumption. The total annual yield in the 1983 to 1997 period was 40 000 to 45 000 tonnes.

The potential yield estimated was 77 000 tonnes. Current reported catch is limited to 25 940 tonnes (2015). Some "amateur" fishing is carried out on the lakes. The main species targeted are the tilapias, carps, black bass and fibata (*Channa striata*) (introduced from Asia in the mid-1970s). The inland fish catch is dominated by tilapia (Table 2-2).

This level of inland fish production contributes about 1 kg per year to the diet and potentially more to specific segments of the population that are more dependent upon the inland resource.

Table 2-2: Inland fish production by species and year in Madagascar

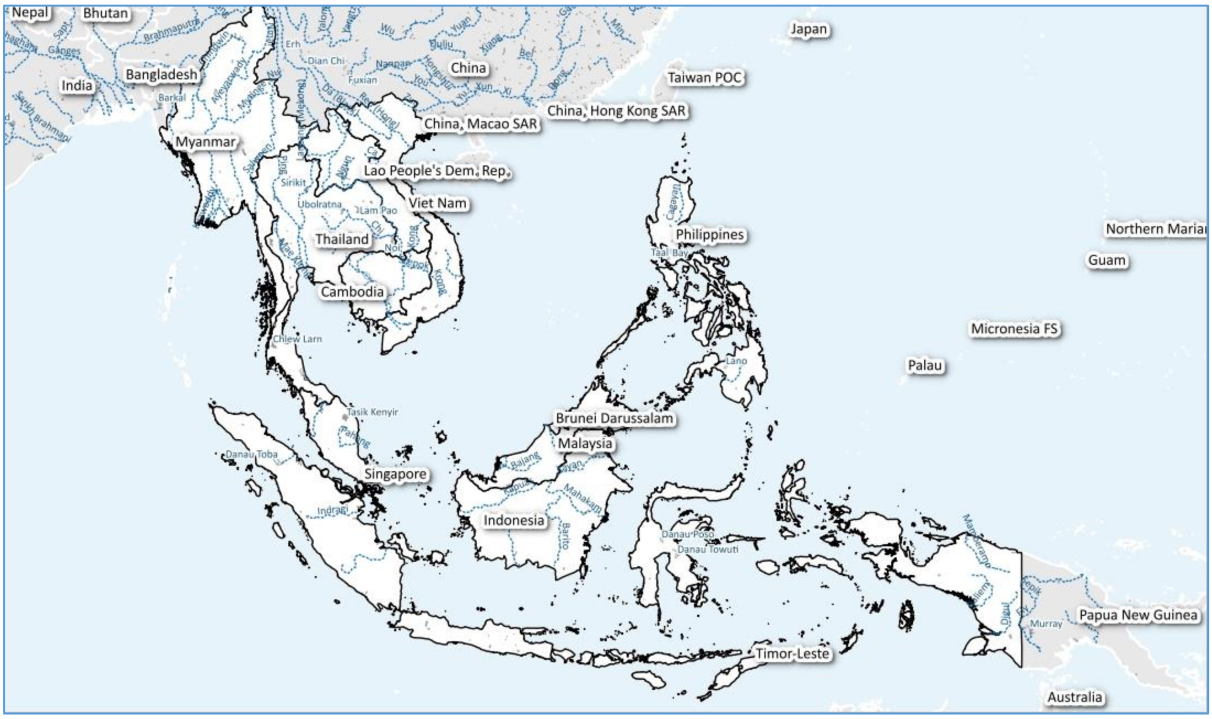
Species/years	2000	2001	2002	2003	2004	2005	2006
Cichlids nei	21 500	21 500	21 500	21 500	21 500	21 500	22 000
Common carp	2 480	2 350	2 400	2 500	2 500	2 500	2 500
Cyprinids nei	4 000	4 000	4 000	4 000	4 000	4 000	4 100
Freshwater fishes nei	4 500	4 500	4 500	4 500	4 500	4 500	4 500
Nile crocodile	6 606	9 408	6 936	7 300	4 760	4 850	4 850
Rainbow trout	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Tilapias nei	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

Source: FAO country profile citing Ministry of Fisheries, Madagascar

2.2 ASIA

Subregion	Inland capture fishery catch (tonnes) (2015)	Total renewable surface water (km3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)	Percentage of global inland fishery catch	Per capita inland fishery production (kg/cap/yr)	Number of inland fishers	Number of post-harvest workers
South Asia	2 591 358	3 444	752	11.4	6.5	2 820 694	4 424 796
Southeast Asia	2 427 041	6 237	389	10.7	11.8	24 059 879	1 303 853
China	2 281 065	2 739	833	19.9	1.67	755 622	475 000
West Asia	148 571	384	387	0.7	0.7	19 680	0
Central Asia	90 441	395	229	0.4	0.7	11 201	0
East Asia	47 201	563	84	0.2	1.1	84 723	0
TOTAL	**5 304 612**			**23.4**		**27 751 799**	**6 203 649**

2.2.1 SOUTHEAST ASIA



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch (%)	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Continental						
Myanmar	863 450	53 259 000	24.46	7.53	1 157(i)	746
Cambodia	487 905	15 135 000	34.89	4.25	472(i)	1 035
Viet Nam	150 100	91 680 000	2.15	1.31	848	177
Thailand	196 600	67 011 000	3.14	1.76	427(i)	460
Lao PDR	62 636	6 770 000	5.93	0.55	334(i)	188
Malaysia	5 924	29 717 000	0.2	0.05	5 661	10
Archipelagic						
Indonesia	457 060	249 866 000	1.65	3.99	1 973	232
Philippines	203 366	98 394 000	2.04	1.77	444	448
Timor Leste	-	1 133 000	-	0	-	
Brunei Darussalam	-	-	-	-	-	-
Singapore	-	-	-	-	-	-

Note: i = FAO Aquastat estimate http://www.fao.org/nr/water/aquastat/data/query/index.html

The Southeast Asian region consists of two principal areas, continental and archipelagic. The continental part of Southeast Asia comprises Cambodia, Lao People's Democratic Republic, Myanmar, Singapore, Thailand, Viet Nam and Peninsular Malaysia. Its major river basins include the Mekong, Salween and Irrawaddy, Chao Phraya, Red River. The region has extensive river systems linked to these rivers and their deltas and floodplains are hugely productive. There are a number of major lakes (Tonle

Sap, Songkhla Talay Sap, Hue Lagoon, Inle Lake), but more significantly, a huge number of small floodplain waterbodies and large and small irrigation reservoirs.

The archipelagic areas of Southeast Asia comprise the large and small islands of Borneo (Brunei Darussalam, Sabah Malaysia, Sarawak Malaysia, Kalimantan Indonesia), the archipelagos of the Philippines, Indonesia and Timor-Leste. The significant river basins include Kapuas, Mahakam, Batang Kuantan, Batang Hari, Bengawan Solo. There are some large lakes (e.g. Laguna de Bay, Taal, Toba as well as Lanao) and large wetlands/peatlands of Sumatra, Java and Kalimantan.

There are 63 taxa reported for the Southeast Asian region, some of which are groupings of species. The majority of the reported catch consists of finfish, with small amounts of crustaceans (1.7 percent) and molluscs (2.8 percent). This does not reveal the actual picture of exploitation of aquatic resources. Where detailed field studies have taken place, a very wide range of species are caught and consumed or otherwise utilized. A significant part of this catch comprises fish and other aquatic organisms that are not reported organisms and hence their contribution to diets is considerably higher than reports would suggest (Meusch *et al.*; 2003, Halwart, 2006; Halwart *et al.;* 2006; Hortle, 2007). A few countries report their catches at the family level. A substantial proportion of the reported production is "freshwater fishes nei".

Per capita consumption is high in this region, with Cambodia being the highest, where detailed analysis by Hortle (2007) shows that annual consumption patterns vary between provinces, from 105.2 kg per capita in riparian provinces to 43.4 kg per capita in those that are less dependent on the river.

This region is also characterized by considerable efforts being made to enhance fisheries in waterbodies (mainly man-made, but some natural lakes as well) through stocking activities, either on a repeated or occasional basis.

The Southeast Asian subregion represents 25 percent of total reported global inland capture fishery production, however the country details reveal varying degree of overestimation or underestimation. The trend is highly driven by the reported catch of Myanmar.

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Cambodia

Fishery resources based around the Mekong River, its tributaries and associated floodplains are considerable. The massive Tonle Sap is another major inland fishery resource. Productivity as a function of renewable surface water is high (1 070 tonnes/km^3/yr). Most of this productivity is natural, reflecting the massive productivity of the Mekong River system. There are minimal stocking activities in large waterbodies.

Inland fisheries have been central to Cambodian culture since ancient times. Cambodia's inland fisheries are among the largest and most significant in the world, based on hundreds of species that are caught using at least 150 kinds of gear. Millions of Cambodians work full- or part-time in fisheries-related activities. Fish are crucial for nutrition and food security because they provide Cambodian people with up to 80 percent of their animal protein. Fish consumption figures are amongst the highest in the world and largely derived from inland fish (Hortle, Lieng and Valbo-Jorgensen, 2004).

The rapid increase in inland fishery production reported in the late 1990s was largely a result of a revision to the statistical reporting to include floodplain fisheries (Hortle, 2007; Lymer and Funge-Smith, 2009). Cambodia itself has declared its statistics not to be retroactively compatible before this date (Welcomme, 2011).

There has been a subsequent general trend of increasing catch, rising from the original estimates of 375 tonnes to 425 000 tonnes to the reported level of 487 420 tonnes (FishStatJ, 2015). The statistics are not disaggregated by species or family, although FAO estimates crustacean production (principally freshwater prawn) at 575 tonnes.

Estimates of total production through the use of household surveys indicate that in 2009 the reported inland fishery production of 390 000 tonnes was lower than the production inferred from of the household survey model, which was 575 901 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This latter figure is equivalent to an inland fish consumption figure of 40.9kg/capita/yr.

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Thailand

Thailand has considerable inland water resources in the form of several large river basins (Mekong River and its several tributaries, Chao Praya River basin, Ta Chin River basin). Other significant inland water resources include Songkhla Lake basin, swamps and wetlands and a huge rice growing area. Inland capture fishery production increased rapidly between 1986 and 1996 rising from about 100 000 tonnes to over 200 000 tonnes. It has fluctuated between 200 000 tonnes and 230 000 tonnes up to the present level of 196 600 tonnes (2015). Data is reported for eight species and a number of groups. Production is dominated by unspecified freshwater fish (93 100 tonnes in 2015), which comprises 47.4 percent of the reported catch. Climbing perch, tilapia, silver barb, striped snakehead and clariid catfish are the major identified species. Production is derived from extensive floodplains and a number of large waterbodies. Thailand stocks its large-sized and medium-sized reservoirs and much of the reported catch is attributed to production from these waterbodies. With an area of over 330 000 ha and productivities ranging from 7 to >50kg/ha (De Silva and Funge-Smith, 2005) this more than accounts for the reported national production figure.

The floodplain and wetland fisheries (including ricefields and associated waterways) are notoriously hard to estimate, but there are indications that production from these may be considerably higher than the total production reported. The Mekong River Commission (MRC) estimated the inland capture production from the Mekong basin part of Thailand was over 900 000 tonnes (including aquaculture) (Hortle, 2007) and Lymer *et al.* (2008) estimated the national inland fishery catch to be about 1 060 000 tonnes (2003). The estimate derived from the household survey model Fluet-Chouinard, Funge-Smith and McIntyre (2018) is more conservative at 570 877 tonnes (2011), but still considerably higher (254 percent) than the reported figure of 224 708 tonnes for the same year.

Clearly, there is value in establishing a better baseline of inland fishery production that accounts for hidden production from wetlands and floodplains outside of large waterbodies. Care needs to be taken to disaggregate and correctly attribute the substantial amount of freshwater aquaculture production that takes place in all sizes of waterbodies throughout the country. Productivity from renewable surface waters is much lower (427 tonnes/km^3/yr) than that of Myanmar and Cambodia, but would be significantly higher (more than 2.6 times) and completely in line with these countries, if unreported catches were included.

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Viet Nam

Viet Nam with its narrow profile has few major rivers (the Red River), but does contain the massive Mekong delta. Much of its water resources originate outside of the country and flow through the country to the sea. It has a few lakes and some large reservoirs. The overall trend in inland fishery production in Viet Nam has risen steadily since 1999 to over 240 000 tonnes in 2001.There is probably little to be inferred from the statistical trends and reported production has been relatively consistent about 200 000 tonnes since 2003. There is no species detail in the reported production. In 2009 the reported catch was 144 800 tonnes, although alternative estimates for the Mekong delta area alone indicate the inland capture fishery production might be closer to 852 000 tonnes (Hortle, 2007). The reported statistics may be covering only part of the inland fishery (Coates, 2002) and significant other sources of production at household level may be unrecorded. If inland capture production is underestimated then re-evaluation of the actual baseline is warranted.

There are other freshwater resources in Viet Nam outside of the Mekong delta (such as Lake Ho-Tay and Lake Ba Be reservoirs and 1 967 reservoirs with a storage capacity of at least 0.2 km^3, as well as Hue Lagoon and northern upland ricefields) that also have inland fishing activity. Although it has relatively limited surface water in the form of natural lakes and reservoirs, the renewable freshwater resources of Viet Nam (848 km^3/yr) are nearly double that of Thailand but largely generated outside the country and seasonal.

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Lao People's Democratic Republic

Lao PDR sits almost entirely within the Mekong basin, and has a large number of tributary rivers, and wetlands and a few reservoirs. Lao PDR is a mountainous, land-locked country with an area is 236 800 km^2 of which 88 percent drains into the Mekong River, contributing about 35 percent of the Mekong River's discharge. The rest of the country in the northeastern area drains into Viet Nam. The people of Lao PDR, especially in the rural communities are highly dependent upon the country's fish and other aquatic animals as their most reliable sources of animal protein intake. MRC estimates that the actual fish consumption per capita of inland fish is 24.5 kg/capita/year and that of other aquatic animals account is a further 4.1 kg. There are more than 481 fish species (including 22 exotic species). These consumption figures are considered underestimates by Phonvisay (2013).

Inland capture fishery production in Lao PDR has increased steadily since 2003, but this data has principally been FAO estimates interpolated from occasional official reports. The current estimate of 42 200 tonnes is substantially lower than the estimate of 208 503 that was derived from the MRC fishery programme valuations (Hortle, 2007). The inland capture fishery productivity as a function of surface water resources is unusually low (126 tonnes/km^3/yr) considering the wide dependence upon fishery resources in the country and the abundance of water resources. However, this must be considered in the light of the mountainous terrain of Lao PDR and its low population density relative to the rest of the region. Employment in inland fisheries is high (1 052 000) reflecting the widespread engagement or Lao rural people in fishing activities on a full-time or part-time basis.

The 2008 production inferred from the household survey is 88 292 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018), is 300 percent higher than the estimated capture fish production reported for that year (29 000 tonnes) although only half of the MRC estimate (208 503 tonnes according to Hortle, 2007). One reason the inferred household survey production may still be underestimated, is that the massive increase in aquaculture production (also estimated by FAO) may in fact be partly misattributed inland capture fishery production. A more accurate survey and estimate of aquaculture production together with improved disaggregation of rice field fishery production might assist in validating the relative contributions of aquaculture and inland fisheries to the Lao diet.

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Myanmar

Myanmar has rich and extensive freshwater and inland fishery resources. The country has renewable surface water resources amounting to 1 157 km^3/yr, the highest of the continental Southeast Asian countries. Myanmar's largest river is the Ayeyarwady River (Irrawaddy River) which is 2 150 km long. Although the Ayeyarwady has only half the length and half the basin area of the Mekong the two rivers have similar annual discharges. Other major rivers are the Chindwin River, a tributary of the Ayeyarwady River, Salween River and the Sittaung River. It is estimated that Myanmar contains 8.1 to 8.2 million ha of surface water, the bulk of which is associated with the country's major rivers, estuaries and lakes (FAO-NACA, 2003). It is also estimated that 1.2 million to 1.3 million ha of Myanmar's freshwater resources are located in permanent wetlands, and the remaining almost 7 million ha are seasonal floodplains (FAO-NACA, 2003; Soe, 2008).

Prior to 1999, Myanmar's inland fishery production reported to FAO was relatively low, varying between 140 000 and 160 000 tonnes. This level of production was questioned by Coates (2002) as indicative of underestimation of Myanmar's inland fishery, which has considerable water inland fishery resources. The large number of concession fisheries throughout these systems were also considered to be efficient at capturing the large amount of inland fish production generated from these tropical river systems. It was considered that the production therefore should be comparable with that of the Lower Mekong Basin fisheries.

The initial dramatic increase in the catches in Myanmar is probably a result of the re-estimation of the contribution of floodplain fisheries. These fisheries are principally the *inn* fisheries (large fishing concessions based on traps that capture floodplain fish during recession of water at the end of the monsoon season) and the "leasable" fisheries (e.g. fixed bagnet fisheries based in the Ayerwaddy delta. Some of the increase is also attributed to management measures applied in the *inn* fisheries such as enhancement through stocking of nursed fish.

The reported production now exceed that of the Mekong River basin and consistent year by year increase indicates that these reports are not based on direct measurements of production, but are estimates. Comparison of reported production in 2006 (631 120 tonnes) with the estimated total production derived from the household survey model (783 617 tonnes) indicates that the reported production was still perhaps 19 percent underestimated (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This is equivalent to an inland fish consumption of 16 kg/capita/yr.

The reported inland capture fishery production has increased dramatically since the first jump to 196 000 tonnes in 2000. Between 2006 and 2014 this has doubled to reach 1.38 million tonnes, making Myanmar's inland fishery production second only to that of China. The reliability of these statistics has been questioned (FAO, 2016; Soe *et al.*, 2017) and the most recent figures for inland catch have been revised retrospectively. The 2015 inland catch is now 863 450 tonnes, which gives a similar per capita inland fish availability (16.4 kg/capita/yr) to the 2006 figure.

The fish productivity as a function of renewable surface water (1 194 tonnes/km^3/yr) is the highest in the region exceeding that of Cambodia. This is perhaps another indication that estimates of production are reaching an upper limit.

As Myanmar now represents more than 46 percent of the total production of Southeast Asia, it seems desireable to attempt to derive another validation of the likely inland capture fishery production of Myanmar through a household survey, targeted consumption surveys and dedicated inland fishery survey.

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Malaysia

The inland fisheries of Peninsular Malaysia are concentrated in major rivers, although occasional fishing takes place around most small rivers and waterbodies. Peninsular Malaysia has no major natural lakes, but does have large reservoirs. The inland capture fisheries of Sabah (on Borneo/Malaysia Timur) are largely conducted in rivers as there are few lakes, reservoirs and flood plains. The major river in Sabah is the Kinabatangan River with a length of more than 560 km.

The total reported production for Malaysia (Peninsular and Borneo) in 2015 was 5 924 tonnes. There has been a rising trend in reported production since the early 1990s. The annual fish production from lakes and reservoirs in Malaysia in 2006 was estimated to be 3 950 metric tonnes (Ambak and Jalal, 2006). The official report to FAO in the same year was 4 165 tonnes indicating that river and floodplain fisheries provided the rest of the production (~6 percent).

In Sabah, reported catches dropped from earlier levels of about 1 200 tonnes to less than 100 tonnes by 1999, which was attributed to environmental degradation and destructive fishing (Wong, 2003). Coates (2002) considers the fishery production for Sabah and Sarawak to be considerably under-reported. Although, the low population densities in the internal areas are likely to result in lower fishing effort and production than that seen in other Southeast Asian countries, the current figure of less than 100 tonnes does appear to be too low.

The fishery productivity as a function of renewable surface water is the lowest in the region (1 tonne/km^3/yr). This is a function of the very low inland fishery production as well as the fact that Malaysia has the greatest quantity of renewable surface waters in Southeast Asia. Reports generally indicate that impacts on water quality as a result of agricultural plantation runoff, deforestation and mining have variously had a serious impact on inland fisheries productivity (Khoo *et al.*, 1987).

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Philippines

The archipelago of the Philippines has few major river basins and floodplains (Mindanao River, Agusan River) reflecting the geography of the country. The inland fisheries are predominantly located in lakes (de Bay, Lake Taal, Lanala, Lake Mainit) and reservoirs. Despite this, the fishery productivity of the renewable surface waters (481 tonnes/km^3/yr) is double that of Indonesia and comparable to that of Thailand.

The trend in inland fishery production is marked by a massive peak (369 254 tonnes) in 1983. This was entirely driven by increasing production of freshwater molluscs nei. In the Philippines CountryStat data these are identified as clams (*kabibi*), Manila clam (*tulya*), oysters (*talaba*), snails (*suso* and *kuhol*) and other molluscs. The overwhelming majority of production is the black river snail (*suso*), which is found in large quantities in paddy systems. The reported production declined after this point to its lowest of 131 098 tonnes in 2002, attributed to overfishing and environmental degradation (pollution, siltation) (Neiland and Béné, 2008) and under-reporting (De La Cruz, 1998). However, the entire decline in the production is because of the decline in the production of freshwater molluscs nei. Inland fishery production started to increase in 2003 to reach 179 491 tonnes in 2014. Of this amount, 59 428 tonnes of the total production (30 percent) are freshwater molluscs nei (principally freshwater black river snails, and another 54 180 tonnes (30 percent) are tilapia.

The reason for the increase in production may be attributed to better environmental management of large waterbodies or possibly improved statistical monitoring after 2002. It is important to note that some of the species reported are brackishwater species and this is partly because of the Philippine's delineation of inland fisheries, which can include some brackishwater areas, especially lagoons, river mouths and bays.

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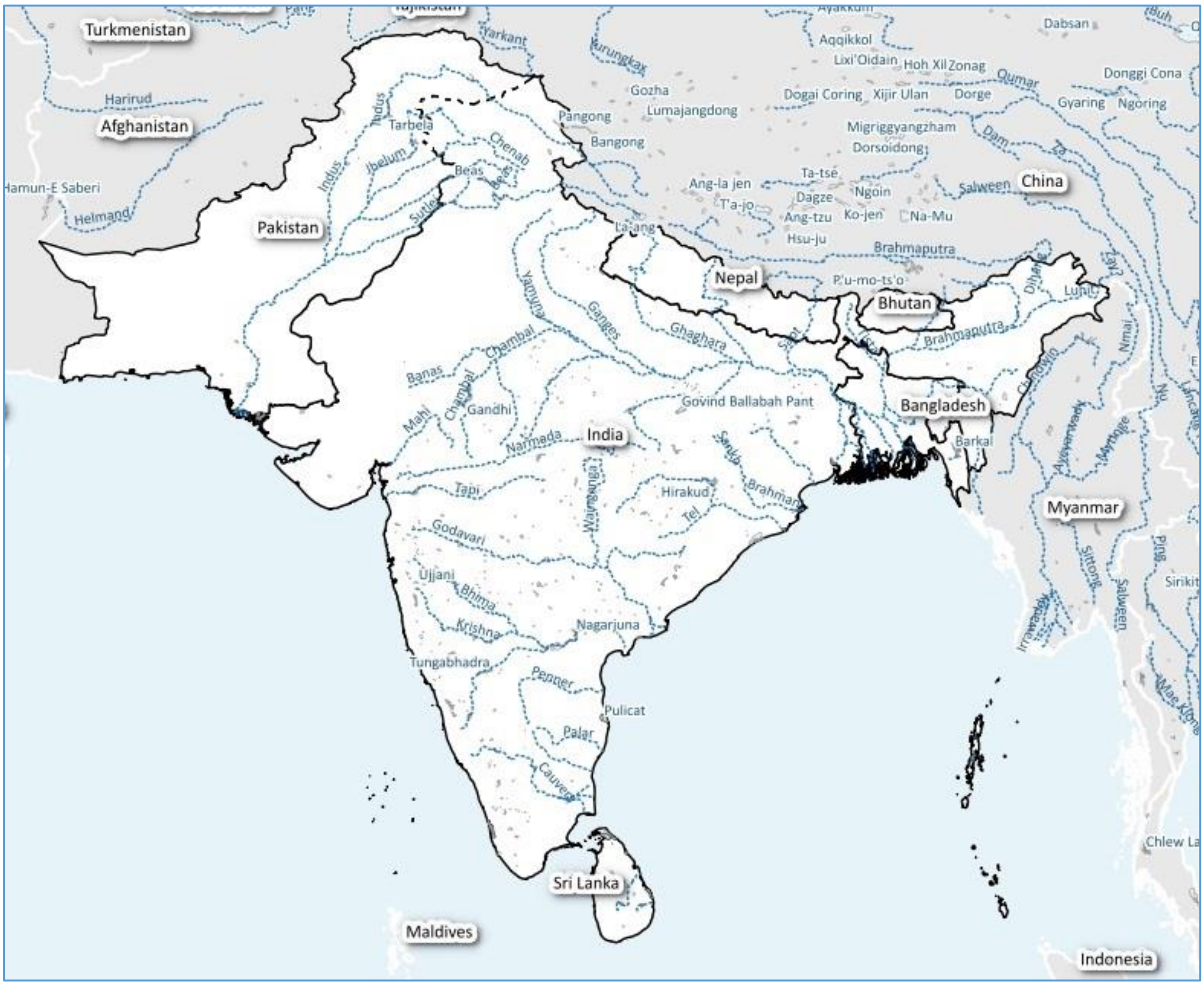
Indonesia

Indonesia has considerable inland fishery resources in the form of some large river basins particularly in Kalimantan (Mahakam, Kapuas), as well as smaller rivers volcanic lakes, smaller waterbodies and ricefield systems (in Sumatra, Java and Sulawesi).

The inland capture fishery production of Indonesia rose gradually between 1974 (252 740 tonnes) and 1994 (336 141 tonnes) and then fluctuated between 288 66 and 318 334 tonnes until 2009. More recently the production has increased sharply (>50 percent within five years) reaching 420 190 tonnes in 2014. The reason for this is unclear and may be a result of more recent re-estimation or considerable increase in fishing effort or enhancement.

The reported inland fishery catch for Indonesia of 368 578 tonnes in 2011 is higher than the estimate derived from the household survey model for the same year (236 934 tonnes). Overall, the inland capture fishery production as a function of the renewable surface water resource is quite low (213 tonnes/km^3/yr).

2.2.2 SOUTH ASIA



FAO Map disclaimer: Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
India	1 346 104	1 252 140 000	0.98	11.74	1 869	720
Bangladesh	1 023 991	156 595 000	6.14	8.93	1 206	849
Pakistan	132 456	182 143 000	0.68	1.15	239	554
Sri Lanka	67 300	21 273 000	3.15	0.59	52	1 294
Nepal	21 500	27 797 000	0.77	0.19		n.a.
Bhutan	7	754 000	0	0.00	78	0

India

There are 14 major and 44 medium sized river systems in India, along with innumerable smaller systems. Their combined length is about 195 210 km (FAO, 2006). Their basins contain floodplain lakes and wetlands, which are known variously as *mauns*, *chaurs*, *jheels* and *beels*. The total estimated area of natural wetlands is 5.31 million hectares and man-made wetlands add another 2.27 million hectares to this figure. This is a total area of 75 800 km^2 (Bassi *et al.*, 2014). These wetlands are arguably the most important environments for fish production, with river fisheries contributing relatively little to the total inland fishery production of India. Inland fish production in India (fish, crustaceans and molluscs) was 1 346 104 tonnes in 2015 (FAO estimated), and has shown a general increasing trend over the past 20 years from a 1995 production of 608 378 tonnes (FAO, 2017). There have been occasional (four) major increases and decreases during this period, and these are attributed to revision of catch statistics or the underlying assumptions on which they are based (see Lymer and Funge-Smith, 2009, for more discussion). This production is equivalent to just over 1 kg/capita/year contribution, however if vegetarian Indians (44 percent) are excluded, it is equivalent to 1.8 kg/capita/year. Although this contribution may appear modest, it should be understood in the context of the massive rural populations of India and the quality of their diets, which do not have considerable amounts of animal protein. Many of the Indian states are landlocked, thus although they are part of a single country, they are remote from the sea and marine sourced products are either hard to access or too expensive to purchase for the majority of their rural populations (Uttar Pradesh, Bihar, Jharkhand, Assam, Arunachal, Chattisgarh, Rajasthan, Madhya Pradesh, Punjab, Chandigargh, Meghalaya, Manipur, Mizoram). There are also states that have access to freshwater resources as well as marine fisheries, where inland fisheries are still important, e.g. Andhra Pradesh, Gujarat, Karnataka, Orissa, West Bengal, Tamil Nadu, Maharastra and Kerala.

There has been increasing attention in recent years to the prospects of enhancing the productivity of reservoir fisheries through stocking, recommended as early as 1995 (Sugunan, 1995). However, as a crude estimate, current productivity of all inland waters (annual production divided by the area of lakes and inland water wetlands) is 177 kg/ha/year, which is relatively productive (see discussion in van Zweiten *et al.*, 2011). The total production as a function of renewable surface water is 720 tonnes/km^3/yr, which is comparable with that of Bangladesh.

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Bangladesh

Bangladesh is situated in the giant delta formed by the outlet of the combined rivers Ganges Brahmaputra and Meghna and wetlands of many different types are a dominant feature of the geography. Rahman (1989) mentions 10 300 km^2 of rivers, canals and estuaries, 1 142 km^2 natural depressions (*beels* and *haors*), 1 619 km^2 of ponds and tanks, 55 km^2 of oxbow lakes, Kaptai Lake (the Karnafuli reservoir) with 688 km^2, 28 000 km^2 floodplains and 873 km^2 of brackishwater farms.

Bangladesh is one of the world's largest producers of inland fish and has reported its inland catches almost without exception since 1950. The country has been experiencing increasing catches since 2012, with the highest catch on record in 2009 (FishStatJ). In 2015, the landed volume was 1 023 991 tonnes corresponding to 63 percent of combined inland and marine catches and roughly 50 percent of aquaculture production. Of the total landings, 51 717 tonnes were crustaceans and 135 396 hilsa shad (13 percent), the rest is reported as nei (FishStatJ). However, according to FRSS (2017), about 11 percent are Indian major carps, 7 percent snakeheads, 7 percent sheatfish, 5 percent small catfishes and 4 percent exotic carps (mostly common carp).

The estimated total production derived from the household survey model (1 925 040 tonnes in 2009) is substantially higher than the production reported for that year (1 119 094 tonnes) (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This may indicate that statistics are underestimated, however it is also possible that there is confusion about the production from culture-based aquaculture and true inland fisheries, as the species are often the same. No matter what figure is correct, the country has the highest per capita fish consumption in the reigon and fish is an important contributor to the Bangladeshi diet.

About 71 percent of the inland fishery landings come from floodplains, 17 percent from rivers, 9 percent from *beels*, 2 percent from the Sundarbans, and 1 percent from Kaptai Lake and *baors* (FRSS, 2017). Comparing statistics from 2012-2013 with 2015-2016 the production from all environments has increased (river fisheries by 21 percent, Sundarbans (6 percent), *beels* (9 percent), Kaptai Lake (6 percent), floodplains (7 percent) and *baors* (26 percent) (FRSS, 2014 and FRSS, 2017).

The recent increase in catches to a large extent is because of improved catches of hilsa, which are up 6 percent since 2014 and more than a doubling of the inland catch since the low point at the beginning of the 2000s. This could be the result of improved management practices of the hilsa fisheries. Since 2003, the Bangladeshi Government, in attempt to arrest declining catches, has put several protection and conservation measures in place, including the closure of some areas to fishing, restrictions on fishing gear, a closed season and regulations for fishing vessels. Fishers are given incentives during the closed season in the form of food and alternative income generation (Islam, Mohammed and Ali, 2016). Hilsa is an anadromous species and roughly two-thirds of the hilsa are caught in the sea. The management measures put in place seem to have had a positive impact on marine hilsa catches almost immediately, as they have shown a constant increase since 2003 until they reached a peak in 2014, after which there was a 2 percent decline in 2015. However, the disruption of longitudinal connectivity after the construction of barrages is also thought to have affected the species negatively.

Among other species, the Indian major carps are doing better in all environments (apart from Kaptai Lake where there appears to be a problem with reporting at the species level as all species except "others" are in decline) (FRSS, 2017). Since the major carps are migratory this could be an indication of improved lateral connectivity, however, since the introduced Chinese carps are also doing well in most environments it is probably a result of the government's open water stocking programmes.

There are concerns regarding the conservation status of some of the small indigenous barbs (*Puntius* spp.) (Mian *et al*., 2013), but this is not reflected in the catch statistics except in rivers where the species has almost disappeared. The reason for this is likely an issue of identification and particularly the lumping of indigenous and introduced barbs in the statistics. Catches of the migratory *Pangasius* catfishes are also improving, but it is not clear if this is the indigenous *Pangasius pangasius* species or the introduced *Pangasianodon hypophthalmus*.

For other species it is more difficult to interpret the trends, especially since there are no species level detail in reports to FAO. Already in 1985 more than 8 100 km^2 of floodplain was lost, and another 20 000 km^2 was predicted to disappear by 2005 (MPO cited by Parveen and Faisal, 2003). Between 2003 and 2014 Bangladesh lost 1 600 km^2 of fish habitat as a result of flood control, water drainage and construction of dams and barrages etc. and at the same time 3 500 km^2 of waterbodies was allocated to culture-based fisheries as part of a national policy to increase availability of fish (Shamsuzzaman *et al*., 2017). Although this, in some cases, has the potential to increase fish production, there are serious concerns regarding the distribution of benefits (Valbo-Jorgensen and Thompson, 2007).

Loss of lateral and longitudinal connectivity as well as pollution with chemicals, pesticides and fertilizers are other threats to inland fisheries (Ministry of Fisheries and Livestock, 1998; Parveen and Faisal, 2003). Although it is possible that the government has succeeded in reversing these trends, there are other possibilities including rainfall and flooding patterns that may have contributed to this. However, the number of years with an increase is too short, and the species level information not sufficient to make conclusions at this stage. Further, the sampling frame used for the collection of statistics has not been redefined since 1985, which may lead to inaccuracies in the production estimates (FRSS, 2017).

About 1.2 million people are engaged full time and another 10.2 million are engaged part time in the fisheries sector for their livelihoods (Ministry of Fisheries and Livestock, 1998). This represents about 10 percent of the total labour force active in the sector, and an estimated three-quarters of the population (90 million people) engage in fishing activities occasionally (Shankar, Halls and Barr, 2004). Most of these people appear to depend on inland fisheries resources, as 60 to 70 million people own less than 0.2 ha of land and live in floodplains (Shankar, Halls and Barr, 2004).

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Pakistan

Freshwater capture fisheries are dominated by the Indus River basin, which has a total area of 1.2 million km^2 (Qamer *et al*., 2009) with a 9 700 km^2 floodplain. The fish fauna of the Indus system in its northern part is cold-water type, whereas the greater middle and southern parts of the system are warm-water fisheries zones. In the Sindh Province alone there are more than 100 natural lakes of different sizes covering an area of about 1 000 km^2. Among them, Lakes Halijee (18 km^2), Kinjhar (120 km^2)

and Manchar (160 km^2) are quite important for fish production. Apart from these big lakes, a cluster of small lakes called Bakar Lake extends over 400 km^2. The natural lakes in Punjab cover about 70 km^2.

Six large reservoirs have been created in the past four decades through the construction of dams and barrages across rivers, which provide about 2 500 km^2 for fish production. The largest reservoir is the 400 km^2 Chashma on the Indus itself, the other large reservoirs are the Tarbela and Mangla (respectively 271 km^2 and 267 km^2). In addition, there are several smaller reservoirs and the irrigation system of Pakistan is one of the largest in the world, serving 144 000 km^2 of irrigated land with 58 500 km main canals and 1.6 million km^2 ditches (Akhtar, 2003; FAO, 2009).

Pakistan reported landings of 132 456 tonnes from inland fisheries in 2015 and has experienced continuous growth since 2003. The maximum reported catch was reached in 1999 with 179 865 tonnes. The large artificial waterbodies remain the major source of fish production and about 25 percent comes from the six major reservoirs. Catches from natural lakes are generally of secondary importance. Coldwater streams and rivers have low production, although they may be important for local subsistence fishing and have considerable potential for recreational fisheries (Akhtar, 1995; Akhtar, 2003).

Pakistan has never reported any species detail regarding fish landings, with everything reported as nei (FishStatJ). Akhtar (2003) mentions that there are about 30 commercial species including Indian major carps, snakeheads, catfishes, sheatfish, featherback and others as well as exotic species including tilapias, Chinese carps, common carp and trouts. Hilsa used to be an important species, however, the construction of barrages has prevented it from reaching its spawning sites in the Indus (George, 1992). A similar situation has occurred with the large Mahseer (Akhtar, 2003).

Fisheries authorities are poorly equipped to manage fisheries. Fishing rights are traditionally auctioned and although certain management measures are in place, there is little enforcement of the management and information related to catches is poor (Akhtar, 2003). Short leases leave little incentive to apply good management practices, and although stocking is sometimes undertaken it is carried out without a scientific basis or a stocking protocol and without adequate monitoring or follow-up, and this has frequently led to failures (George, 1992; Akhtar, 2003).

At present, riverine fishery resources are considered harvested close to their potential (Akhtar, 1995). However, flow regulations and deforestation have led to habitat degradation and pollution with pesticides is a serious issue (Akhtar, 1995; Schmidt, 2014) as well as discharge of raw sewage near Karachi, and wetlands are lost because of land reclamation (Schmidt, 2014). Although reservoirs and irrigation infrastructure have considerable fisheries potential, fishers are not considered to be important user group and therefore they are not managed to benefit fishers (Akhtar, 2003; Schmidt, 2014).

The Pakistanis in general are not big consumers of fish, but fish does provide an important food component in some areas. Poor handling practices and inadequate infrastructure are responsible for post-harvest losses of 20 percent from river fisheries (Akhtar, 2003). In 2014, there were an estimated 211 609 inland fishers (some of these working only part time). This means that more than 50 percent of all fishers in the country are employed in inland fisheries (FAO, 2017).

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Sri Lanka

Sri Lanka does not have significant renewable surface freshwater resources (52 km^3/yr), but has a historic system of water storage that considerably increases the productive potential of the country (Table 2-3). There are few large rivers and floodplains. The medium sized Sri-Lankan reservoirs and small irrigation tanks are highly productive, with catches sometimes well above 200 kg/ha/yr (Kolding and van Zwieten, 2006; Pushpalatha and Chandrasoma, 2010; Amarasinghe, 2013), often achieved through stocking. In seasonal irrigation tanks that drain or dry out completely on an annual basis, restocking is practiced (culture-based fisheries) and this is currently being promoted under government and community-based programmes (Amarasinghe, 2013).

Table 2-3: Type and area of Sri Lankan inland waterbodies

Type of waterbody	**Area (ha)**
Large reservoirs	70 850
Medium reservoirs	17 004
Minor reservoirs	39 271
Seasonal tanks	100 000
Flood lakes and villus	4 049
Upland reservoirs	8 097
Mahaweli reservoirs	22 670
Total	**261 941**

Reported production in 2015 was 67 300 tonnes declining slightly from 2014, but overall there has been a rapid rise in production from 25 570 tonnes in 1991 until the present. Tilapia comprises 60 percent of the production. In 2006-07, FAO recorded inland fish production of 35 290 tonnes, but the consumption survey model indicates this could have been as much as 42 986 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018) suggesting about 22 percent underestimation.

The inland capture fishery production as a function of the renewable surface water resource is the highest in the South Asian subregion (1 457 tonnes/km^3/yr**)** and highest overall in Asia, surpassing Myanmar and Cambodia. This is a clear indication of the efficiency of inland fish production from Sri Lanka's inland reservoirs and small irrigation tanks. It is also an indication of how well tilapia is suited to medium and small reservoirs and irrigation tank systems.

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Nepal

Nepal has approximately 17 percent of flat land located in the southern end of the country commonly known as *terai*, and in the northern part, 83 percent is occupied by hills and mountains. The climate ranges from sub-tropical (<1 000 metres above sea level to alpine/arctic at high altitude (>5 000 metres above sea level). Nepal possesses a large number of rivers fed with perennial supplies of water from melting snow from the Himalayas. It also has a considerable amount of smaller lakes as well as a large number of reservoirs.

Inland capture fisheries in Nepal are exclusively small scale, with fishers using traditional gear mainly for subsistence fishing. Fishing also takes place in irrigated paddy fields and marginal swamp areas, (410 000 ha). There are approximately 1 500 ha of man-made reservoirs. The planned construction of hydro-electric plants and irrigation projects is likely to increase the number of waterbodies in the future.

According to official statistics, 11 320 tonnes of fish were produced from capture fishing in the fiscal year 1995/96. FAO currently records 21 500 tonnes.

In the early 1990s, there was relatively little fish in the Nepalese diet, but recently the amount of fish protein in common people's diets is increasing. This suggests that the fish production, availability, affordability, purchasing capacity and awareness might have led to the increased consumption. Various aquatic products other than fish are consumed in different parts of the country. Including pila (*Pila globosa*), bivalve (*Lammelidens marginelis*), crabs, shrimp, frogs (*Paa liebigii, Paa blanfordii*), turtle, Makhan (*Euryale ferox*) (Gurung, 2016).

The household consumption model indicates that the inland fish catch of 42 584 tonnes (2003) is considerably higher than the reported catch for the same year (18 888 tonnes). This may indicate that more inland fishery resources are exploited than has been estimated, but it almost certainly also indicates that there is a degree of unrecorded trade with neighbouring India as the imports recorded in the model are extremely low (only 4 tonnes). This is a similar situation to Bhutan. The freshwater fish consumption based on the household consumption survey is 1.7 kg per capita per year. Little exact information is available on fish trade. However, there is a relatively important activity taking place on the Indo-Nepalese border, and it appears that considerably more fish is being imported than exported, transported by trucks and to some extent on public buses. In addition, some imports to Kathmandu are carried out by airfreight from Calcutta (India).

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Bhutan

The Kingdom of Bhutan has five major river systems from west to east (Amo, Wang, Chang (Sankosh), Tongsa and Manas) with the total length of rivers and their tributaries estimated to be about 7 200 km. Bhutan has over 590 natural lakes of various sizes, the majority of them being small and located above an altitude of 2 200 m. The estimated total area of these lakes is about 4 250 ha. There is one man-made reservoir in Bhutan (Chukha) with an area of 150 ha. With current interest in hydropower developments, more man-made waterbodies are to be expected in the near future (Funge-Smith, 2013). Access to fish for food in Bhutan has traditionally come from the wild riverine and lake fisheries of the country and via imports from neighbouring India. The level of production in the country is hard to estimate, since one of the results of the general ban on fishing in 1974, enacted in 1995 (excluding permitted fishing), means that illegal catches are undeclared. Capture fishery production currently reported to FAO is 7 tonnes (FishStatJ 2015). The lack of knowledge of the true production from freshwaters limits estimation of the actual national demand, although this has been estimated in previous FAO reports up to 150 tonnes (FishStatJ). Fish caught locally may be marketed, but generally the fish in markets will be imported fish from India. Import of fish is reported at 4 652 tonnes per year and this comprises a mixture of fresh fish (predominantly Indian major carp and *Pangasius hypothalamus*) and dried fish (comprising a mixture of freshwater and marine species) (Department of Revenue and Customs, 2014).

The household survey inferred consumption model indicates that inland capture fishery production in Bhutan might be as high as 1 772 tonnes, although unrecorded/hidden imports may constitute part of this figure (Fluet-Chouinard, Funge-Smith and McIntyre, 2018) as there is trade between Bhutan and neighbouring India.

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2.2.3 CHINA

FAO Map disclaimer: Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
China	2 280 959	1 385 567 000	1.67	19.89	2 739	833
Taiwan POC	106	23 330 000	0	0.00	n.a.	n.a.
China, Hong Kong SAR	0	7 204 000	0	0.00	n.a.	n.a.
China, Macao SAR	0	566 000	0	0.00	n.a.	n.a.

Note: This review does not include the culture-based fisheries and rice-fish production of China, which are considerable, but which are more correctly accounted for under aquaculture production.

China has rich surface water resources that include over 20 000 rivers with drainage catchments of 100 km^2 or more. Of these, 228 have drainage basins exceeding 1 000 km^2 (Ministry of Water Resources and Power, 2012). The main resources are based on several large river systems, including the Yangtze River (Chang Jiang), Tarim, Yellow River (Huang He), Pearl River (Xun Jiang) and Bei Jiang/His Rivers. The Yangtze River and rivers to the south of it carry 82 percent of the total runoff of Chinese rivers. China also has numerous natural lakes and waterbodies, as well as rice fields. China has more than 22 104 dams over the height of 15 metres with 85 000 reservoirs of varying size.

Four provinces, namely Jiangsu, Anhui, Jiangxi and Hubei, have the highest catches, accounting for more than half of the total freshwater catches, followed by catches from Shandong, Hunan, Guangdong, Guangxi, Hebei, Zhejiang, Fujian, Heilongjiang. The catches from all these provinces account for about 80 percent of the total national freshwater capture production (Zhao, Gozlan and Zhang, 2015).

These resources are all located in mainland China. Taiwan Province of China reports 100 tonnes of inland capture production, and China, Macao SAR and China, Hong Kong SAR do not report any inland capture production.

Under increasing pressures to intensify and increase production from inland waters, China embarked on a range of interventions in its inland waters, including stock enhancement and repeated stocking and even fertilization. Starting in the 1950s until at least a decade ago, the impact on inland capture fisheries and culture-based fisheries of China has massively increased productivity in waterbodies, but at the same time there were serious declines and impacts on riverine fisheries.

The intensification of fisheries also coincided with China's development of irrigation and hydropower. The country's dams account for about 50 percent of the total number of dams globally (Zhao, Gozlan and Zhang, 2015). Degradation of inland water resources damming and loss of flow and connectivity as well as overfishing has impacted all forms of inland fishery (wild capture and culture-based). This is most severe and potentially permanent in the case of riverine fisheries. The decline of the riverine catches of all species, but particularly migratory species, is recorded (Zhao, Gozlan and Zhang, 2015).

There has been a history of translocations and introductions of non-native species into waterbodies throughout the country and this has resulted in their establishment and the consequent decline in indigenous species in those waterbodies (Kang, Huang, Li, Liu, Guo and Han, 2017; Zheng (cited in Zhao, Gozlan and Zhang, 2015). Targeting of broodstock fish is also considered a driver in the decline of a number of species (Yu and Chen cited in Zhao, Gozlan and Zhang, 2015). Fishing effects have been observed in the form of declining size ranges of commercial fish species.

The trend in inland capture fisheries of China is now one of relative stability after a period of steady growth from the mid-1970s until it slowed in the late 1990s. Catch has been relatively stable since 2007 at about 2 280 959 tonnes (2015). This does not indicate the gains and losses in individual fisheries and systems. In 2012, the State Council's *Decisions on Strict Water Resources Management* established the concept of the "Three Red Lines" and this required effort to be directed at improvement of water use and the restoration of water quality. However, this policy does not explicitly address the restoration of aquatic ecosystems and associated biodiversity affected by impacts on water. It also does not focus on the restoration of river flows and the impacts of flow alterations by water management infrastructure (e.g. dams, reservoirs, polders, river training, flood control measures) (Global Environment Facility, 2014).

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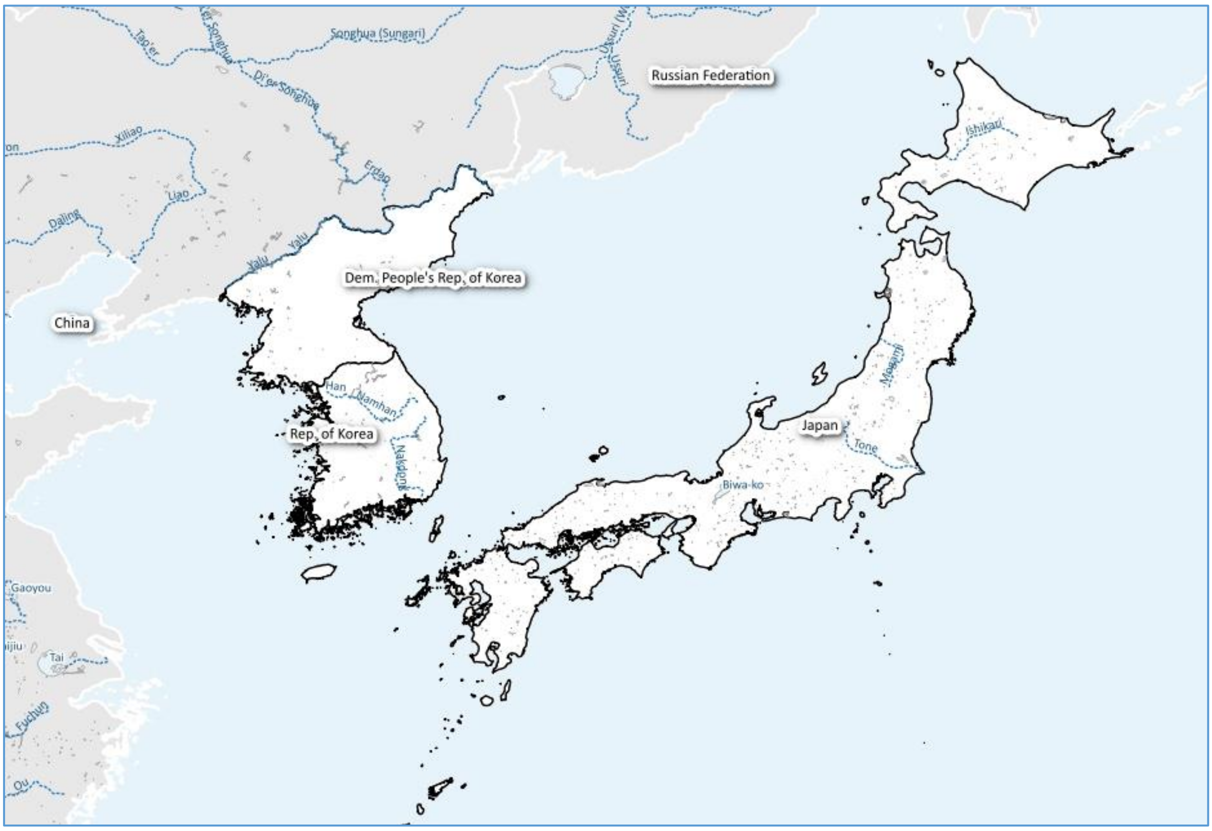
2.2.4 EAST ASIA



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water ($tonnes/km^3/yr$)
Japan	32 868	127 144 000	0.27	0.29	420	78
Republic of Korea	9 133	49 263 000	0.15	0.08	67	136
Dem. People's Republic of Korea	5 200	24 895 000	0.2	0.05	76	68

Japan

Inland fisheries are dominated by salmonids and ayu sweetfish, together with eel, pond smelt and carp species (Katano, Hakoyama and Matsuzaki, 2015). Japanese inland fishery production decreased from 94 282 tonnes in 1996, to a stable, but much lower level (34 2621 tonnes) in 2011. This is attributed to a combination of factors including disease and invasive species. Enhancement of inland water for recreational fisheries takes place and there is some indication that the retained recreational capture of fish accounts for more than 12 000 tonnes (Cooke *et al.*, 2017).

The Hokkaido Island chum salmon marine fishery is the highest volume chum fishery in the world. It produces over 100 000 tonnes of chum salmon, but relies almost exclusively on hatchery production for the smolts. This is because of the degradation of riverine spawning environments and loss of connectivity with approximately 27 percent of the total spawning area of Hokkaido Island inaccessible from the sea because of damming.

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Republic of Korea

The total area of inland waters is approximately 5 700 km^2 (National Geographic Information Institute of the Republic of Korea, cited by Park, 2010). The ten major rivers have a combined length of 3 413 km, the longest river is the Makdong, which is 1 348 km long (Yeong, 1976). The five largest river basins have a total of 27 484 km of streams (Kwater cited by Yoon *et al.*, 2015). However, almost all rivers and streams have now been dammed or regulated and the country has over 18 000 reservoirs (Card, 2009), and in the five major basins there are 33 718 weirs (Yoon *et al*., 2015).

Republic of Korea has reported on their inland fisheries to FAO every year since 1950. In 2015 landings were reported at 9 133 tonnes (FishStatJ). There have been some fluctuations with the minimum in in 2002 being 5 690 tonnes. In the 1980s up to 51 934 tonnes were reported.

The most important species are Japanese corbicula and common carp. However, almost half of the production is not identified at species or genus level (FishStatJ). Only 103 tonnes of salmonids that historically were very important were landed in 2015 (FishStatJ; Park and Hong, 2013).

Water pollution, overfishing, habitat destruction and mismanagement of fisheries resources are thought to have resulted in the decrease in commercial capture fisheries (Park, 2010). Also, water management practices appear to have had a seriously negative impact on migratory freshwater resources (Card, 2009; Yoon *et al*., 2015), and there are now attempts to install fish ladders around many weirs (Yoon *et al*., 2015) and the stocking programme of chum salmon is being expanded (Park and Hong, 2013).

Fish and seafood have always been an important part of the Korean diet and although this has mainly relied on marine products, crucian carp and black bass were introduced in the 1970s to feed the population (Park, 2010). However, the Korean population never got used to the taste of many of the introduced species, and it was also realized that several species had negative ecological impacts and were therefore declared invasive. Enhancement programmes thus turned towards indigenous species (Park, 2010). Today the demand for freshwater species as food is largely met by aquaculture, whereas stocked and naturally reproducing fish are mostly targeted by the growing recreational fisheries sector (Park, 2010; Hart, 2016). There are 30 000 recreational bass fishers in the Republic of Korea (Hart, 2008).

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Democratic People's Republic of Korea

The country's aquatic ecosystems comprise wetlands around tidal flats including lagoons, river estuaries, lakes, alpine wetlands, reservoirs and paddies (UNEP, 2003). FAO (2010) mentions a total of 1 300 km^2 of waterbodies. The Democratic People's Republic of Korea (2005) has identified 100 natural lakes and 1 700 reservoirs.

Most of the country's rivers are short and their basins small. The major river basins are shared with neighbouring countries and in several cases form a natural border. Most of the rivers rise in the mountain ranges of the north and east of the country and run west to the Yellow Sea. There are five river basin groups:

- the Yalu River flows southwest from the Changbai mountain range to the Korea Bay;
- the Tumen River which flows east from the Changbai mountain range to the Sea of Japan;
- the Taedong River basin is internal and is the largest one within the country. The Taedong River flows west to the Korea Bay near Pyongyang; and
- the east coast and west coast river watersheds comprising many small streams rising in the northern and eastern mountain ranges (FAO AQUASTAT, 2012).

Reporting by the Democratic People's Republic of Korea on inland fisheries to FAO has been very irregular, and FAO has estimated catches since the last report in 2001 when 4 928 tonnes were landed. Those landings represented a serious decline since the previous reports of 20 000 tonnes/year from 1994 to 1997. In the period 1961 to 1996, FAO has estimated catches of up to 60 000 tonnes (1987). There is no indication of the composition of the catch in FishStatJ. However, historically chum salmon was an important resource during their spawning migration runs (Park and Hong, 2013).

The environmental conditions in the river basins are deteriorating because of pollution from industry and agriculture (UNEP, 2003).

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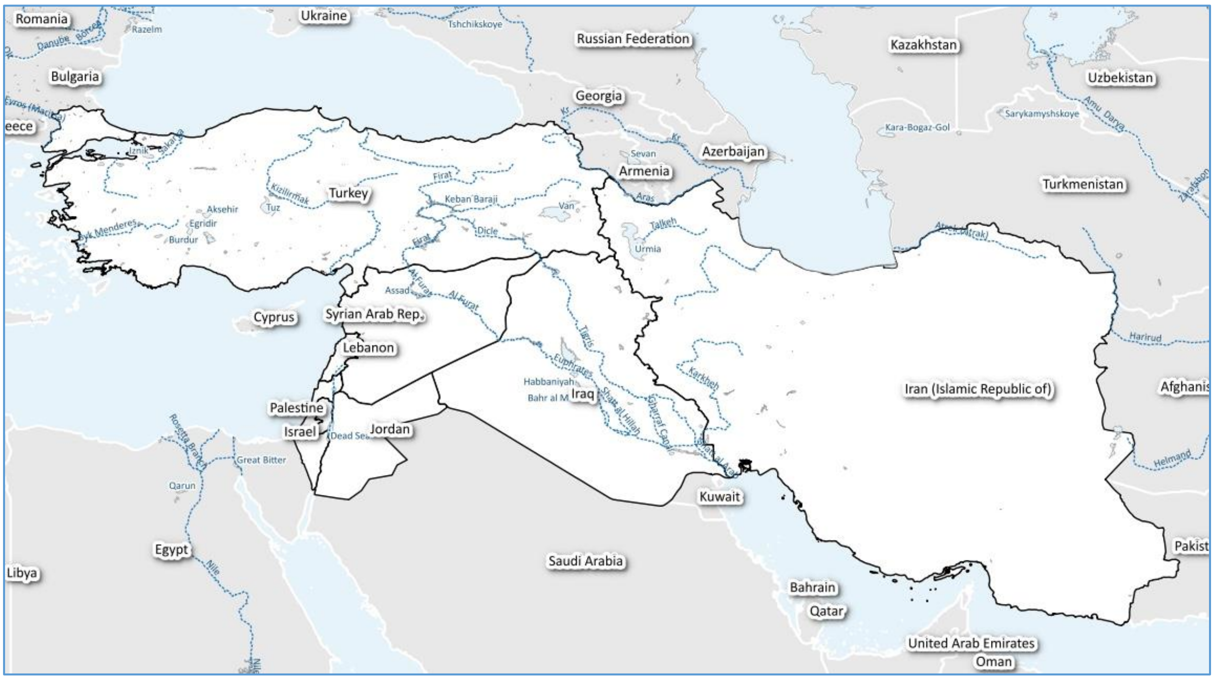
2.2.5 WESTERN ASIA



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Iran (Islamic Republic of)	88 047	77 447 000	1.11	0.77	106	*832
Turkey	34 176	74 933 000	0.47	0.30	172	199
Iraq	22 848	33 765 000	1.58	0.20	89	258
Syrian Arab Republic	2 400	21 898 000	0.13	0.02	13	190
Jordan	596	7 274 000	0.07	0.01	1	917
Israel	484	7 733 000	0.04	0.00	1	872
Lebanon	20	4 822 000	0.01	0.00	4	5
Palestine	0	4 326 000	0	0.00	0	0

*This figure for Iran IR is artificially high as the fish catch includes the Caspian Sea production, which is not included as renewable surface freshwater.

This region consists of countries that have mainly arid land and low rainfall. There are two important rivers, the Tigris and Euphrates. This region also includes part of the Caspian Sea. Catches in the West Asian area are heavily dependent on cyprinids (37.5 percent), with clupeids (Caspian Sea kilka) playing a secondary role in 2009 at 18.5 percent. In 1998, clupeids contributed 40 percent of the catch versus 32 percent of cyprinids, which provides further witness to the collapse of the Clupeonella stocks over the last decade.

The Islamic Republic of Iran

There are two main fisheries in Iran, the northern fishery (the Caspian Sea); and the inland fishery. Gilan and Mazandaran Provinces on the Caspian Sea are at present the most important provinces in the country for inland fisheries production. This is largely because of the high rainfall resulting in the presence of a considerable number of permanent freshwater bodies. There are more than 588 reservoirs, many rivers (the largest is the Karun), several lagoons and lakes. Sturgeon and semi-migratory fish enter rivers and lagoons connected with the Caspian Sea, for spawning and feeding. The presence of marsh-type aquatic vegetation in some lagoons and in the Gorgan River discharge area is of considerable importance for fish. Gilan Province has about 10 000 ha of inland waters, of which more than 90 percent is estimated to be available for the inland fishery. Mazandaran has some 13 000 ha, of which 40 percent is with permanent water, the rest drying out during the summer. River regulation and intensive fishery have also led to a decline in common carp stocks of the lower reaches of Iranian rivers and in some lagoons of the Caspian Sea basin (FAO, 1987). This also impacts sturgeon migrations, and possibly the Caspian trout, which is in serious decline as a result of illegal fishing activities. It has been demonstrated that the fecundity and size of the Caspian trout at maturity is decreasing possibly as a result of increasing water temperatures (Niksirat and Abdoli, 2009).

Inland fish catches are largely driven by the catches from the Caspian Sea in the Islamic Republic of Iran and these peaked in 1999 (146 000 tonnes). They collapsed to less than half by 2003, and have been recovering since, reaching 88 047 tonnes in 2015. The decline of the Iranian fishery corresponded to a general decline in the clupeoid group (mostly *Clupeonella*) in the Caspian Sea fishery.

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Turkey

Turkey's inland resources are varied in terms of water quality, trophic status, altitude, climate, ecosystem diversity and species diversity. The total area of inland waters is 17 000 km^2. Turkey possesses 6 000 km^2 of lakes and reservoirs on which 3 149 licensed fishing boats were engaged in fishing activities in 2009. The Lake of Van, Atatürk and Keban dam reservoirs are the major fishing grounds in Eastern Turkey with significant contributions to inland capture fisheries. Most of the inland capture fisheries catch is landed by cooperatives in Mediterranean, Eastern and Central Anatolia regions (Rad and Rad, 2012). Productivity (catch per unit area) varies between 9.4 and 27.2 kg/ha depending on the size of the reservoir (Tüfek cited in Rad and Rad, 2012). In 2006, there were 7 670 licensed fishers working on inland waters (Mitchell, Vanberg and Sipponen, 2010).

A range of issues impact inland fisheries including water quality and water management problems, sand mining, flood, erosion, pollution, habitat degradation, draining of wetlands, conflicts between water users, illegal fishing, overfishing and exotic species (Yerli, 2015).

The inland catch of Turkey was 54 500 tonnes in 1999 and has been slowly declining to the current level of 34 176 tonnes in 2015. There is evidence of the increasing economic importance of aquaculture and consequent changes in market dynamics for freshwater aquatic products in Turkey, which is leading to a diminished role for inland capture fisheries (Rad and Rad, 2012).

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Iraq

Iraq's inland fishery is based on the Tigris-Euphrates riverine system, which is the main source of inland fresh water in Iraq. This system has extensive lake and marsh resources and floods seasonally. Catches were fairly stable in Iraq until the southern marshes were drained, but the fishery has apparently recovered after the partial refilling of the wetlands. The seasonal flooded area is 15 000 to 20 000 km^2. Inland freshwater bodies cover between 600 000 and 700 000 ha, made up of natural lakes (39 percent), dams and reservoirs (13.3 percent), rivers and their branches (3.7 percent) and marshes (44 percent). The mean production from these waterbodies for 1981 to 1997 was 18 800 tonnes per year, compared to an estimated 8 000 tonnes in 2001. Previous estimates of annual sustainable production from inland waters have been put at 30 000 tonnes although this is unlikely to be achievable given the environmental changes that have taken place (FAO, 2014). The inland fisheries are principally based on carps (*Cyprinus* spp.) and the indigenous barbs species (*Barbus* spp.). There are some estuarine species (e.g. Liza) in the lower reaches.

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The Syrian Arab Republic

Syrian inland fisheries take place in reservoirs and waterbodies throughout the Tigris-Euphrates basin in North and Northeastern Syria. The fishery sector plays a minor role in the Syrian economy, not only because of the scarcity of resources and the low natural productivity of fishing grounds, but also because of technical, administrative and legal constraints. The reporting on licensing, fishing activity, catches, species, fish markets and prices has become infrequent and the data currently received is probably unreliable. There is some evidence that there are many new entrants to the fishery sector as an opportunistic coping mechanism. This increasing number of fishers, together with the lack of controls on inland fishing activity means that IUU fishing on inland waters is prevalent and there is a likely scenario of overfishing and the use of banned fishing practices/gears. The availability of inland wild fish has considerably decreased in the fish markets of Damascus, but availability has increased in all other major cities, each of which is in the vicinity of one or more inland fishing areas.

Jordan

There are no natural lakes and most of the rivers in the country are seasonal. Most of the streams and large springs are in a limited area of the north and northwestern part of the country and primarily belong to the Jordan River system. A few belong to the water system of the Dead Sea. The Jordan River system has about 470 ha of water surface (in 1967) (FAO, 1967).

The country has ten reservoirs with a total storage capacity of 326 million cubic metres. Irrigated agriculture in Jordan is the largest user of water, consuming 60 percent of the total. The usage is derived from 50 percent of renewable groundwater and 90 percent of treated wastewater.

A total of 15 endemic freshwater fish species have been identified in the inland waters of Jordan (Hamidan, 2004). A number of non-native species have been introduced into the inland waters of Jordan primarily for aquaculture, but some have also been released into open waters. The common carp (*Cyprinus carpio*), and *Oreochromis aureus* were the most introduced species. Other species include:

Acanthobrama lissneri, *Clarias gariepinus* and *Coptodon zillii*, *Oreochromis niloticus* and *Mugil cephalus*. *Oreochromis aureus* is considered to have the highest impact on local endemic freshwater fishes, (e.g. *Aphanius sirhani* and *Garra ghorensis*, *Aphanius dispar richardsoni*). This is mainly because of competition for breeding sites and predation of eggs and young stages (Khoury *et al*., 2012).

Inland fishery resources in Jordan are limited, with annual production reported to FAO (2014) of 596 tonnes. The fishery resources are in the mainstream of the river Jordan and the country's reservoirs. Ziglab irrigation reservoir was stocked with carp and tilapia fingerlings starting in 1966 (FAO, 1973). *Clarias gariepinus* is the most common species in the King Talal, Sharhabeel dam (also known as the Ziglab dam), and in the Karameh and Wadi Al Arab dams. All these fish populations may have originated from the Jordan River basin (Khoury *et al*., 2012).

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Israel

Israel has a total area of 21 060 km², with inland waterbodies occupying 440 km² (FAO, 2007). Commercial freshwater fishing (purse seine and gillnets) occurs in Lake Kinneret (also known as the Sea of Galilee or Lake Tiberias) (Dill and Bentuvia, 1988). This is the sole freshwater body in Israel (FAO, 2007). In 2005, three purse seiners and about 68 small boats (<11 m) with gill and/or trammel nets operated in Lake Kinneret (FAO, 2007). In 2005, the commercial catch in Lake Kinneret was 1 396 tonnes and this was considered the maximum sustainable yield. Fishery management measures imposed have capped capacity (fishing licenses) and reduced fishing effort (three-month fishing ban) (Mitchell, Vanberg and Sipponen, 2010). The catch has now declined to 484 tonnes (2015).

The principal species that are caught are cichlid species (*Sarotherodon galilaeus* is the highest catch amounting to 308 tonnes) followed by *Oreochromis aureus* (7 tonnes). Carp species contribute 89 tonnes mainly from silver carp (*Hypophthalmichthys molitrix*) (65 tonnes) and common carp (11 tonnes). The *Acanthobrama terraesanctae* (Kenneret barb) catch is 37 tonnes and mullets comprise 42 tonnes.

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Lebanon

There was a small fishery of 18 vessels fishing around the inner lake of Qaraoun in Bekaa Valley in 2005. The majority were wooden (*flouka*) vessels some of which have inboard engines and the others were unpowered. The vessels land their catch along the lakeshore near their respective villages. All vessels use trammel nets and are operated year round. The target species are carp and catfish. There are 27 species of freshwater fish identified in Fishbase). Fish are sold fresh and not processed (Majdalani, 2005). The reported catch reached a peak in 2003 at 285 tonnes. FAO has estimated catch since 2007 and this is now only 20 tonnes.

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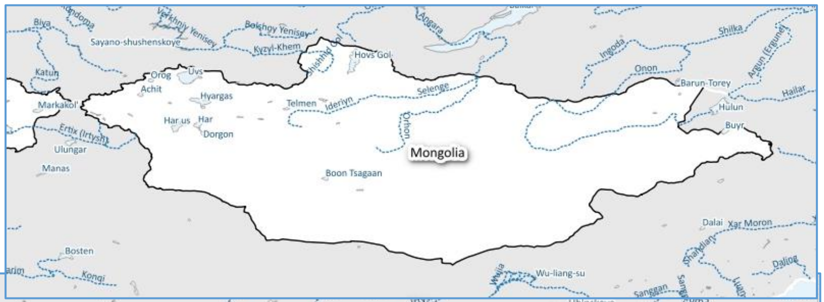
Palestine

There has been no inland fishery catch reported to FAO.

2.2.6 CENTRAL ASIA



FAO Map disclaimer: Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties.

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Kazakhstan	41 489	16 441 000	2.11	0.31	100.6	369
Uzbekistan	22 954	28 934 000	0.54	0.19	42.07	535
Turkmenistan	15 000	5 240 000	2.86	0.13	24.36	616
Armenia	8 140	2 977 000	1.35	0.04	4.858	987
Tajikistan	1 176	8 208 000	0.14	0.01	18.91	62
Afghanistan	1 000	30 552 000	0.03	0.01	55.68	18
Azerbaijan	568	9 413 000	0.08	0.01	32.52	27
Kyrgyzstan	63	5 548 000	0.02	0	21.15	11
Mongolia	31	2 839 000	0.02	0	32.7	1
Georgia	20	4 341 000	0	0	62.1	0

Kazakhstan

The larger part of the Caspian Sea (371 000 km^2) and part of the Aral Sea (historically 67 000 km^2) lie in the territory of the former Kazakh Soviet Socialist Republic, as do an estimated 48 000 lakes (3 041 of which have a surface area greater than one square kilometre), although a number of them dry up in the hot summer period. The most important lakes are Lake Balkhash (17 000 km^2), Alakol, or (more properly) the Alakol lake system (3 700 km^2), consisting of four large lakes (Sasykkol, Koshkarol, Alakol and Zhalanashkol), and Lake Tengiz (1 382 km^2). As a result of agricultural irrigation programmes in the 1960s where water flowing to the endorheic Aral Sea was diverted, evaporation exceeded inflow and the lake decreased significantly in both depth (from 15 m to 8 m) and area (60 percent) and salinity increased from 10 ppt to 35 ppt by 1990, with serious consequences for the fishery (Small *et al*., 2001). Man-made waterbodies include 475 reservoirs, the most prominent being the Bukhtarma, Kapchagay and Shardara reservoirs. The major reservoirs are in the south, where there are 75 reservoirs in total, with a combined volume of 95.5 km^3 and a surface area of over 10 000 km^2. The great majority of large reservoirs are multipurpose, providing hydropower and irrigation facilities, and their surface area and depth consequently fluctuate sharply over the year. They are also important sources of fish catch. The country also possesses more than 8 500 permanently or seasonally flowing rivers, but these are of limited importance for commercial fisheries, although a number are important for recreational fishing (including the Ural, Irtysh, Shelek, Tekes, Syr-Darya, Ili and Kigach). There are also more than 96 000 km of irrigation canals (Timirkhanov, *et al*., 2010).

Since 2001, when production hit a historic low of 22 960 tonnes, production has climbed to reach a reported 41 489 tonnes in 2015, with just over half sourced from the Ural-Caspian basin. However, current production levels lie well below historic levels, which were as high as 112 000 tonnes (1965). This decline is attributed to the collapse of the Aral Sea fishery, poor water management in the reservoir system, and overfishing in the Balkash and Alakol lake systems and the Caspian Sea. In the latter case, concerns have also been raised about the likely impact of the introduction in the early 2000s of the comb jelly (*Mnemiopsis leidyi*) on catches of the planktivorous kilka/sprat (*Clupeonella spp*), the mainstay of Caspian landings in recent years (Mitrofanov and Mamilov, 2015). Aquaculture production also dwindled sharply as a combination of reduced state funding, rising costs and recurrent water shortages that caused the majority of farms to close between 1995 and 2005. Indeed, the production figure in 2006 amounted to only 190 tonnes. Since then, there has been a recovery in aquaculture output to 471 tonnes in 2015, valued at USD 621 000.

Most authors acknowledge that the reported statistics do not reflect the considerable levels of catch that go unreported. Mitrofanov and Mamilov (2015) attribute this to the current state strategy of selling, under the auspices of the Kazakh Fisheries Research Institute (KazNIRKH), quotas on the basis of "one waterbody - one quota - one lot", thus monopolizing the fish catch in each waterbody. Excluded fishers therefore have little alternative but to fish illegally. The same authors go on to suggest that poaching has increased dramatically in the Caspian basin, where fishing is a traditional way of life for many people. Timirkhanov *et al*. (2010) estimate that illegal, unreported and unregistered (IUU) fishing is so widespread that perhaps less than one-third of fish production is reported. If World Bank (2004) estimates that there may be as many as 110 000 fishers compared to the 17 300 that appear in official reports are correct, then real production levels could be three to four times those currently reported to FAO.

The estimated inland fishery production using the survey-production model returned a figure of 91 267 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018), confirming that the scale of the hidden fishery is certainly considerably greater than official reports. The low levels of aquaculture production provide a degree of confidence that this result is largely attributable to inland fish production. The FAO apparent per capita freshwater fish consumption figure of 1.7 kg in 2013 is probably an underestimate, as it does not account for fish accessed through informal channels. If the adjusted figure is used, then per capita consumption of inland fish alone would be 5.5 kg per capita per year.

Although some 1 000 recreational fishers are officially registered as sport fishers, there are no data available about the total number of recreational fishers in the country. It is also not possible to estimate how many people fish in support of household food security. It is widely known however that such “subsistence” recreational fishing is conducted in all waterbodies of Kazakhstan where fish exist. This household fishing will also add to the overall hidden inland fishery catch of the country.

Notwithstanding the magnitude of IUU production, government estimates suggest that fish, crustacean and mollusc production has more than doubled in value from KZT 3 075 million (USD 9.85 million) in 2004 to KZT 8 367 million (USD 26.81 million) in 2013.

UN Comtrade data identifies Kazakhstan as the principal fish and crustacean product trading nation in the region over the period 2012 to 2016. Imports in this period totalled USD 297 million sourced from 53 nations, with the main trading partners being Norway, the Russian Federation and Viet Nam. Exports over the same period increased to USD 385.1 million (although, the value of fish products exported in both 2015 and 2016 was about USD 50 million – less than half the USD 104 million generated in 2012) and were distributed among 29 trading partners. The main destinations were Lithuania, Germany, Denmark, Russian Federation and Poland. As there are no specialized enterprises manufacturing nets and/or fishing vessels, all fishing equipment (as in most of the Central Asian countries) is imported.

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Uzbekistan

Historically, fisheries in Uzbekistan were centred on the Aral Sea and the Amu Darya river basin and peaked at about 25 000 tonnes in 1958. Subsequently, the construction of an extensive irrigation network saw water abstraction and salinity increase, the Aral Sea shrink and Uzbek catches from the Sea itself cease in 1983. The centre of fishing operations shifted to a group of about 20 lakes (970 km^2) in the Amu Darya delta, and the Aydar-Arnasay lake system (3 700 km^2) midway along the course of the Syr Darya River. These systems are complemented by a number of lakes (2 330 km^2) spread across the country, and 39 multipurpose reservoirs (3 310 km^2), of which the most important in fisheries terms are the Tudakul, Shorkul and Mezhdurechye reservoirs. Most of the country’s 600 rivers, save those in the mountains, are exploited for irrigation purposes, with riverine fishing activities both limited and concentrated on the Amu Darya, Syr Darya, Zarafshan and Kashkadarya. The irrigation canal network is extensive, and extends to about 150 000 km, but generates little fishing activity (Karimov *et al.*, 2009).

Since the demise of the Aral Sea fishery, inland capture fishery production never (until recently) exceeded 6 000 tonnes, with FAO reporting production as generally being in the region of 2 000 to 4 000 tonnes. In 2011, the inland capture estimate more than doubled to 8 513 tonnes, and since then has shot up to 22 954 tonnes (2015). The basis for this substantial revision in capture levels is not disclosed. Realization that such low levels of capture fishery production were insufficient to meet national needs led the Soviet state to establish a large-scale carp-centric programme of pond culture in the 1960s and 1970s covering 205 km^2. Initially under state control, these ponds were expected to annually produce 26 000 tonnes, but were producing less than 6 000 tonnes annually until 2010. Then too, reported aquaculture output increased sharply: from 8 772 tonnes in 2011 to 36 898 tonnes in 2015. Again, the reasons for the increase are not disclosed, although Thorpe and van Anrooy (2009) suggested that a FAO support programme, which included the identification of effective livelihood-supporting policy interventions, and an influx of new investors (such as Asia Agro Alliance, Tashinvest, NT Fish Farm [Tashkent] and Akva Tudakul) could see sharp increases in aquaculture output. In 2017 the Vietfish magazine reported that the Uzbek government had set up a joint venture with VINAFISH (Viet Nam) to support the development of fish farming, fish feed production, processing and distribution in Uzbekistan. The dramatic increase in aquaculture production had seen the revenues it generates increase from USD 3.9 million in 2000 to USD 83.5 million in 2015.

UN Comtrade data identifies Uzbekistan as a net importer of fish and crustaceans over the five-year period 2012 to 2016. Fish exports totalled just USD 1 390 000 in this period, going principally to Turkey and the United States, with lesser amounts being exported to five other countries. Imports over the same period were sourced from twenty countries and totalled USD 19 731 000. The principal suppliers included Norway, the Russian Federation and Kazakhstan.

Although Karimov *et al.* (2009) report the poaching of fish is widespread, this appears to be less of a problem in Uzbekistan where a combination of small waterbody size and a system of long-term regulatory leasing have combined to curb commercial poaching. Since 2003, (Decree No. 350), waterbodies are leased out to fishery enterprises on a rental agreement basis. Fish capture in reservoirs and lakes is carried out by fishery enterprises that conclude contractual rental agreements with local administrations for periods of ten years or more. These enterprises catch fish on a quota-free basis, but are required to take measures to conserve species and to maintain the productivity of waterbodies. One beneficiary of this was Akva Tdakul whose culture-based programme on the reservoir of the same name saw output rise from 170 tonnes to over 1 000 tonnes in the space of four years.

Recreational fishing in Uzbekistan is unregulated, although two national fishing and hunting societies exist. All citizens are entitled to fish in any waterbody across the republic that is not subject to protected area status or has been leased out to fishing enterprises or fish farms. Karimov *et al.* (2009) suggest fishing is not considered to be of major importance for household food security. This might seem to be true based on the low apparent fish consumption per capita in the country (0.5 kg per capita per year, FishstatJ).

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Turkmenistan

Turkmenistan has a 611 km coastline on the Caspian Sea and Turkmenbashi is the country's only industrial deep water fishing port. The country is dominated by the Karakum desert (284 900 km^2), which is one of the world's largest sand deserts. Turkmenistan's largest lake, Lake Kara-Bogaz (18 000 km^2), is a shallow lagoon separated from the Caspian Sea by a narrow strip of land. Its high salinity (35 percent, compared to surface salinity of up to 1.4 percent in the Caspian) places it on a par with the Dead Sea, and makes it uninhabitable to fish populations. Lake Sarygamysh (800 km^2), shared with Kazakhstan, is the only inland lake of note, and nine reservoirs offer limited fishing possibilities. The major rivers are the Amu Darya (which flows along the country's northeastern border before entering the Aral Sea), the Tejen and the Murgab (which originate in Afghanistan), and the Atrek (which originates in the Islamic Republic of Iran). No significant rivers originate in Turkmenistan. The

Karakum canal (1 400 km in length) draws its waters from the Amu Darya, and is the centrepiece of an extensive network of irrigation canals that stretches for just over 37 000 km.

The country's major fishery has historically been the Caspian kilka/sprat fishery, accounting for more than 98 percent of national landings. Production has dropped sharply from a peak of more than 50 000 tonnes during the Soviet era following the closure of the Soviet fishing cooperatives, and is now estimated at 15 000 tonnes. In 2014, three new fishing vessels (each with a GRT of 400) were introduced into the kilka fishery, although their impact on catches is not yet in evidence. Annual sturgeon catches throughout the Caspian declined from more than 25 000 tonnes in the 1970s to 470 tonnes in 2000, and sturgeon fishing in the Caspian Sea is now forbidden. The lack of domestically produced feedstuffs and reservoir siltation has also inhibited the development of the aquaculture sector, with production declining from 2 100 tonnes in 1991 to an estimated 30 tonnes (worth USD 84 000) per annum today. In early 2015, the country registered a new joint-stock company (Hazar Balyk) charged with setting up a new land-based sturgeon farm near Turkmenbashi designed to produce up to 60 tonnes of sturgeon annually.

UN Comtrade data identify Turkmenistan as having imported USD 19 068 000 worth of fish and crustacean products from 24 different countries over the five-year period 2012 to 2016. In 2012 the country imported USD 7 763 000 of fish products. The main Turkmen suppliers were the Russian Federation), Belarus and Turkey. Fish exports were only recorded in 2013 and 2014 with all of these exports going to the United Arab Emirates.

Fisheries access is controlled through the 1998 Provision on Protection of Fish Stocks and Regulation of Fishing in Territorial and Inland Waters. IUU fishing would appear to be extensive, with UNECE (2012) reporting that the amount of poached fish was "at least 10 to 13 times more*"* than the officially permitted fishing quotas. The Department of Protection of Flora and Fauna reported 653 instances of illegal fishing activity in 2010 for example, with a further 1 121 instances being reported within the country's protected areas. The same source also reported that there were no administrative penalties to punish certain infractions, such as in the case of the trade in illegally caught sturgeon, which was being sold openly in markets in Ashgabat.

The Society for Hunters and Fishermen is the official body for recreational fishers, and polices its own waterbodies. No indications as to the size of its membership are available however.

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Armenia

Armenia's principal fishery is based on Lake Sevan (1 256 km^2), the largest lake in the Caucasus region, which historically provided some 90 percent of the fish and 80 percent of the national crayfish catch. Another 17 lakes (covering 7 km^2) and 18 reservoirs (10.5 km^2) are of limited importance in the fisheries context. Although there are an estimated 9 480 rivers in the country, less than four percent are longer than 10 km and many dry up in the summer months. Riverine fisheries capture is negligible. There are also 310 km of irrigation canals in the country (Savvaitova and Petr, 1999).

Since the Sevan-Hrazdan hydropower cascade was completed in the 1930s, excessive water extraction saw Lake Sevan's volume dwindle by 44 percent, and the water level drop by over 19 metres. Attempts to raise water levels using the Arpa-Sevan (1980s) and Vorotan-Arpa (2004) tunnels have been partly successful, and between 2001 and 2013 the lake level rose by 3.9 metres and its volume by 5.5 billion m^3. Water abstraction and overfishing however had led to the collapse of the Sevan trout, khramulya and barbel fisheries by the mid-1970s, and in 1984 all three endemic species were placed on the Red Book of Armenia list. Ladoga and Lake Chud whitefish, introduced to the lake in the 1920s, ensured landings remained between 1 000 and 2 000 tonnes over the period 1935 to 1991. However, unrestrained fishing in the post-Soviet period saw the lake's whitefish population decline from 30 000 tonnes in the early 1990s to just 7 or 8 tonnes in 2012, and fishing bans were regularly introduced on the lake after 2002 (Yu, Cessti and Lee, 2015). FAO reports current trout and whitefish production as just under 300 tonnes (2014).

The bulk of Armenia's reported inland capture fisheries production is accounted for by Danube crayfish, which has leapt from 360 tonnes in 2012 to 4 350 tonnes in 2014. The reasons for this surge are unclear. Although pond culture had produced 5 000 to 6 000 tonnes annually during the Soviet period, output had dropped to less than 10 percent of this by the turn of the century.

UN Comtrade data identifies Armenia as a net exporter of fish and crustaceans over the five-year period 2012 to 2016. Fish exports totalled USD 108 million in this period, peaking at USD 32.5 million in 2013, before falling back to USD 113.6 million (2015) and USD 10.1 million (2016). The reason for the sharp decline is unclear. Although fish products were exported to 23 countries over the period, the main export markets were the Russian Federation, Belgium and the Ukraine. Fish imports in the same period totalled US17.4 million, and were sourced from a total of 54 countries, the main partners being Norway, Viet Nam, and Spain.

Although Lake Sevan is the only waterbody in the country where fishing is regulated, Hovhannisyan *et al.* (2011) note that illegal fishing takes place on the lake because of the poor economic situation confronting many lake-dwellers. Fishing in other natural and artificial public waterbodies and rivers is unregulated. Fish catches depend entirely on natural propagation, as there is no stocking.

It is widely believed that most of the poorer segments of rural population fish regularly for their own consumption and about 20 percent do this regularly (effectively >590 000 people). Hovhannisyan *et al.* (2011) estimate that annual per capita consumption of fish increased sharply from 0.3 kg to 1.8 kg between 2005 and 2008. If national production and net exports are aggregated, annual per capita consumption of fish and fishery products was about 2.25 kg in 2008.

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Tajikistan

Tajikistan is one of the most well-endowed countries in the world in terms of water resources (13 000 m^3 per capita). It provides about 55 percent of the water flowing into the Aral Sea basin, and accounts for 12 percent of the total river flows in the Central Asian region. The country has 1 300 lakes (covering 705 km^2), with the majority (78 percent) over 3 500 metres above sea level located in the Pamir/Gorno-Badakhshan region. These include the two biggest (Lake Karakul (380 km^2) and Lake Sarez (75.8 km^2)). Many of these natural inland waterbodies are relatively inaccessible, and the low fertility of the water limits productivity. Part of this glacial meltwater is captured by eight major multipurpose reservoirs, the biggest being Nurek (98 km^2) in the central part of the country, and Kayrakkum (52 km^2) in the northern part of the country. The country has more than 25 000 rivers, although only 967 extend over more than 10 km, and one of the region's two major rivers (the Amu Darya) sources about 76 percent of its waters in Tajikistan. The irrigation canal network is about 33 250 km, with water losses between source and field varying from 50 to 65 percent because of the high number (>60 percent) of unlined earthen canals.

Historically, fish production in Tajikistan was based on small-scale cyprinid pond culture with limited commercial capture fishing development taking place (from the 1930s onwards) following Soviet surveys of the lakes of the Pamir, central and southwestern regions. Capture fisheries production was boosted following the completion and stocking of the Kayrakkum reservoir in 1956, and Khaitov *et al*. (2013) report catches of 400 to 500 tonnes per annum (principally carp and bream) over the 1960 to 1989 period. Capture production at Nurek (completed 1980) was never as successful because of low levels of phytoplankton and zooplankton, leading Khaitov *et al.* (2013) to suggest the reservoir be turned over to sport and recreational fishing, and trout aquaculture. A large-scale aquaculture production programme extending across 2 600 hectares was developed in the early 1960s by the Soviet authorities, with outputs of 3 to 4 tonnes per hectare being recorded by the 1980s.

Both capture and culture production declined sharply following independence because of a combination of institutional failure (cessation of state support in the light of hard budget constraints) and market failure (the inability to acquire fish feed or fishing equipment once the trading relationship with the Soviet Union was broken), civil war and increased poaching (Thorpe and van Anrooy, 2009). In 1990, capture and culture output totalled 3 857 tonnes. Seven years later it was down to just 191 tonnes, and remained below 350 tonnes until 2008. Sectoral employment also fell, from 6 000 in the early 1990s to about 1 500 a decade later.

Since 2008 there has been a recovery in both capture and culture production, with FAO reporting inland capture production rising from 380 tonnes in 2008 to 1 174 tonnes in 2014 (culture production rose from 26 tonnes (worth USD 64 000) to an estimated 450 tonnes (USD 1.8 million) over the same period). The reasons for the sharp increases are not documented.

The 2007 household survey figure suggests 2 997 tonnes of inland fish was produced in 2007 (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). This is higher than the FAO estimate for inland capture fishery production in 2007 (225 tonnes) and is closer to the historic production levels reported for the country.

Poaching is reportedly widespread, with Khaitov *et al.* (2013) reporting "rampant poaching" of indigenous trout populations in recent years. However, some of this can also be considered unregulated recreational fishing as most of the catch (both legally and illegally caught fish) is rarely recorded officially.

UN Comtrade data identifies Tajikistan as importing USD 7 926 000 of fish and crustacean products from 16 different countries over the five-year period 2012 to 2016. The main suppliers were the Russian Federation, the United Arab Emirates and Uruguay. In 2012, USD 708 000 of fish products was imported from Viet Nam. Exports have leapt from USD 3 018 000 in 2012 to USD 25 014 000 in 2015, generating a healthy fish trade surplus. The vast majority of exports over the 2012 to 2015 period have been destined for the Algerian market.

The Association of Hunters and Fishers of the Republic of Tajikistan (AHFRT) was established in May 1956 and in conjunction with a number of fishing clubs issues licences for recreational fishing in the country. Most recreational fishers are not members of these associations however, and are entitled to fish in any waterbody that is not in private hands or assigned to a fishing club. The AHFRT estimate that between 50 and 60 tonnes are landed by recreational fishers annually, with at least 10 percent of this total being sold in local markets (Khaitov *et al.*, 2013).

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Azerbaijan

Azerbaijan has more than 450 natural lakes covering 394 km^2, although only Lake Sarysu (65.7 km^2) and Lake Aggol (56.2 km^2) are over 20 km^2 in size. The country has a Caspian Sea coastline of 713 km and 3 218 of its 8 359 rivers, including the two longest (the Araz and the Kura), drain directly into the Sea. Mingachevir (605 km^2) and Shamkir (116 km^2) are the largest of the country's more than 60 reservoirs (covering a total area of over 1 000 km^2) and the country also has an estimated 65 900 km of irrigation canals. Commercial fishing activities are concentrated on the Caspian Sea (predominantly kilka *Clupeonella* spp.), the Mingachevir and Shamkir reservoirs, and the Kura River (European carp *Cyprinus carpio;* shemaya *Chalcalburnus chalcoides*; eastern bream *Abramis brama;* pike-perch *Sander lucioperca*), with a small commercial fishery also existing on Lake Sarysu.

The Azeri commercial fishery produced 32 000 tonnes in the 1930s, and this figure rose to just over 55 000 tonnes (96 percent kilka) in 1988. However, unfavourable hydrological conditions in the 1990s and the accidental introduction and rapid proliferation of the comb jelly (*M. leidyi*) saw a steady drop in exploitable biomass. As the fleets of the Caspian nations chased an ever more scarce resource, overfishing merely accelerated stock collapse in the late 1990s (Mamedov, 2006). Kilka landings halved to 10 389 tonnes in 2001 following the privatization of the Azerbalgyg State Concern and the selling off of its 100 vessels. Private enterprise had little success in resuscitating the fishery. Kilka landings fell to below 1 000 tonnes in 2009, and then to below 150 tonnes in 2015, putting the kilka catch on a par with the landings of Caspian shad, mullet and Caspian kutum. Reported reservoir and river capture production halved to 220 tonnes over the period 2003 to 2010, and more recent figures point to a further substantive decline.

In 2014, FAO reported total inland capture fisheries production at 878 tonnes. Although activity for restocking of waterbodies in the country dates back to 1954, commercial aquaculture practices were only developed from the 1980s onwards, and production peaked in 1991 when 2 176 tonnes was produced. Since 2000, output has roughly quadrupled to reach 561 tonnes in 2015, with revenues generated rising from USD 120 000 to USD 3.56 million over the same period.

The reported production of fish in Azerbaijan reported by the State Statistical Committee of the Republic of Azerbaijan (2017) indicates that the national fish production was 47 025 tonnes in 2011. This fish production figure is reasonably close to the figure derived from the survey-production model (53 103 tonnes) (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Both these figures for inland fish catch are far higher than the report to FAO (1 061 tonnes) for the same year.

Salmonov *et al*. (2013) suggest reported catches are likely to be underestimated on two counts. First, as the real level of recreational catches is likely to be much larger than the 100 tonnes per annum reported by the Society of Hunters and Fishers. Second, as data on Caspian catch levels are based on information submitted by commercial fishing companies or individuals at the time they receive their quota, rather than on the volumes landed in the coastal ports.

UN Comtrade data identifies Azerbaijan as a net importer of fish and crustaceans over the five-year period 2011 to 2015. Fish exports totalled just USD 89 000 in this period, going to the Russian Federation, Georgia, and Kazakhstan. In contrast, imports over the same period totalled USD 36.2 million and were sourced from 49 different countries. The major trading partners were the Russian Federation, Luxembourg, Viet Nam, and Iceland.

Azerbaijan has about 20 000 recreational fishers, most of whom are members of one of the branches of the Society of Hunters and Fishers. Recreational fishing is governed by the Regulations of Sport and Amateur Fishing (1999). These allow fishers to catch up to 5 kg of non-predatory species daily (there is no daily catch limit for predatory species). Salmonov, Qasimov, Fersoy and van Anrooy (2013) suggest recreational fishing is primarily for personal consumption, and takes place chiefly along the Caspian Sea and some of the inland lakes.

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Afghanistan

Afghanistan hosts five major river basins: the Kabul (drainage area 54 000 km^2), the Helmand (190 000 km^2), the Hari Rod and Murghab (both approximately 40 000 km^2), and the Amu Darya (91 000 km^2). Most of the rivers flowing into these basins are perennial, with peak flows in the spring months as the snows in the Hindu Kush mountains melt, dwindling to small rivulets devoid of fish during the dry summer months. The Kabul River (which is a tributary of the Indus) is the only river reaching the sea, the majority ending in salty swamps or terminating abruptly in arid areas of the country. The country has few lakes, and these are also small in size (Zarkol on the Tajik border, Shiveh in Badakshan, Istadehye Moqor near Ghazni, and the six lakes in the Band e Amir National Park). The country boasts 23 dams, though years of neglect have taken their toll, and there is no information on the size of the accompanying reservoirs (nor of their suitability for fishing activity) (Petr, 1999).

Fish resources are relatively scarce in the country, although the country has 85 native species (Coad, 2015). FAO has estimated inland capture fishery production since 1970 until the present. The current estimate of 1 000 tonnes is unchanged since 2000 and represents an approximation of the likely level of fish production from unmonitored fisheries in Afghanistan. Estimated aquaculture production has increased, from 450 tonnes annually over the period 2001 to 2006, to 1 150 tonnes (worth USD 3.68 million) in 2015.

UN Comtrade data indicate that Afghanistan exported USD 11 000 of fish products to Pakistan in 2014, but nothing in the years 2011, 2012, 2013 or 2015. There is no record of fish product imports to the country, although fish products from neighbouring countries (Islamic Republic of Iran, Pakistan, Uzbekistan, and Tajikistan) are present in markets along all the borders.

The fish production figure derived from the survey-production model (4 483 tonnes) is higher than the current FAO estimate (1 000 tonnes). FAO has estimated aquaculture production since 1969 (1 050 tonnes in 2014). There is no way to establish the relative contribution to fish consumption by the wild fishery or the small aquaculture operations that exist in the country. Aquaculture may be underestimated by FAO and imports from neighbouring Pakistan and the Islamic Republic of Iran are probably not accounted for. This means that the 4 483 tonnes estimate could be too high.

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Kyrgyz Republic (Kyrgyzstan)

The Kyrgyz Republic (or Kyrgyzstan) possesses the world's second largest mountain lake, Lake Issyk Kul (6 236 km^2). Most (84 percent) of the country's other 1 922 lakes lie at altitudes of between 3 000 and 4 000 metres, including Lake Son Kul (275 km^2) and Lake Chatyr-Kul (175 km^2), and their relative inaccessibility and low fertility limits productivity. More than 30 000 rivers and streams flow across Kyrgyz territory, the longest being the Naryn (535 km, which becomes the Syr Darya after passing through the Fergana Valley), the Chatkar (205 km), and the Chui (221 km). Thirteen artificial multipurpose reservoirs covering 378.2 km^2 were created to regulate the runoff of five transnational rivers (the Chui, Naryn, Talas, Ak-Bura and Kara-Darya), the biggest of these being the Toktogul reservoir constructed on the Naryn in 1974 (284.3 km^2) and the Kirov (26.5 km^2) on the Talas in 1975. The irrigation network comprises 12 835 km of canals, the majority (82 percent) earthen.

Historically, fishing activity was centred on Lake Issyk Kul (Lake Chatyr Kul is fishless, and fish were only introduced into Lake Son Kul in 1959) and dominated by catches of low value dace (*Leuciscus schmidti* and *Leuciscus bergi*). New carnivorous species were introduced into the waterbody by the Soviets in the 1930s (Lake Sevan trout, *Salmo ischchan*) and the 1950s (principally whitefish and pike-perch) to increase the value of the fishery (Alpiev *et al*., 2013; Kustareva and Naseka, 2015). As these species became established and preyed on the endemic species, absolute catches declined from their peak (1 335 tonnes) in 1965. Widespread restocking from the 1960s onwards has meant that the fish fauna in most Kyrgyz waterbodies have changed and that most fish currently harvested are non-indigenous species (Djancharov, 2003; Alpiev *et al*., 2013). By the 1990s catches had slumped to approximately 300 tonnes, and fell further to approximately 30 tonnes in 2005. This led to the government introducing fishing moratoria on Lake Issyk Kul in 2003, and Lake Son Kul in 2006. Since then, reported catches have climbed to 227 tonnes (2014).) As capture fisheries have declined, the government has promoted the development of pond aquaculture. This too suffered following the break-up of the Soviet Union, as a shortage of hatchery equipment and fish feed curtailed production activities, and most state hatcheries were privatized, although it has recoved in recent years through an upsurge in caged trout culture on Lake Issyk Kul.

Sarieva *et al.* (2008) suggest that a large part of the fish caught is caught illegally, is unreported, and takes place in an unregulated environment. Since 2000, fishing (when permitted) on Lake Issyk Kul has been leased out to 17 fishing enterprises in the form of 40 lots, but there has been "little control as to whether the enterprises observe regulations and their quotas" (Sarieva *et al*., 2008). At the same time, the dire economic situation and soaring unemployment have encouraged poaching. In 2006, 100 fishers were caught poaching. In 2008 the Department of Fisheries estimated there were 500 to 1 000 poachers in the Issyk Kul region alone, and each was catching between 10 kg and 50 kg of fish daily. If true, this would suggest IUU fishing levels easily exceed the reported capture production figures.

UN Comtrade data identify Kyrgyzstan as a net importer of fish. Over the period 2012 to 2016, just USD 126 000 worth of fish products were exported to Serbia, Kazakhstan and Uzbekistan. In contrast, USD 43.3 million worth of fish and crustacean products were imported over the same five-year period. Although these imports were sourced from 34 countries, the main supplier of imported fish products was the Russian Federation, Norway and Lithuania.

Recreational fishing takes places across the country. All rivers, lakes and reservoirs where fishing is not commercially important (and recreational fishing is possible) are leased to the Hunting and Fishing Union (HFU, Kyrgyzohotrybolovsoyuz), which in turn licences recreational fishers. In 2007, the HFU reported 23 656 members. Sarieva *et al.* (2008) note that the 11 reservoirs leased to the Chui branch of the HFU over the period 1999 to 2006 were visited by between 3 000 and 6 000 licensed fishers every year, who landed between 15 and 23 tonnes of fish.

Per capita fish consumption in Kyrgyzstan is far below average per capita fish consumption in Asia (18.5 kg/year) and the country's own recommended levels of fish consumption (9.10 kg/year), at about 3 or 4 kg/year (Ilibezova *et al*., 2014). The same authors calculate that the share of fish and fish products is less than 10 percent of household expenditure on total meat and fish consumption.

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Mongolia

Mongolia covers 1.5 million km^2 and is the fifth largest country in the world. With an average altitude of 1 580 metres above sea level it is also one of the highest countries in the world. The country has 3 060 natural lakes with a surface area larger than 0.1 km^2, but only 200 have a surface area that exceeds 5 km^2. The largest lake is Lake Uvs (3 518.3 km^2), but it is relatively shallow (average depth 10.1 metres), like the majority of Mongolian lakes. The second largest, Lake Khuvsgul (2 770 km^2), is more than ten times deeper, and holds 74 percent of the country's total freshwater resources. Other lakes of note include Lake Khar-Us (1 496 km^2, but with an average depth of just 2.1 metres), Lake Khyargas (1 481.1 km^2), Lake Buir (615 km^2) and Lake Khar (565 km^2). Many of the medium (>200km^2) and smaller lakes dry up once or twice every decade, resulting in the near complete loss of all aquatic life as fish, aquatic plants and animals are stranded on the drying lake-bottoms. This is however a ntural phenomenon and the lake ecology is able to recover.

The lakes are complemented by 4 113 rivers extending across 67 000 km. The major rivers are the Orkhon (1 124 km), the Selenge (1 024 km), which carries 30.6 percent of the country's total river flow, the Kherlen (1 090 km), the Zavkan (808 km), the Tuul (704 km) and the Hovd (593 km). The country also possesses a number of small reservoirs created for irrigation purposes through the construction of 27 earthen dams.

Commercial capture fisheries in Mongolia dates from the 1950s and was centred upon Lakes Buir, Ugii (25 km^2) and Dood Tsagaan (10.5 km^2). Mean annual catches of more than 725 tonnes were recorded in the late 1950s, as fisheries management focused upon expanding fish stocks by introducing fish species (mainly Artic and Siberian cisco (*Coregonus autumnalis* and *Coregonus sardinella*), and peled (*Coregonus peled*)) into selected waterbodies. However, overfishing saw annual catches decline to under 200 tonnes by the late 1980s. In the early 1990s, fishing was prohibited on both Lake Ugii and Dood Tsagann because of such concerns (Dulmaa, 1999; Ganbaatar, 2003). FAO data suggest current reported capture fisheries production in the country is approximately 49 tonnes, although FAO has estimated the annual fish production potential of the Mongolian lakes and rivers to be in the range of 650 to 750 tonnes. This is in good agreement with the catch based on the household consumption model estimate of 610 tonnes (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

Dulmaa (1999) suggests there exists little potential for aquaculture production as the low water temperatures make the culture of carp uneconomic, and trout production would require considerable investments in pond construction and water supply to ensure profitability.

Ocock *et al.* (2005) identified IUU fishing as the dominant threat to capture fisheries production in the country, despite attempts by the Mongolian Parliament to regulate fishing activity. The market for such IUU fish "appears to be indiscriminate, the only requirement being that they are large enough to consume" (Ocock *et al.*, 2005). Particularly vulnerable are taimen (*hucho taimen*), the world's largest salmonid, which require at least ten years to grow to a size of one metre or more, despite commercial harvesting of taimen being illegal.

UN Comtrade identifies Mongolia as a net importer of fish. Over the period 2011 to 2015 USD 3.6 million tonnes of fish products were imported from 28 countries. The main suppliers were Republic of Korea, China and New Zealand. Over the same period USD 393 000 of fish products were exported to China.

There is no data on the number of recreational fishers in Mongolia. However, Jensen et *al.* (2009) note that recreational fisheries are an important income source in the poorer regions of Northern Mongolia. Recreational fishers are permitted to fish taimen upon purchase of a licence.

Fish and fish products play only a minor role in Mongolian nutritional profiles. Dulmaa (1999) reports that the Ministry of Health recommended annual per capita fish consumption levels of 3 to 6 kg (1 to 2 kg fresh, 2 to 4 kg fish products) in rural areas, and 4 to 24 kg (3 to 10 kg fresh, 1 to 14 kg fish products) in urban areas. In 2013 FAOSTAT suggested the supply of fish products was just 0.68 kg/capita per year.

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Georgia

Capture fisheries production in Georgia primarily takes place along the country’s 330 km Black Sea coastline. The country has 25 075 rivers, two-thirds of which drain into the Black Sea, and one-third into the Caspian Sea. The main Georgian rivers are the Alazami (391 km), the Mtkvari (351 km), the Rioni (333 km) and the Enguri (206 km). However, 99.4 percent of the country’s rivers are less than 25 km in length. The country also possesses 860 lakes covering 170 km^2, although the two largest, Lake Paravani (37.5 km^2) and Lake Kartsakhi (26.3 km^2), have maximum depths of less than four metres. The country’s deepest lake, Lake Ritsa (1.5 km^2, depth 101m), is rich in trout. Thirty-seven reservoirs cover 258.3 km^2, the largest being Mtvari (112.3km^2), Khrami (27.7 km^2), Sioni (12.8 km^2), Tkibuli (12.1 km^2) and Shaori (10.2 km^2). Although 134 of these waterbodies are used for fisheries purposes, Van Anrooy *et al.* (2006) report that the productivity of most of the lakes and reservoirs is poor because of low water temperatures, wide fluctuations in water levels, lengthy coverage of the surface with ice, limited natural reproduction of the main commercial species, and an absence of restocking in recent decades. The country’s 36 main irrigation canals extend over 1 296 km, but the irrigated area has fallen from its maximum of 500 000 hectares at the end of the 1980s.

Commercial capture (marine and inland) fisheries in the republic date to 1930 when the joint-stock company Saktevzi was established. Production grew from approximately 2 000 tonnes in the early 1930s to reach 113 889 tonnes in 1980, as the country’s fleet of 48 industrial fishing vessels traversed the Azov and Black Seas, and ventured further afield in pursuit of fish to supply processing factories located in Tbilisi, Kutaisi, Batumi, Sukhumi and Gagra. The principal target was anchovy, which accounted for 98 percent of landings in 1980, with inland fisheries production contributing just 2 percent of the total. By 2000, the sale of the ocean-going fleet to Ukraine, the closure of most fish processing plants, internal strife, and the fracturing of trade links with Russia saw total capture production collapse to about 2 500 tonnes a year. The anchovy fishery along the Black Sea staged a recovery to reach 55 000 tonnes in 2010, but Goradze *et al.* (2014) expressed strong reservations about its sustainability given that over half the catch comprised undersized fish.

FAO report capture production data for Georgia of 50 tonnes or less (20 tonnes in 2014) since 1996, although van Anrooy *et al*. (2006) estimated total inland capture fisheries catch to be about 400 tonnes in 2004. This is supported by the consumption survey model estimate of 492 tonnes for 2011 (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

Evidence suggests the level of IUU fishing is high. Van Anrooy, Mena Millar and Spreij (2006) report that most of the internal catch is taken by poachers, and Goradze *et al.* (2014) note that the use of illegal fishing methods has become more widespread and that there is both illegal entry into protected areas and uncontrolled fishing for high value endangered species, most notably sturgeon.

Recreational fishers in Georgia are expected to follow the rules laid down in Order No.512 of MEPNR (2005) governing amateur and sport fishing. Khavtasi *et al*. (2010) suggest the number of recreational fishers is “rather high” and they may be responsible for landing several hundred tonnes a year. This may explain the discprepancy between reported inland catch and the household consumption model estimate.

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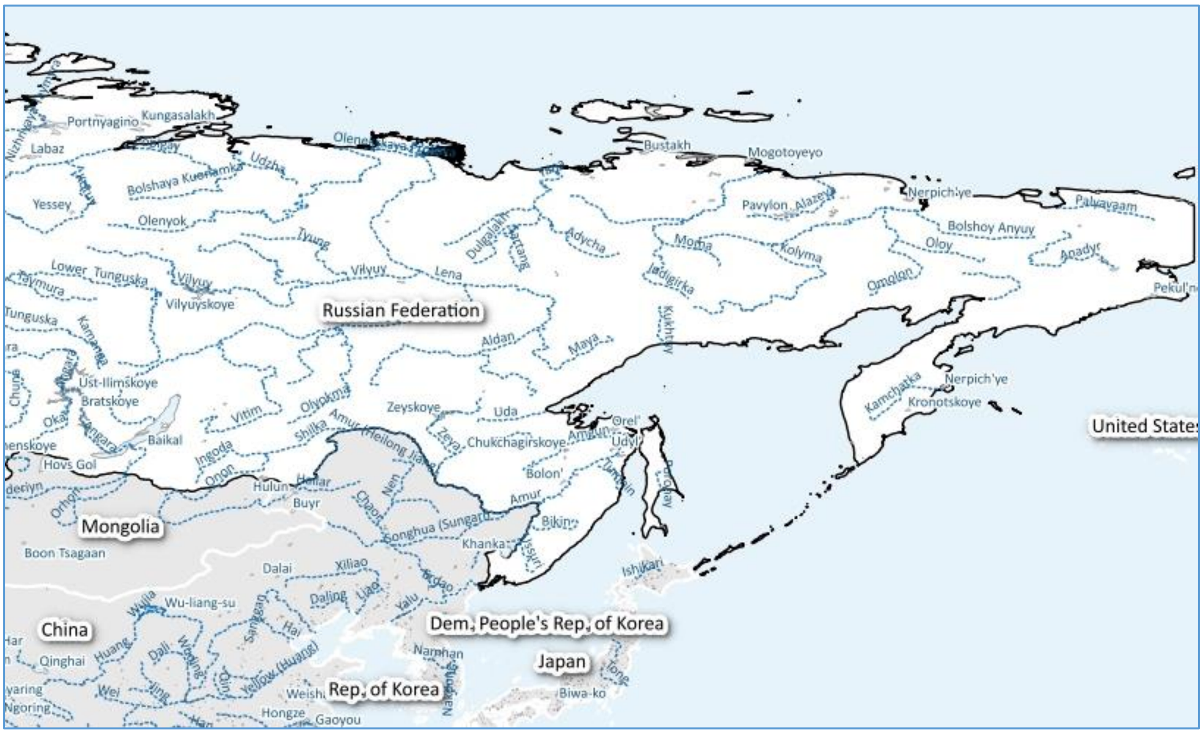
2.3 RUSSIAN FEDERATION



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery production (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Russian Federation	285 090	142 834 000	1.84	2.49	4 249	67

The Russian Federation spans both Asia and Europe, and has extensive inland water resources. Much of the country's fish production is also derived from waterbodies outside of the European subregion. The Russian Federation, as a statistical entity, has been included in Europe, however the importance of its inland fisheries in the central and eastern (Asian) parts of the country means it is more meaningful to treat the Russian Federation as a subregion.

Russia has more than 2.5 million small rivers with a total length of more than 8 million km. The length of the important rivers used for fisheries is estimated to be 615 000 km, 200 000 km of which are significant as spawning and nursery areas (Mamontov *et al*. cited in Dgebuadze, 2015). It has more than 2 million freshwater lakes (OECD, 1999) with an area of approximately 350 000 square kilometres (35 million hectares) (Dgebuadze, 2016). Many of Russia's freshwater bodies are situated in places that are difficult to access, and therefore, only 40 percent of them are used for fisheries (Dgebuadze, 2016). The importance of the large rivers has declined with successive damming to form large multi-purpose reservoirs. The remote nature of many Siberian rivers is another reason for the low levels of exploitation. (Berka, 1989).

In the western part of the Russian Federation, there are the Ponto-Caspian River basins (the Volga, Don and Ural Rivers) with associated lakes and reservoirs. Lake Ladoga, Lake Onega, Lake Ilmen are the largest waterbodies in the western part of the Russian Federation. Lake Peipus-Pikva (Pskovsko-Chudskoe) is shared between the Russian Federation and Estonia. There are reservoirs on the two large river systems in the western part of the Russian Federation, namely the Kuibyshev, Rybinsk, Volgograd, Cheboksar, Saratov and Gorkiy reservoirs on the Volga river and the Tsimlyansk reservoir on the Don River.

In the northern central part of the country, several large rivers drain into the Arctic Ocean (including the Ob, Lena, Enisei and Irtysh Rivers) and represent the largest riverine production of the country. Ob-Irtysh basin catches have traditionally combined catch from three types of waterbodies: rivers, lakes and bays. Catches are reported from the rivers of Tyumen, Tomsk, Novosibirsk, Omsk, Kurgan and Kemerovo administrative regions and the Altai Territory (including the rivers of the Altai Republic). Lake catches come from Tyumen and Tomsk regions and the coastal catch comes from the Ob and Taz bays of the Kara Sea. This excludes inland salt lakes with production of artemia and amphipods/gammarus.

Catch in the Ob-Irtysh basin in 2013 amounted to 22 900 tonnes. It is concluded that declines in catches of most species of fish are because of the long period of low water levels (the Ob-Irtysh River system has considerable fluctuations in inter-annual water regimes), reduced feeding efficiency and reproduction in the Ob-Irtysh basin. This is also strongly affected by the high fishing effort as well as poaching (IUU fishing).

Total fishery product of Yenisei River basin in 2013 is reported at 4 260 tonnes (rivers 1 910 tonnes; lakes 1 100 tonnes; reservoirs 1 240 tonnes). It is estimated that commercial fishing accounts for 97.5 percent of the fish caught, with amateur or recreational fishing accounting for 2.5 percent. Fishing effort is concentrated on the most valuable and available fish species found in the mainstream rivers and reservoirs located near populated areas. The riverine catch is dominated by whitefish (*Coregonus* spp.), pike and burbot. Makoedov and Kozhemyako (2007) state that roach, omul and bream make up to 80 percent of the harvest, however this information dates from the mid 2000s.

In the centre of the country, Lake Baikal has a surface area of approximately 31 500 km^2. Only a shallow part of the lake has commercial significance, as it is here that fishing is conducted mainly for Baikal omul (*Coregonus migratorius*). The total catch of omul in Lake Baikal in 2013 amounted to 1 900 tonnes, remaining at the level of 2012 (1 870 tonnes). Coregonus catches are reported to have declined, mainly as a result of the unfavourable situation in the fishing of certain fishing areas and a high proportion of illegal and unreported catches. The status of stocks of other species of fish (bream, pike, catfish, perch and others) in the lake is considered to be quite stable. The low overall catch reported is attributed to the poor organization of fishing and the high degree of illegal fishing.

In the east, there are two large river systems: the Lena River entering the Arctic Ocean and the Amur River entering the Sea of Okhotsk, as well as numerous shorter eastern Siberian rivers. Fisheries in this region are largely based on salmon, particularly on the Pacific coast, and the fishing often takes place in quite remote areas. Subsistence fishing by indigenous groups is important and takes place mainly in estuaries, lagoons and rivers (for anadromous fish). Indigenous fishers are legally bound to use the catch only for local consumption and are not allowed to sell their catch (FAO, 2007). Where commercial fishing in undertaken, the fish are collected for sale from fishing camps. Elsewhere recreational fishing for salmon is of increasing value. Improved salmon returns in some rivers are attributed to better control of marine driftnet fisheries. The salmon catches of Russia are reported to be 470 900 tonnes (Glubokovsky *et al.* cited in Dgebuadze, 2015), but are reported in the marine catch of the Russian Federation.

Inland capture fisheries have always been important, with earlier catches for Russia as part of the Union of Soviet Socialist Republics (USSR) at about 124 000 tonnes in 1980 (Berka, 1989), with an additional inferred catch by recreational and informal fishing of 67 000 tonnes (Berka, 1989). Riverine catches represented approximately 50 000 tonnes of this (Berka, 1989).

In 1988, when the Russia Federation first reported as a separate entity, the inland fish production stood at about 437 000 tonnes. Catches subsequently declined to 217 858 in 1994 and have stabilized since then. In 2014, the reported production figure was 224 895 tonnes. Of this total, some 48 800 tonnes come from monitored fisheries in rivers, lakes and reservoirs. This does not also include the recreational and informal fishing sector, which is considered to produce a significant level of retained catch (Titova, 1984) and is estimated to comprise about 15 million people (Dgebuadze, 2015). IUU fishing is variously estimated as between 20 to 100 percent more than the officially reported catch for the country (Dgebuadze, 2015).

Official statistics of the Russian Federation (Ministry of Natural Resources and Ecology of the Russian Federation, 2014) for freshwater bodies indicate that the catch of aquatic biological resources was 105 960 tonnes in 2014, but this is presumed to be the catch from monitored commercial fisheries.

There are increases in catches observed mainly in waterbodies in basins in western Siberia, western Volga-Caspian and eastern Siberia. There are continuing declines in the fish catches in waterbodies of the northern part of the country and the Azov-Black Sea basin fisheries and Lake Baikal, caused mainly by the deteriorating hydrological regime of these waterbodies.

Most Russian reservoirs continue to have declining stocks of the most valuable fishery species (sturgeon and freshwater salmonid), attributed to IUU fishing and long-term impacts on hydrology and environmental water quality, habitat alteration (obstruction of migration routes and reduction in the area of spawning grounds) as well as competition with alien species (Berka, 1989; Dgebuadze, 2015). Particularly damaging was the construction of the Volgograd dam, which prevented several sturgeon species (including the beluga) access to most of their spawning grounds. The stocking programmes by the riparian states have not been able to compensate for this loss (Secor *et al.*, 2000).

There have been efforts to increase production and offset impacts on rivers and waterbodies throughout the Russian Federation. These range from habitat provision (spawning nest for Chinese carp) introduction of Chinese carp and bream (*Abramis abrama*) to reservoirs, through to active stocking of hatchery reared salmon in rivers (Berka, 1989). Dgebuadze (2015) reports that nonindigenous species comprise more than 15 percent of species in most Russian river basins.

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2.4 EUROPE

Subregion	Inland capture fishery catch (tonnes) (2015)	Total renewable surface water (km3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)	Percentage of global inland fishery catch	Number of inland fishers	Number of post- harvest workers
Eastern Europe	63 663	1.22	87	0.6	14 405	n.a.
Northern Europe	45 096	0.42	50	0.4	1 486	n.a.
Western Europe	27 921	0.09	35	0.2	4 330	n.a.
Southern Europe	13 337	0.09	22	0.1	10 637	n.a.
TOTAL	**150 017**	**0.24**	**194**	**1.3**	**30 858**	**n.a.**

Previous editions of the *Review of world fishery resources: inland fisheries* included the Russian Federation in the statistics for Europe, despite that fact that a substantial part of the production of the Russian Federation is derived from basins lying outside of the European region. The Russian Federation is now treated separately from the European region.

Total European region catch in 2015 (150 017 tonnes) was 1.3 percent of the global total. This largely derived from the commercial fisheries, which are monitored in Europe. There is also unregulated informal fishing activity that is not recorded and substantial recreational fisheries. Some of the recreational fishery catch is retained and consumed, especially in Northern and Eastern Europe.

The most recent estimate of total annual catch of commercial inland fisheries of the European Union countries is a 2007-2008 average, estimated at 35 000 tonnes, and valued at USD 147 million to USD 161.7 million (EUR 100 million to EUR 110 million). There were an estimated 17 100 commercial inland fishermen operating within the European Union in 2008-2009, many of whom were part time.

Commercial inland fisheries exist in 22 of the 28 European Union Member States, but only in 19 Member States are these fisheries significant (>100 tonnes). They target a wide range of both freshwater and diadromous fish species. Non-European Union countries also have significant inland fisheries. Passive gear, such as traps, pots, fyke nets, lines, trammels, gill nets and other passive nets are the most widely used gears.

Under-reporting is common in many of the countries, which makes analysis of the data and trends unreliable. Commercial inland fisheries target a wide range of both freshwater and diadromous fish species. Diadromous species are among the most valuable species targeted by commercial inland fisheries. They are targeted in coastal areas, estuaries and the downstream, tidal parts of rivers, and constitute the main species exploited in these areas. Diadromous species exploited in the European Union include:

- Salmonidae: Atlantic salmon (*Salmo salar*) and sea trout (*Salmo trutta*).
- Clupeoidae: including the allis shad (*Alosa alosa*), twaite shad (*Alosa fallax*), pontic shad (*Alosa pontica*) and other species of shad (*Alosa spp*.).
- Petromyzonidae: including sea lamprey (*Petromyzon marinus*) and river lamprey (*Lampetra fluviatilis*).
- Anguilllidae: including the European eel (*Anguilla anguilla*).
- Acipenseridae: which includes different species of sturgeons, European sturgeon (*Acipenser sturio*) and Beluga sturgeon (*Huso huso*). Mugillidae: with various species of mullets (*Mugil* spp.) including red mullet (*Mullus barbatus*).

The member countries of the European Inland Fishery and Aquaculture Advisory Commission (EIFAAC) reports approximately 30 000 commercial inland fishers and a catch of 90 000 tonnes, but this includes some non-European Union countries. EIFAAC data only reflect declared catches; the extent of unreported or illegal catches is usually not accounted for (Mitchell, Vanberg and Sipponen, 2010).

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2.4.1 EASTERN EUROPE

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Ukraine	20 116	45 239 000	0.61	0.18	170	118
Poland	18 376	38 217 000	0.49	0.16	60	306
Hungary	9 937	9 955 000	0.65	0.09	104	96
Romania	4 464	21 699 000	0.12	0.04	212	21
Czechia	3 841	10 702 000	0.35	0.03	13	292
Serbia	3 150	9 511 000	0.53	0.03	n.a.	n.a.
Slovakia	1 971	5 450 000	0.36	0.02	50	39
Belarus	869	9 357 000	0.07	0.01	58	15
Montenegro	662	621 000	1.35	0.01	n.a.	n.a.
Slovenia	141	2 072 000	0.07	0.00	32	4
Bulgaria	86	7 223 000	0.02	0.00	20	4
Republic of Moldova	50	3 487 000	0.01	0.00	12	4

Eastern Europe has significant river and lake resources centred on the extensive Danube basin, its tributaries and delta, as well as the Dnieper and Dniester Rivers. The reservoirs of the Ukraine and the extensive lake district of Poland are important resources as these two countries dominate the production of this region.

Inland water fish have been an important source of food in many eastern European countries, and they developed important fisheries, especially during the period when governments invested in stocking and promotion of inland fisheries as part of the centrally planned economies. This support disappeared following the breakup of the Union of the Socialist Soviet Republics and this was reflected in the reported catches until about 1998. The production of Ukraine increased after 1998, and because of the country's dominant position this drove the regional trend, although the catch of other countries has remained largely stable throughout.

Ukraine contributes about 32 percent of the catch for the region and Poland about 29 percent, Hungary a further 16 percent. The rest of the catch is shared between the other countries with catches ranging between 50 tonnes and 4 464 tonnes. The region's catches consist mainly of cyprinid species (especially common carp). However, a wide range of other species is stocked in lakes and reservoirs to support the remaining commercial fisheries and a growing recreational sector.

There are reports of high levels of participation in recreational fishing, or fishing for the family in the Eastern European subregion (see Chapter 8 in this publication). This suggests that there may be considerably more fish entering households than is revealed in the reported catch statistics.

The total area of all inland freshwater waterbodies in Ukraine is about 24 000 km^2: 73 000 rivers and streams (about 250 000 km total length), about 20 000 lakes and estuaries, 1 160 reservoirs and 28 700 artificial ponds, 1 190 km of large canals, and another 1 032 km of sluices. The largest rivers are the Danube, the Dnieper and the Southern Bug and the largest dam the Dnieper Cascade, with a total area of 6 920 km^2. Most Ukrainian lakes are located in the drainage basins of the Danube, Dnieper, Pripyat, South Donets and of the small rivers in the Poles'ye region. The Sea of Azov is a brackishwater inland sea shared with the Russian Federation.

According to FishStatJ, inland fisheries catch in Ukraine reached 20 116 tonnes in 2015. For the last 10 to 15 years funding for fisheries research has been extremely limited and no recent data were found on how catches are distributed geographically within the country. However, Table 2-4 shows catches from different basins in the period 1997 to 2003. In that period catches from freshwaters made up about 20 percent of all capture fisheries production in the country.

Table 2-4: Inland fish catch from Ukranian waterbodies

Area	Landings tonnes (mean)
Dnieper reservoirs	7 100 to 8 800 (8 200)
The lower Dnieper and the Dneprovsko-Bugskiyy (Southern Bug−Dnieper)	1 200 to 3 800 (2 100)
Danube with its deltaic lakes	800 to 1 600 (1 000)
Dniester	400 to 600 (500)
Other waterbodies	200 to 400 (300)

Note: Catches from the Sea of Azov appear not to be reflected in reported inland catches and are presumably recorded as marine catch.

There is also a significant catch by recreational fisheries and poaching (possibly one-third of the legal catch and in some cases more) which is not considered. Most catches were from the large reservoirs on the Dnieper where yields have been fairly stable. This is not the case for other fisheries that have experienced serious decline. The worst decline is in the rivers and lakes of the Volynsk region where catches were 76.5 tonnes in 1990, but had almost disappeared within a decade. Fisheries comprise 30 to 35 species, mostly exotic and indigenous cyprinids, perches, pike, catfish and clupeids (Movchan, 2015).

High levels of industrial pollution and environmental degradation are seriously impacting freshwater ecosystems and thus fisheries; also the accident at the Chernobyl Nuclear Power Station had serious long-term consequences for the country's environment. Flow regulations of the main rivers have degraded the conditions for natural reproduction and feeding of many fishes, and blocked migration routes. There are attempts to compensate these losses through stocking programmes mainly using exotics; currently some twenty exotic species have been introduced, of which nine have become established (Movchan, 2015).

The Sea of Azov is highly productive. Between 1930 and 1952 the average annual catch was about 200 000 tonnes with a maximum 275 000 tonnes in 1936. Anadromous, semi-anadromous, and freshwater species made up 59 percent of the landings including up to 15 000 tonnes of sturgeon. By the end of the nineteenth century, and during the 1990s, overall landings decreased to just 10 percent of the peak. Since 2000, fisheries have somewhat recovered to about 45 thousand to 50 thousand tonnes per year (Diripasko *et al.*, 2015). Catches from the Sea of Azov appear not to be reflected in inland catches reported to FAO and are presumed to be included in marine catch reports. In order to maintain sturgeon stocks in the Black and Azov Seas, Ukraine has a state funded stocking programme with Russian sturgeon (*Acipenser gueldenstaedtii*).

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Poland

Poland has about 6 000 km^2 of surface waters. The Vistula and Oder Rivers are the most important watercourses (Kaczkowski and Grabowska, 2016). There are 3 200 km^2 of lakes where most of the commercial fishing takes place. In 2015 Poland reported 18 376 tonnes of fish landed from inland fisheries (FAO FishStatJ), 8.5 percent were identified as indigenous cyprinids, other important species were pike, perch, pike perch and vendace and 87 percent were unidentified species. Catches of European eel, a species that was important in the past, are now just 0.4 percent of the landings.

The average Pole consumed 12.3 kg of in 2014, in the period 1995 to 2002 the consumption of fish and fish products comprised only 7 to 9 percent of total meat consumption. Among freshwater species imported *Pangasius* and salmon together with carp are the most important (Rucinski, 2015).

The inland fishing sector employs about 1 650 people (Ministry of Agriculture and Rural Development, 2008).

In Poland, there are approximately 1.5 million recreational fishers (Wolos cited in Trella and Mickiewicz, 2016). It is estimated that in 2005 the catches from recreational fishing amounted to nearly 10 000 tonnes of fish, whereas in 2006 it was nearly 15 000 tonnes. Anglers associations have a large technical potential and are a major employer in the fisheries sector (Ministry of Agriculture and Rural Development, 2008).

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Hungary

The total area of surface water suitable for fisheries is 1 400 km^2. The Danube and the Tiesza, its main tributary, are the two most important rivers. Several large lakes are also important, namely Lake Balaton (596 km^2), Lake Fertö (75 km^2) and Lake Velence (7.5 km^2) and the Lake Tisza reservoir (64 km^2) (Specziar and Erös, 2016).

In 2015, 9 937 tonnes were landed (inland fisheries), a significant increase compared to 7 463 tonnes and 6 472 tonnes respectively in 2014 and 2013 (FAO FishStatJ). However, this is still far from the peak catch of 22 704 tonnes in 1984. The recovery is mainly a result of the good performance of the common carp, which with 7 307 tonnes (more than double the catch in 2013) now constitutes 74 percent of the reported catch (FAO FishStatJ). Specziar and Erös (2016) explained that the sustainable exploitation of several stocks including common carp (the main species) depends on regular and continued stocking, and several other stocks have already collapsed because of overfishing.

National policies have favoured the recreational sector (with 332 000 anglers) at the cost of inland commercial fisheries that are now restricted to Lake Balaton, the main rivers and associated oxbow lakes (Specziar and Erös, 2016).

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Romania

In Romania there are about 3 500 very small (<1 km^2) lakes, although the former lagoons of the Black Sea, Razim (425 km^2) and Sinoe (171 km^2), are relatively large, and the Danubian lakes, Oltina and Brates, with areas of respectively 22 km^2 and 21 km^2 are also significant. There are also the reservoirs created by the Iron Gates dams. The total length of the country's principal rivers including the Danube, (Europe's second largest river) is 22 569 km (Ministry of Agriculture and Rural Development, undated).

Inland fisheries is mainly practiced in the Danube and the Danube delta, but also takes place in the Razim-Sinoie lake complex, in artificial lakes and in various other waterbodies. (Ministry of Agriculture and Rural Development, undated).

The Romanian inland fisheries sector was hard hit by the transition to a market economy. Maximum production was achieved in 1987 with 26 690 tonnes, however, from that moment there has been an almost continuous decline until about 2010 when just 2 457 tonnes were landed. Since that year, the trend appears to have reversed with year on year improvements and in 2015, 4 464 tonnes were caught (FishStatJ). The major share of landed fish comprised goldfish (47.5 percent), and the remainder comprised bream (9.3 percent), roaches (6 percent), Wels catfish (5.4 percent) and common carp (4.9 percent). Silver carp, grass carp and bighead carp that were among the dominant species when there was a planned economy have almost disappeared from the catches (FAO FishStatJ). However, there are probably significant amounts of unrecorded landings, and there are no statistics of the increasingly important recreational fisheries, although there are 200 000 registered anglers (Ministry of Agriculture and Rural Development, undated).

Some 2 500 fishers operate in inland waters, using 2 256 registered vessels. Until the 1950s inland fisheries was the main economic activity along the Danube and its delta, today it is the main economic activity only in the delta region where 1 500 people (or 10 percent of the delta population) work in inland fisheries. However, inland fisheries continue to be mostly carried out by traditional fishers as a full-time occupation, although they can be a subsistence activity for people with insufficient income from other sources (Ministry of Agriculture and Rural Development, undated).

Recorded fish consumption dropped from more than 8 kg/person/year in 1989 to a minimum of about 2 kg/person/year between 1993 and 1999. Since then, it has been increasing again and reached 4.5 kg/person/year in 2005. However, although the country was able to meet the national demand almost entirely during the planned economy, the country is now relying on imported fish for about 85 percent of the supply (Ministry of Agriculture and Rural Development, undated).

Since the 1950s, the policy of controlling the floods and converting the floodplains into arable land by damming the Danube, has not had the expected positive impacts on agriculture, but fish catches have declined severely as a response. It seems that this policy has come to an end and is now being replaced by a new strategy that will allow the rehabilitation of wetlands and the flooding of certain areas (Ministry of Agriculture and Rural Development, undated). Also, the quality of water in rivers and lakes is improving, and the water quality of the Danube is generally at an acceptable level. However, the two Iron Gates hydroelectric dams blocked the upstream migration of fishes including sturgeons.

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Czechia

Since Czechia is without access to the sea, inland fisheries still constitutes 100 percent of annual commercial catches. The fishery nevertheless is very small, and it is licensed to a company employing just four part-time fishers fishing in the Vestonice reservoir. The annual catch was 24 tonnes (2006). The extensive pond system in the south of the country, although mainly used for aquaculture purposes, may have some relevance for fisheries as well. The limited commercial fishery stands in sharp contrast to the 4 095 tonnes caught by the 330 000 anglers in the recreational fisheries sector (Ernst & Young, 2006). According to FAO FishstatJ, 3 841 tonnes were landed in 2015 of which 78 percent was common carp. In the last decade or so catches of most species appear to be relatively stable (FAO FishStatJ), but compared to the situation at the turn of the millennium, pikeperch, brown trout, eel and especially grayling are experiencing a decline, whereas introduced brook trout and rainbow trout are doing well. A particular success story is wells catfish where catches have more than doubled to 126 tonnes since 2000 (Horky, 2016).

Hydropower development has had a negative impact on migratory species such as eel, however water pollution levels seem to be improving. The main concern appears to be stocking with non-native species, as well as local overfishing by recreational fishers.

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Serbia

Serbia is a landlocked country, and has neither any marine fisheries activities nor any fishing vessels operating at sea under the Serbian flag. FAO fisheries statistics on Serbia as an independent state start in 2006. Landings reached a peak in 2011 with 5 384 tonnes, however, catches have experienced a 41 percent drop since then to 3 150 tonnes in 2015. Thirty percent of the catch was reported as not identified freshwater species, goldfish (16 percent), common carp (10 percent), pikeperch (6 percent), and silver carp (5 percent).

In 2013, 5 040 tonnes were caught by professional fishermen and recreational fishermen who landed 2 235 tonnes and 2 805 tonnes respectively. The number of professional fishermen was 511, and 77 589 permits were issued for recreational fishing (European Commission, 2015). Similar to what has been happening elsewhere in Europe, the influence of the recreational sector in shaping fisheries development is increasing (Smederevac-Lalić *et al*., 2012).

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Slovakia

Slovakia is drained by rivers forming part of the Danube basin, which drains an area of 47 087 km^2. In addition, there are 8 164 km of canals for drainage, irrigation and navigation (Novomeská and Kovač, 2016. The country also features many relatively small, mainly artificial, waterbodies (ponds and reservoirs) with a total area of 938 km^2 (Novomeská and Kovač, 2016).

Fishing is only recreational, with 120 000 registered fishers. Commercial fisheries basically disappeared when the country became independent (Novomeská and Kovač, 2016), and catches have since then fluctuated between 1 185 tonnes and 1 971 tonnes (the most recent reported catch in 2015). Catch reports are very detailed with 99.2 percent identified at genus and mostly at species level (FishStatJ). The dominant species is common carp with 75 percent of the catches (FishStatJ). The Iron Gates dams in Serbia and Romania have had serious impacts on the entire Danube River, and current hydropower development is an area of concern. Many aquatic ecosystems and fish habitats also became seriously degraded in the 1970s. The Nagyoras-Gabcikovo dam (initiated in 1977) seriously affected the internal delta of the Danube and required a lot of mitigation structural work. However, currently, surface waters are managed in line with the European Union Water Framework Directive.

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Belarus

Belarus has 53 rivers that are more than 100 km long. The biggest are the Dniepr, Prypiat, Zapadnaya and Neman Rivers. There are 10 000 lakes in the country of which 90 percent are oxbows of the Dniepr and Prypiat Rivers. Twenty-two lakes are larger than 10 km^2, of which the largest are the Naroch, Chervonoe, Vygonovsoe, Lukomlskoe, Nescherdo and Drisviaty lakes. In addition, there are 144 reservoirs with storage greater than 1 km^3.

Annual catches have varied between 553 tonnes and 1 122 tonnes since 2000. In 2015, 869 tonnes were landed. The 2015 catch is only about a quarter of the maximum landing recorded in 1989 (3 640 tonnes). Most of the catch is cyprinids, among which bream with 30 percent of total catches was the most important, and other important species were goldfish and roach (FishStatJ). In contrast, Semenchenko, Rizevski and Ermolaeva (2015), report that total catches reached 8 961 tonnes in 2010, of which roughly 30 percent came from the large lakes and 5 percent from reservoirs. It is not clear what is behind this discrepancy, however, it appears that catches by recreational fishers, which added up to more than 8 000 tonnes in 2010 (Semenchenko, Rizevski and Ermolaeva, 2015), are not reported to FAO.

The fishery is managed through stocking programmes and licensing. According to Semenchenko, Rizevski and Ermolaeva (2015), many lakes and rivers appear to be overexploited as the total fisheries potential is approximately 5 000 tonnes. Other negative impacts result from invasive species, dam construction and spawning habitat degradation.

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Montenegro

The annual catch in Montenegro was 662 tonnes of fish in 2015 (FishStatJ). The freshwater catch amounts to 520 tonnes from Lake Skadar (370 km^2) comprising mostly carp, but also bleak, crucian carp and eels. Catches consist mostly of trout (78 percent) and common carp (22 percent) (FishStatJ). The aggregated catches seem to be fairly stable. However, there is no definitive view as to whether the stocks are under fished or over fished. There are 400 licensed fishers with two hundred artisanal vessels. There is a high demand for Skadar Lake products at the local market. Most of the fish (mainly smoked carp) is sold informally, but 270 tonnes of fish is sold to a fish canning factory that has a fishing concession on Lake Skadar (MAFWM, 2006).

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Slovenia

Inland fish catch in Slovenia in 2015 was reported as 141 tonnes, the lowest reported to date. The highest catches were in 1994 with 339 tonnes. In spite of the low volume of the catch, the level of detail is impressive with more than 90 percent of the landings reported at the species level. The dominant species is common carp with 38 percent, followed by rainbow trout with 13 percent (FishStatJ). There were more than 14 000 recreational fishers in the country in 2004 (IUCN, 2004).

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Bulgaria

Natural waterbodies in Bulgaria are limited, consisting of 570 ha of lakes (Zlatanova cited in Mitchell, Vanberg and Sipponen, 2010). Bulgaria has 5 107 dams with a total water surface area of 637 km^2, and a total length of rivers for inland fishing of 20 231 km (150 km^2), including 471 km of the Danube River. Commercial inland fishing in Bulgaria occurs in the Danube River, artificial reservoirs and some natural lakes (Mitchell, Vanberg and Sipponen, 2010).

Inland catches were reported as 86 tonnes in 2015, just 3 percent of what was landed less than two decades ago in 1999 when the highest catch of 2 475 tonnes was recorded (FishStatJ). Half a decade ago inland fisheries made up 10.3 percent of the commercial landings, of this 17 percent came from the Danube and the remainder was caught in reservoirs. The detail of reporting to FAO is very good, showing that the fisheries for all species appear to have collapsed including common carp, goldfish, big head and silver carp. As recently as 2012, the landings of these four species were 1 239 tonnes (FishStatJ). It is recorded that 1 620 people worked in inland fisheries in 2010.

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Republic of Moldova

The Republic of Moldova is framed by two large rivers and a few middle-sized ones, and it is webbed by several thousand other rivers and water flows. Both the topography and water resources of the country are ideal for the construction of small water reservoirs and fish ponds. This is why the total artificial water surface in the country is so large. There are 41 707 ha of water reservoirs and ponds, of which 20 507 ha (49.2 percent) are used as fish farms.

Moldova has not reported inland fisheries catches since 2010, when 44 tonnes were landed. Since then FAO has estimated the catch at 50 tonnes per year. The highest catch ever recorded was 2 331 tonnes in 1990 (FishStatJ). However, since that year catches have never been above 200 tonnes, indicating that these fisheries probably were relying on continuous intensive stocking programmes that were not maintained after the transition to a market economy.

Most landings are from reservoirs and consist mainly of various cyprinids. Also in rivers, cyprinids and breams dominate (Zubcov *et al*., 2013).

Hydropower generation from dams on the Dniester River is causing damage to spawning sites because of daily fluctuations in water level. It also generates temperature variations which creates an unfavourable environment for fish. As a result, fish resources in the middle sector of Dniester River are now reduced by 94 percent, and the migration of juveniles from spawning sites has decreased by 84 percent (Zubcov *et al*., 2013).

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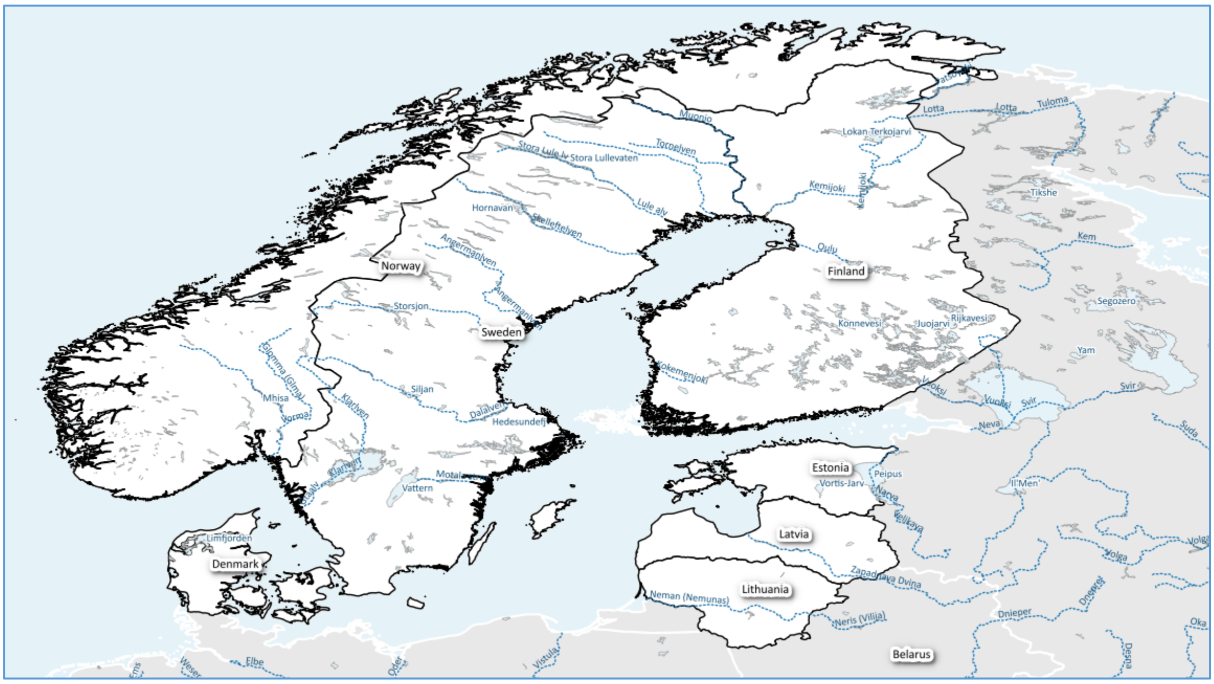
2.4.2 NORTHERN EUROPE



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Finland	29 476	5 426 000	4.34	0.26	110	268
Sweden	10 520	9 571 000	1.1	0.09	173	61
Estonia	2 654	1 287 000	2.26	0.02	12	225
Lithuania	1 437	3 017 000	0.48	0.01	24	59
Norway	408	5 043 000	0.07	0.00	387	1
Latvia	226	2 050 000	0.15	0.00	35	7
Iceland	201	330 000	0.57	0.00	166	1
Denmark	174	5 619 000	0.03	0.00	4	47

The main aquatic resources of Northern Europe are found around the extensive glacial lake networks that pervade the subregion. There are many short, steep rivers suitable for migratory salmonids, although some of these have lost connectivity because of damming.

Finland

The catch of Northern Europe is dominated by the catch of Finland, which contributed 65 percent of the subregion’s catch. Finland has a very large area of inland waters, which total 31 560 km^2 or 9.3 percent of the country's total land area. Finland still has a commercial lake fishery sector and the number of registered inland commercial fishers is 849 (Penttinen cited in Salmi and Sipponen, 2016), and about 3 percent of the fishers are women. The majority of the catch is taken by the recreational fishery sector that also catches fish for consumption (23 000 tonnes in 2014 according to Luke, 2016). Reported catches declined between 1995 and 2008 but have stabilized since then.

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Sweden

Sweden reported 10 520 tonnes in 2015 and this is an increase over the 2012 catch of less than 3 000 tonnes. It is assumed that this rise is the result of an improvement in assessment of the inland fishery catch.

Estonia

Estonia has 420 rivers of which ten are longer than 100 km. There are 1 200 lakes larger than 1 ha with a total area of 2 115 km^2. Most lakes are eutrophic although water quality is improving. The most important waterbody is Lake Peipsi-Pihkva, which is shared and jointly managed with the Russian Federation. It is the fourth largest lake in Europe (3 558 km^2) and it is a relatively shallow and productive lake.

Estonia reported a catch of 2 654 tonnes in 2015. The level of species detail in the report is excellent with almost all catch identified to species. The catches were dominated by perch (32 percent), bream (30 percent), pike-perch (18 percent), roach (10 percent) and northern pike and river lamprey (2 percent). The remaining 22 species all contributed less than 1 percent to the landings (FishStatJ).

European smelt, which used to be a very important species in the past with 1 421 tonnes in 1998 has now completely disappeared from the catches. A small-scale fishery in Lake Võrtsjärv for European eel relies on the stocking of elvers (Mitchell, Vanberg and Sipponen, 2012).

More than 90 percent of the catch comes from Lake Peipsi-Pihkva. According to the agreement with the Russian Federation, 20 seine boats (Danish seines) can be used on the Estonian side. However, the license holders own several boats that they rotate in use to make the most of their licences. Gillnets are also widely employed especially when the lake is ice covered. Fyke nets are used during the ice-free period (Vetemaa, Järvalt, and Vaino, 1999).

The number of people employed in inland fisheries has increased since 1999 when Vetemaa Järvalt, and Vaino (1999) reported that 400 to 500 people were employed in inland fisheries to 963 in 2008 (Mitchell, Vanberg and Sipponen, 2012). The number of vessels was 350 in 2006 whereas the number of permits was 291. This means that the licence holders used several boats and crews in rotation (Vetemaa, Järvalt, and Vaino, 1999; Mitchell, Vanberg and Sipponen, 2012).

Recreational fishery is important in Estonia, however very limited information about this subsector is available.

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Lithuania

Lithuania is rich in waterbodies. Of the country's 3 000 lakes, 2 827 are larger than 0.5 ha and 2 675 are large enough to support a commercial fishery. There are also 650 reservoirs and 1 589 ponds are larger than 0.5 ha (874 km^2). The largest waterbody, and the most important for fisheries is the brackishwater Curonian lagoon, which is shared with the Russian Federation (413 km^2 or 26 percent belong to Lithuania) (FAO, 2005; Mitchell, Vanberg and Sipponen, 2012). There are 30 000 rivers (of which 733 are longer than 10 km), as well as streamlets, brooks and canals. The largest river is the Nemunas and the Nemunas basin covers about 2/3 of the country. The Kaunas dam was built on the Nemunas River for hydropower generation (FAO, 1997). Other basins are the Lielupe, the Venta and the Daugava. The basins are shared with the neighboring countries (FAO, 2005; Mitchell, Vanberg and Sipponen, 2012).

Lithuania reports inland catches very regularly to FAO. Landings were 1 437 tonnes in 2015. There is no obvious trend in catches in recent years and they are usually about 1 500 tonnes. However, catches are markedly lower than the highest catch of 5 970 tonnes in 1990. The degree of species detail is very good with almost 100 percent of the catch assigned to species. In 2015 that catch was distributed among some 18 species. The most abundant species in the catches were: silver bream – 494 tonnes (34 percent) roach – 307 tonnes (21 percent); European smelt – 269 tonnes (19 percent); pike-perch – 106 tonnes (7 percent); vimba bream – 57 tonnes (4 percent); European perch – 49 tonnes (3 percent) and vendace – 43 tonnes (3 percent). Only 24 tonnes (2 percent) were reported as nei (FishStatJ).

The Curonian lagoon is the most significant inland fishing area. It is shared with the Russian Federation and has a productivity of over 30 kg/ha and accounts for about 80 percent of all inland fish, and is fished by about 75 companies. Ponds yield 100 to 150 tonnes per year, and rivers 150 to 170 tonnes, however rivers are important as spawning and nursery grounds for many species (Mitchell, Vanberg and Sipponen, 2012).

Inland fisheries constitute about 2 percent of total national landings and employ about 1 500 people, of which 300 are part of commercial operations operating 200 vessels. As in many other countries, recreational fishing is increasing in importance. There was an estimated 1 million recreational fishers in Lithuania in 2004 (Aps, Sharp and Kutonova, 2004) out of a population of 3.3 million people. Recreational fisheries are also very important for the tourist industry.

Overfishing of salmon and trout especially in the Curonian lagoon is significant, because of *inter alia* large-scale unemployment leading to illegal fishing activities. In addition, aquatic habitats are severely impacted by dams, polders, and reduction of natural spawning sites (Aps, Sharp and Kutonova, 2004).

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Norway

Norway has about 1 000 main rivers. The longest are the Glomma River (598 km), Tana River (360 km) and Numedalslågen River (337 km). There are 300 000 lakes with the largest being Mjøsa (368 $km^{2)}$, Femund (210 km^2) and Røsvatn (201 km^2). There are 11 major reservoirs, however many natural lakes have been impounded for hydropower generation which obscures the distinction between reservoirs and natural lakes (Dill, 1990).

Total inland catch reported to FAO in 2015 was 408 tonnes. Since the first report to FAO in 1970, landings have varied between 200 tonnes and 573 tonnes. The catches consist mostly of Atlantic salmon (86 percent), but also sea trout (13 percent) and Arctic char (1 percent). Towards the end of the 1990s Norway reported landings of 11 species, but these seem to have disappeared from the catches (FishStatJ). However, Dill (1990) discusses the challenges with obtaining reliable data on inland catches and indicates that official reports are serious underestimates. In 1980 for example the total yield of Norway's inland fisheries was estimated to be about 5 000 tonnes (Swang cited by Dill, 1990),

Norwegian lakes and rivers are naturally oligotrophic with low productivity and most suitable for salmonids, and Norway has more salmon rivers than any other country. Mjøsa has a yearly yield of 5 kg/ha consisting mostly of whitefish, but also of trout, pike, perch and burbot. The maximum sustainable yield of Arctic char in a mountain lake of central Norway has been estimated as 7 kg/ha/year (Jonsson cited by Dill, 1990).

Inland fisheries in Norway are dominated by recreational fisheries. However, netfishing (mainly bagnets) is allowed in the rivers where fishing rights are privately owned, although they are banned from estuaries (Dill, 1990). There are about ten private inland fisheries enterprises comprising 30 to 50 active commercial fishers (Mitchell, Vanberg and Sipponen, 2010).

Most salmon rivers are in a reasonably good shape in spite of hydroelectric development. This is partly because of the construction of 300 fishways. However, access roads to new hydropower sites have increased fishing pressure.

Eutrophication has in some cases (eg. Lake Mjøsa) led to excessive algal development in naturally oligotrophic lakes, and there are serious problems with acidification of both lakes and streams (particularly in Southern Norway) as a result of air pollution with sulphur and nitrogen oxides and this is affecting the reproductive stages of fish (Wright and Snekvik cited by Dill, 1990). The fish farming industry is a major source of organic waste. The fluke *Gyrodactylus salaris* caused severe losses of salmon parr in the 1980s. Exotic species including pink salmon and brook trout (*Salvelinus fontinalis*) are also potentially displacing native species (Dill, 1990).

The implementation of the European Union Water Framework Directive as of 2006 is expected to have a positive impact on the environmental health of the inland waters and provide a coordinated approach to monitoring procedures (Mitchell, Vanberg and Sipponen, 2012).

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Latvia

Latvia has 2 256 lakes larger than 1 ha corresponding to a total surface area of 1 000 km^2. The largest lakes are Lubana (82 km^2), Razna (58 km^2) and Engure (38 km^2). There are 12 500 rivers, with a total length of 60 000 km^2, 17 of them are longer than 100 km including Daugava, Lielupe, Venta, Aiviekste, and Gauja. There are 3 052 reservoirs including three major hydroelectric reservoirs, namely Kegums, Plavinas and Riga with a total area of 102 km^2 (Riekstins 1999; Mitchell, Vanberg and Sipponen, 2012). In 2015, Latvia reported landing 226 tonnes from inland fisheries. The fisheries have experienced an almost continuous decline since 2000 (FishStatJ). However, inland fishing has never been of significant scale since the country has only once reported landings over 600 tonnes (1 555 tonnes in 1988), indicating perhaps a change in reporting or data collection after independence. For 2015, 12 species are reported among which the most important are bream (26 percent), river lamprey (17 percent), tench (15 percent), pike (12 percent) and pike-perch (10 percent) (FishStatJ). Recreational fisheries are increasing in importance and although there are no statistics on catches these are probably of the same order of magnitude as commercial catches (Riekstins, 1999).

More than one third of those employed in the fisheries sector work in commercial inland fisheries. In 2005 there were 1 262 people working in inland fisheries, however 89 percent fish only occasionally. The level of employment has decreased dramatically in a short time as almost 3 500 people worked in the sector until 2003. There are 139 fishing boats (Mitchell, Vanbeerg and Sipponen, 2012).

Commercial fishing takes place in 202 lakes, 154 reservoirs and 4 rivers. Most of the species are cyprinids and are mostly caught in lakes. The only truly riverine species is the river lamprey, for which there is a traditional fishery and the species is considered a delicacy (Riekstins, 1999). The fishery is enhanced through restocking (Eurofish, undated). The important gears are gillnets, seines, and traps (Riekstins, 1999). However, recently there has been a move towards prohibiting fishing with traps and nets in many lakes and rivers, in favour of recreational fishery and angling.

Migratory species, including salmon, eel and lamprey, have decreased in abundance since the mid-seventies probably as a result of damming, pollution and eutrophication (Riekstins, 1999).

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Iceland

The total area of inland water in Iceland is 2 750 km^2. The source of the water is basically from melting snow and ice. There are about 250 large and small rivers ranging from 60 km to 237 km in length.

The longest rivers are Thjórsá (237 km), Jökulsá á Fjöllum (206 km), Ölfusá-Hvítá (185 km), and Skjálfandafljót (178 km) (Dill, 1990). Iceland has about 1 800 waterbodies (Mitchell, Vanberg and Sipponen, 2012), however they are mostly very small with only 15 larger than 10 km^2 and 68 between 1 and 10 km^2. The largest is Lake Thingvallavatn with an area of 84 km^2. Some lakes, including the second largest Thorisvatn, have no fish at all (Dill, 1990).

The icelandic fish fauna is poor with only five indigenous species: Atlantic salmon (*Salmo salar*) which ascends about 80 rivers up to 100 km; sea/brown trout (*S. trutta*) found in its resident form in any lake with suitable spawning grounds and the anadromous variety in the southern and southwestern part of the country; Arctic char (*Salvelinus alpinus*) occurs throughout the country in both a resident lake form (including a pelagic variety) and an anadromous form; European eel (*Anguilla anguilla*) is found in rivers; and threespine stickleback (*Gasterosteus aculeatus*) (Dill, 1990).

In 2015 total inland catches amounted to 201 tonnes. The highest catch reported was 907 tonnes in 1993. In 2015, only catches of Atlantic salmon was reported although in the past (up to 2013) also sea trout and Arctic char contributed to landings (FishStatJ).

The inland fisheries for salmon, trout and char have traditionally been an important source of food for the farmers, but increasingly serves as a source of income through renting fishing rights out to recreational fishers and mainly tourists. In particular, the salmon fisheries are among the best (and most expensive) in the world (Dill, 1990). Ninety percent of the total salmon catch in Iceland is caught by recreational fishers. The largest remaining net fishery for salmon occurs in the Ölfusa River where angling opportunities are limited (Mitchell, Vanberg and Sipponen, 2012). Fifteen rivers produce 1 500 to 3 500 rod-caught salmon per year and the best river, Laxá, produces 3 000 (some 15 tonnes).

Sportfishing for trout and Arctic char is practiced in both rivers and lakes, whereas commercial fishing for these species only takes place in three lakes (in 1978 Lake Thingvallavatn had an annual catch of 75 tonnes Arctic char). Lake Mývatn yields from 10 000 to 100 000 fish/year, an estimated catch of 20 tonnes/year, about 10 to 15 percent being trout, and the remainder being char (Jónasson cited by Dill, 1990). Winter fishing through the ice is practiced in some places (Dill, 1990).

Although a number of streams and natural lakes have been regulated, inland fisheries are still relatively unaffected by hydropower.

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Denmark

Danish inland waters consist of about 30 000 km of streams (of which 3 970 km are fishable). Two rivers are longer than 100 km, and five are longer than 60 km, the largest is Gudenå which is 158 km long with a basin of 2 700 km^2. There are about 500 mostly small and shallow waterbodies with a total area of 450 km^2. The largest is Lake Arresø (41 km^2) and the second largest Lake Esrom (17 km^2) (Dill, 1990; Rasmussen and Geertz-Hansen, 2001). In addition there are a variety of semi-inland waters: fjords, sheltered bays, estuaries, lagoons and creeks (Dill, 1990).

In 2015, 174 tonnes were landed. Catches have been increasing since 2008 when only 40 tonnes (the lowest catch on record) were landed. The highest reported catch was 7 122 tonnes in 1968 however there appears to be a problem with reporting since 97 percent of the catch at that time was rainbow trout.

In 2015 catches were divided among 11 species, the dominating species were seatrout (42 percent), European whitefish (19 percent), common dace (9 percent) and pike-perch (9 percent). Eel catches are down to 14 tonnes, which is about 10 percent of the catches three to four decades ago (FishStatJ).

Fishing rights to streams and lakes in Denmark generally belong to the owner of the adjoining land. The fishing rights to nearly all streams are privately owned. About 25 percent of lakes are owned by the state, whereas about 75 percent are privately owned. About 50 percent of the former are available for recreational fishing, and 40 percent are hired out to commercial fisheries or angling associations (Dill, 1990; Rasmussen and Geertz-Hansen, 2001).

The main commercial inland fishing areas in Denmark include Lake Arresø and the estuaries of Ringkøbing Fjord, Nissum Fjord, Limfjord, Randers Fjord and Isefjorden/Roskilde Fjord. In 2007 there was only one commercial inland fisher working full-time (on Lake Arresø). But part-time fishers are operating in 20 to 30 other lakes and a few rivers (Mitchell, Vanber and Sipponen, 2012). To these should be added stream and lake fishing by probably several thousand landowners for household use. However, commercial fishing is declining in importance and the number of commercial fishermen in Danish inland waters is expected to fall further in the future. Recreational fisheries are very popular in Denmark, and streams, and to some extent lakes, are already fully exploited, and put-and-take fisheries are increasingly popular (Rasmussen and Geertz-Hansen, 2001).

Virtually all streams and lakes are influenced by human activities. Many of the small lakes are highly eutrophic, and the fish fauna is dominated by cyprinids with few predators, such as pike (*Esox Lucius*) and pike-perch (*Sander lucioperca*). Most streams have been straightened and channelized and only 2 percent are physically unaltered. Numerous fish passes have been installed but are generally considered to be ineffective. Several stream restoration projects have however been undertaken. Efforts are also being made to rebalance eutrophied lakes through manipulating the species composition towards more predators (Rasmussen and Geertz-Hansen, 2001).

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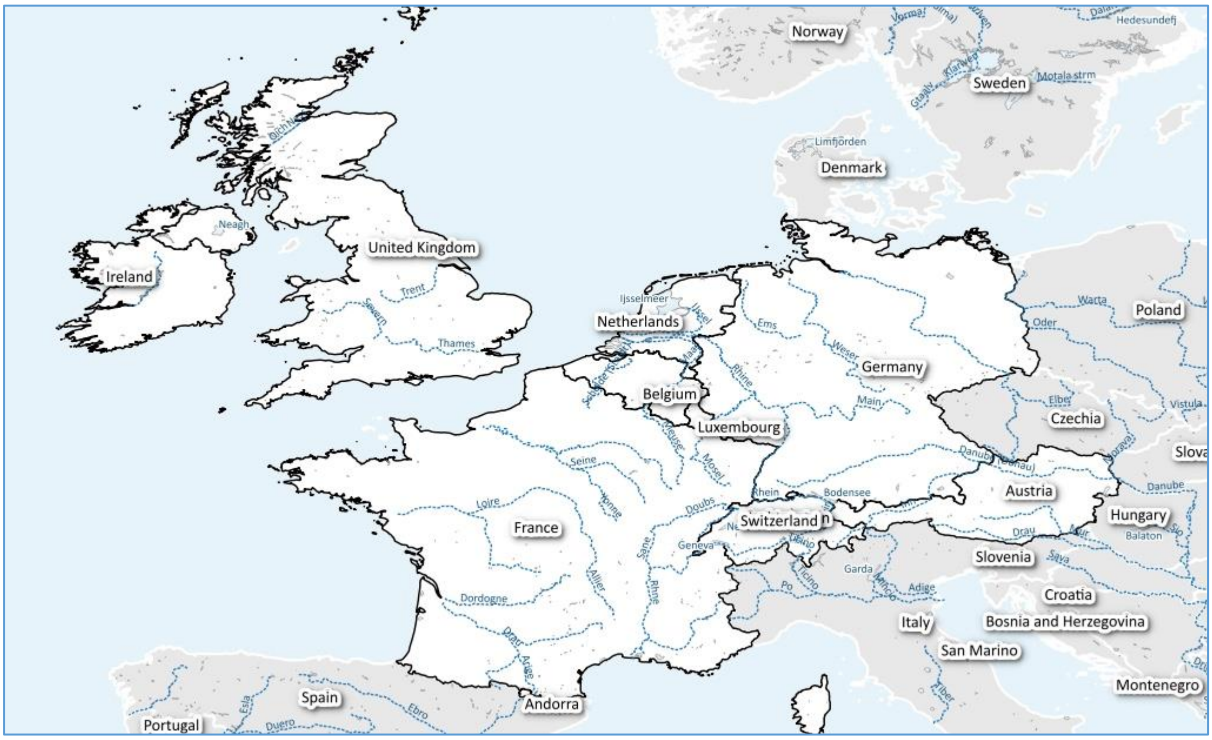
2.4.3 WESTERN EUROPE



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Germany	21 349	82 727 000	0.19	0.19	153	139
Switzerland	2 023	8 078 000	0.23	0.02	54	38
Netherlands	1 904	16 759 000	0.11	0.02	91	21
France	1 187	64 291 000	0.02	0.01	209	6
United Kingdom	747	63 384 000	0.04	0.01	146	5
Austria	350	8 495 000	0.04	0.00	78	5
Belgium	283	11 104 000	0.03	0.00	18	15
Ireland	78	4 627 000	0.02	0.00	51	2
Andorra	0	79 000	0	0.00	n.a.	n.a.
Channel Islands	0	n.a.	n.a.	0.00	n.a.	n.a.
Faroe Islands	0	49 000	0	0.00	n.a.	n.a.
Liechtenstein	0	37 000	0	0.00	n.a.	n.a.
Luxembourg	0	530 000	0	0.00	4	0

The main freshwater resources in Western Europe are the numerous rivers, some of which are large such as the Rhine, the Rhone and the Loire Rivers. There are also some reservoirs and large lakes in some countries. Most countries in Western Europe increasingly reserve their inland fish populations for recreational purposes (see Chapter 8 in this publication), but commercial fisheries do exist (Winfield and Gerdeaux, 2016). In some countries, the catch may be eaten but in others there is a catch-and-return policy. The catch is dominated by Germany, which still has significant commercial inland capture food fisheries. Other Western European countries reported catches from less than 100 tonnes (Ireland) to just over 2 000 tonnes (Switzerland). The trend in reported catch shows general declines for Germany, France, the United Kingdom of Great Britain and Northern Ireland with low, but stable catches for the Netherlands, Switzerland, Austria, Belgium and Ireland. Overall, the region's catch has declined consistently over the past 20 years with a 32 percent reduction from 40 836 tonnes (1995) to 27 921 tonnes in 2015.

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Germany

The Federal Republic of Germany has a total inland water area of about 8 453 km^2. There are many lakes, mainly confined to the northern, eastern and southern parts of the country, but there are numerous small, natural and artificial waterbodies scattered throughout the country. The inland water area in Germany used for inland fisheries (including angling and aquaculture) is about 536 777 ha, of which approximately 250 000 ha is used for commercial fishery on lakes and reservoirs (219 003 ha) and rivers (26 349 ha).

There are commercial fisheries in almost all river estuaries (including Elbe, Weser, Ems, Eider, Warnow, Peene and Schlei, Trave). Commercial river fisheries are locally significant, but not extensive. Important commercial lake fisheries are the pre-alpine lakes in Bavaria, Lake Constance (Bodensee), the lake region of Plön-Eutin in Schleswig-Holstein, the northeastern German lake region (Mecklenburg-Pomerania), and lakes and rivers in Brandenburg and Berlin. The commercial fishery targets eel, pike-perch and perch in the north and whitefish and perch in the pre-alpine region. A 1994 census returned a total of 587 inland fishing enterprises.

Germany is by far the largest producer in the region as there is still a significant commercial inland capture fisheries for food. The trend between 1995 and 2015 is of continuous decline, from nearly 23 000 tonnes to 15 000 tonnes in 2010. This was followed by a period of stable catch and in 2015 a significant increase back to 21 349 tonnes. This may be because of a re-estimation of the catch. The commercial catch in 2007 was 3 031 tonnes, compared with the FAO estimated total inland fish catch of 16 162 tonnes. The majority of fish caught are not specified, presumably because these catches come from unmonitored fisheries (i.e. retained catch from recreational fishing).

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Switzerland

Switzerland has a total inland water area of about 1 740 km^2. Lakes account for 1 422 km^2 of this and the total length of rivers is about 30 000 km. Commercial fishing in Switzerland is in the form of professional lake fishing and there were 349 professional fishers operating on lakes in Switzerland in 2004.The annual commercial catch in Switzerland's lakes since 2000 has averaged about 1 500 tonnes

(Mitchell, Vanberg and Sipponen, 2010). The rest of the country's catch is from non-professional fishing activities. In 2015, Switzerland's inland fish catch reported to FAO was 2 023 tonnes.

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Netherlands

Inland waters of the Netherlands occupy 3 574 km^2 and are comprised of Lake IJssel (2 000 km^2) and its marginal lakes (145 km^2), delta lakes (230 km^2), polder reservoirs (790 km^2) and rivers (212 km^2).The most important waterbody for commercial inland fishing is Lake IJssel. Other important areas include lakes Veerse, Grevelingen, Lauwer and parts of rivers in the south (FAO, 2005). The commercial inland catch in the Netherlands is about 2 450 tonnes (2006) with the majority of the value derived from eel fishery. Decreasing populations of eel are impacting the professional inland fishery with a decline of catches and yields. (Mitchell, Vanberg and Sipponen, 2010). The reported catch in 2015 was 1 904 tonnes (FishStatJ).

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France

France has a total area of inland waterbodies of 1 400 km^2. There are five major river systems with a total length of 270 650 km (Seine, Loire, Garonne, Rhône and Rhine) and 60 000 ha of lakes and approximately 100 000 ha of small lakes, ponds and marshes. Professional fishing in freshwater in France is a traditional activity concentrated in the estuaries of the Loire, Gironde and Adour Rivers and several alpine lakes. This accounts for about 60 percent of catch. The remaining 40 percent of catch is from river fisheries that focus on migratory species in particular. The most important catch species are eel, lamprey, shad, whitefish and perch. In 1997 there were 2 106 professional fishers operating in French inland waters, although by 2009 this was only 532 (Mitchell, Vanberg and Sipponen, 2010).

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United Kingdom of Great Britain and Northern Ireland

The United Kingdom of Great Britain and Northern Ireland has a total inland water area of 3 218 km^2 comprising 2 745 km^2 of lakes (including reservoirs), 38 802 km of rivers and 3 700 km^2 of estuaries. Most of the country's inland waters are exploited for recreational purposes, and there is little commercial exploitation of inland waters other than eel fisheries and limited salmonid fisheries. The most important areas for professional inland fisheries in the United Kingdom of Great Britain and Northern Ireland are Lough Neagh, Lough Erne, Lake Windermere, Lake Coniston, Severn Estuary, River Foyle Estuary, Solway Estuary, estuaries off the northeast coast of England and estuaries off the east, northeast and north coasts of Scotland (Aprahamian, 2007). Over 1 000 people are involved, mostly part-time, in the migratory salmonid and eel net fisheries of England and Wales (2004 to 2009). Increasingly, the government authority is buying out commercial licences, principally because of the recognition of the greater value brought in by recreational fishing and the need to reduce the impact of commercial fishing on this (Mitchell, Vanberg and Sipponen, 2010).

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Austria

In Austria, professional or commercial fisheries are located on Neusiedler See, lakes in the Salzkammergut, some Carinthian lakes and Bodensee (Lake Constance). River fisheries have ceased altogether with the exception of the Danube in Upper Austria, where fishing still provides added income in a few locations. Inland fisheries in rivers are almost completely managed for recreational purposes. Employment for commercial inland fisheries, including aquaculture, totals about 600, but less than 20 professional fishermen make a living from fishing. In 2004, it was reported that approximately 450 tonnes of fish were caught per year, the annual catch being balanced by stocking measures with commercially produced fish (Mitchell, Vanberg and Sipponen, 2010).

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Belgium

The inland fishery in Belgium is practised mostly for recreation and occasionally for subsistence in artificial fishing areas (private ponds, fishing grounds) and in the public hydrographic network of rivers and canals. There are no significant commercial inland fisheries in Belgium (Mitchell, Vanberg and Sipponen, 2010).

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Ireland

Ireland has a total area of 3 350 km^2 of inland waters, including freshwater lakes (1 445 km^2) and main channel rivers with a total length of about 13 840 km. Commercial inland fishing activity centres on commercial net fishing of salmon and sea trout and the exploitation of eels. In 2004, catch comprised of 431 tonnes of salmon and 124 tonnes of other species.

Since 2007 there has been a complete ban on drift net fishing, which accounted for 65 percent of the commercial salmon catch in Ireland. Between 2001 and 2007, declared commercial inland eel catch in Ireland ranged from 86 to 120 tonnes, but the actual eel catch is estimated to be about 250 tonnes per year (FAO, 2006; Mitchell, Vanberg and Sipponen, 2010). The catch reported to FAO in 2015 was only 78 tonnes.

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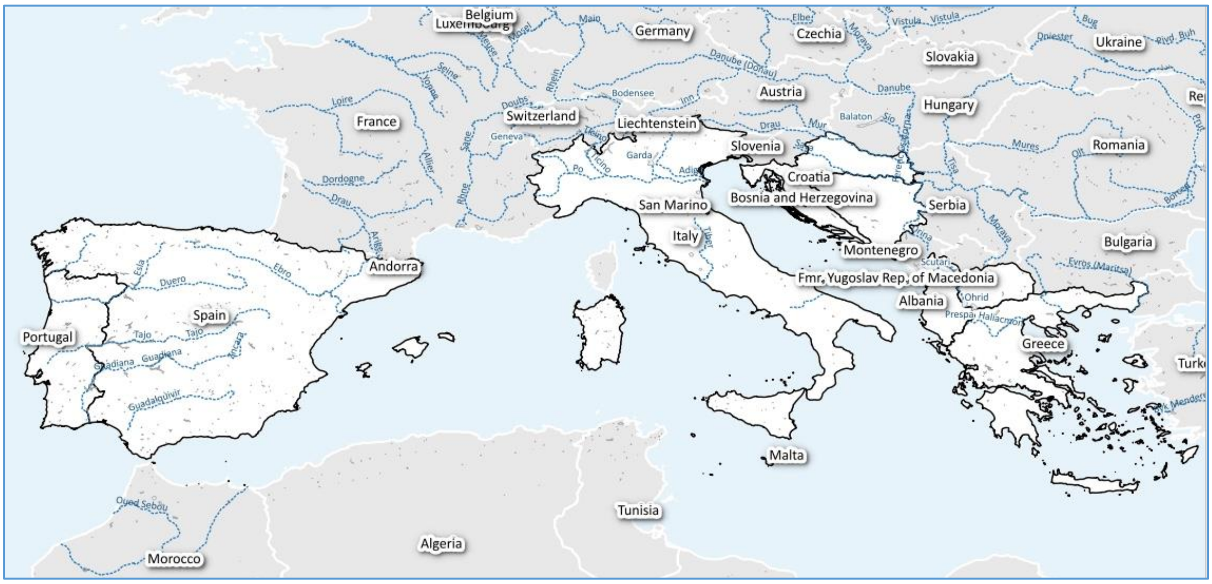
2.4.4 SOUTHERN EUROPE



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km³/yr)	Fish production per unit of renewable surface water (tonnes/km³/yr)
Spain	6 000	46 927 000	0.13	0.05	110	55
Italy	3 800	60 990 000	0.06	0.03	179	21
Albania	1 482	3 173 000	0.56	0.01	26	56
Greece	940	11 128 000	0.08	0.01	66	14
Croatia	444	4 290 000	0.1	0.00	95	5
Macedonia FYR	350	2 107 000	0.16	0.00	6	55
Bosnia and Herzegovina	300	3 829 000	0.08	0.00	36	8
Cyprus	20	1 141 000	0.02	0.00	1	36
Portugal	1	10 608 000	0	0.00	77	0
Malta	0	429 000	0	0.00	0	0

Southern Europe has a mixture of lake and river resources. Catches from the region have declined since the mid-1980s and are stabilizing at about 13 377 tonnes in 2015. The principal producer is Spain, which accounts for 45 percent of the total, followed by Italy with 28 percent, Albania with 11 percent, Greece with 7 percent. FAO has estimated the catch of Spain since 1996, and of Italy since 2011, so these figures may not be reliable and the apparent stabilization of catch in the subregion may reflect that the FAO estimates are unchanging.

Spain

Spain's inland waterbodies cover 655 000 ha. There is a limited number of large natural lakes, but a significant number of reservoirs and lagoons. There are about 72 000 km of permanent rivers (Ebro, Tajo, Guadalquivir, Duero, Miño and Guadiana). Spain’s inland fisheries subsector is concentrated primarily in the rivers. Professional capture fishing in Spain’s inland waters is only practiced in certain parts of the country (Mitchell, Vanberg and Sipponen, 2010). Catches have been estimated by FAO since 1996.

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Italy

Italy has 7 230 km² of inland waterbodies, comprising lakes (2 045 km²), reservoirs (500 km²), lagoons (1 500 km²) and principal rivers (7 782 km). Commercial inland fishing in Italy is limited to some lakes and reservoirs and to a few reaches of the larger rivers. The number of authorized professional inland (freshwater) fishermen was about 400 in 2004. The 3 825 tonnes of catch in 2005 comprised whitefish and trout (21 percent), eel (2 percent), perch and pike (11 percent), bleak, carp and tench (10 percent), big-scale sand smelt and other fish (56 percent). Commercial inland fishing is concentrated in relatively small waterbodies and lacks appropriate resource management models. It increasingly depends on direct restocking for fish recruitment. Inland waters suffer from pollution and habitat modification (Mitchell, Vanberg and Sipponen, 2010).

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Albania

Fishing in lakes, agricultural reservoirs and lagoons in Albania is important to small family-based groups of fishermen. Fishing activity in rivers is performed only in the Buna and Vjosa. Over 2 000 persons are employed in fishing activity in rivers, lakes, lagoons and agricultural reservoirs in Albania. In 2006 the commercial catch from Albanian coastal lagoons was 282 tonnes, whereas the commercial catch from other Albanian inland waters was 2 078 tonnes. The recreational fisheries sector is insignificant (Mitchell, Vanberg and Sipponen, 2010).

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Greece

Greece has inland water resources of 3 060 km^2. There are 14 artificial lakes occupying 26 000 ha. There are about 400 wetlands and nine rivers with a length of over 100 km. The main lakes are located in the centre and north of Greece, and most of the estimated 70 lagoon capture fisheries are in the Messalonghi region of Central Greece. In 2003 there were 919 people employed in commercial fishing.

In 1996 approximately 57 percent of the inland catch volume came from coastal lagoons with the main species caught being sea-bream, sea-bass, eel, mullet, white bream and sole (Mitchell, Vanberg and Sipponen, 2010). These are classified as marine capture catch and not inland catch therefore it is not reflected in the statistics provided by FAO. The actual inland fishery catch of freshwater species in 2015 was only 940 tonnes.

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Croatia

Croatia has 620 km^2 of inland waterbodies and 21 000 km of rivers and creeks. Commercial inland fishing in Croatia is confined to the Danube River and lower parts of the Sava River. Professional fishing is not allowed in lakes, reservoirs or estuaries. The total number of commercial inland fishers with licences is about 30 (2004). Common carp, cyprinid species, catfish, pike and pike-perch are the most important catch species of commercial inland fisheries. In 2004 commercial inland catches in Croatia totalled 46 tonnes (Mitchell, Vanberg and Sipponen, 2010). In 2015, this had reached 444 tonnes although it is unclear if this represents the catch from both commercial and non-commercial (recreational retained catch) fishing activities.

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The former Republic of Macedonia

The former Republic of Macedonia has no direct access to the sea for marine fishing. Inland fishing occurs on Lake Ohrid, Lake Prespa, and the Vardar River. FAO estimates total catch at 350 tonnes (2015).

Bosnia and Herzegovina

Quantitative information is unavailable on inland fisheries. Inland waterbodies occupy 470 km^2. Professional inland fisheries are carried out in the River Sava, but there are no professional fisheries in lakes, reservoirs or estuaries. FAO estimates total catch at 300 tonnes (2015).

2.5 THE AMERICAN CONTINENT

Subregion	Inland capture fishery catch (tonnes) (2015)	Fish production per unit of renewable surface water (tonnes/km^3/yr)	Percentage of global inland fishery catch	Per capita inland fishery catch (kg/cap/yr)	Number of inland fishers	Number of post-harvest workers
South America	362 481	20	3.2	0.90	414 335	n.a.
Central America	156 345	148	1.4	0.73	102 484	n.a.
North America	47 356	8	0.4	0.15	5 000	n.a.
Islands	4 333	57	0.0	0.09	2 505	n.a.
TOTAL	**570 515**	**233**	**5.0**	0.57	524 324	n.a.

The America continent is divided into four subregions that are classified by state of development as much as geographical affiliation. The South American group includes 13 countries (Brazil, Peru, Venezuela (Bolivarian Republic of), Argentina, Colombia, Paraguay, Bolivia (Plurinational State of), Uruguay, Guyana, Suriname, Ecuador, Chile and French Guyana).

The Central American group includes (Mexico, Guatemala, Costa Rica, Nicaragua, El Salvador, Panama, Honduras, Belize).

Mexico, which spans both the North and Central American subregions is included in the Central American grouping because of socio-economic similarities and the continued importance of freshwater fisheries as a source of food catch rather than recreational purposes.

The North American grouping is comprised of Canada and the United States of America.

There are five American islands that report inland fish catch (Cuba, Dominican Republic, Jamaica, Haiti, Falkland Islands (Malvinas).

2.5.1 SOUTH AMERICA

FAO map disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita Inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Brazil	225 000	200 362 000	1.19	1.96	8 647	26
Peru	37 499	30 376 000	0.9	0.33	1 880	20
Venezuela (Bolivarian Republic of)	33 654	30 405 000	1.4	0.29	1 303	26
Argentina	18 885	41 446 000	0.3	0.16	860	22
Colombia	18 554	48 321 000	0.37	0.16	2 360	8
Paraguay	17 000	6 802 000	2.5	0.15	388	44

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita Inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Bolivia (Plurinational State of)	7 000	10 671 000	0.67	0.06	548	13
Uruguay	3 434	3 407 000	0.61	0.03	172	20
Guyana	700	800 000	1	0.01	271	3
Suriname	650	539 000	1.21	0.01	99	7
Ecuador	105	15 738 000	0.01	0.00	432	0
Chile	0	17 620 000	0	0.00	923	0
French Guyana	0	249 000	0	0.00		n.a.

South America represents the most fluvial continent of the world and contains 22 percent of global inland waters (Lymer *et al*., 2016). It is characterized by several major river basins most of which are shared between several countries, including the Amazon (Bolivia (Plurinational State of), Brazil, Colombia, Ecuador, Guyana, Peru, and Venezuela (Bolivarian Republic of)), Orinoco (Colombia and the Bolivarian Republic of Venezuela) and the Plata River (Argentina, Bolivia (Plurinational State of), Brazil, Paraguay and Uruguay) and their tributaries. Other relevant basins are the Tocantins and São Francisco Rivers (Brazil), the Magdalena (Colombia) and the Essequibo River (Guyana and Venezuela (Bolivarian Republic of)). All these rivers flow to the Atlantic Ocean, are long and include both extensive rithronic and potamic areas.

The rivers are traditionally divided into black, clear and white water rivers, of which black and clear water rivers are nutrient poor and have low productivity (Sioli, 1968). Some of the main rivers form important inner deltas (Orinoco and Paraná), or external ones (Amazon and Magdalena), and are characterized by a high sediment load. Rivers draining to the west and the Pacific, because of the presence of the Andes range, generally are rather short, torrential, deep, mountain streams. These have high sediment loads that may lead to the formation of deltas. In the dry southern part, many rivers become seasonal and some basins are endorheic.

Major natural lakes are found in the mountain ranges, many of which are endorheic systems. The largest is the Lake Titicaca (shared between Peru and Bolivia (Plurinational State of)), which with an area of 8 400 km^2 is considered the largest mountain lake in the world (Llames and Zagarese, 2009). Other lakes are found throughout the Altiplano and these are mostly of much smaller size. Many of these lakes are severely threatened by the drier and warmer climate that has been observed in recent years, including the Lake Poopó, the second largest Bolivian lake, previously reaching an area of at least 2 492 km^2 and constituting an important fishing ground, which has now almost dried up completely (Satgé *et al*., 2017). Floodplain lakes are important features of all the major river basins whereas true lakes are very rare in the lowlands. There are a number of large reservoirs on some of these rivers and their tributaries as a result of hydropower dam construction.

The inland fishery catch of South America (362 482 tonnes in 2015) represents 3.2 percent of the global total, although administrators and researchers have admitted that estimates of catch levels are low, as there is a general failure to report any but the most significant landings from the main commercial markets (FAO, 2011). The catch of commercial fisheries of some major tributaries is not recorded and the artisanal and subsistence sectors are almost certainly excluded from most government estimates. Catch from these unreported fisheries may be considerable, especially among poorer riparian populations, however, the population densities and likely number of fishers must also be taken in to account before assuming that the hidden catch is substantially greater than that reported. FAO (2016) compiled information showing that at least 459 555 people are working in inland fisheries in nine South American countries, which points to a substantially higher catch.

South America exhibits the second largest theoretical capture after Asia, with 14.4 million tonnes, mostly derived from floodplains areas (Lymer *et al*., 2016). Compared to other continents, the South American continent shows the most productive fisheries yield for reservoirs (112 kg/ha/year) and floodplains (182 kg/ha/year). In addition, the South American continent has the second largest potential in the world for hydroelectricity behind Asia and contains 20 percent of the world's hydropower potential (Wolf, 2007). In this context, South America includes some of the highest dams and the largest reservoirs, most of them located in the Paraná River basin (Agostinho *et al*., 2008). Some information from consumption studies certainly indicates that the hidden catch may be substantially more than reported for some countries (e.g. the Plurinational State of Bolivia, Colombia) although for several others (Brazil, Venezuela (Bolivarian Republic of)) the opposite is the case (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

It has been pointed out that catch from all Latin American rivers and reservoirs is extremely low compared to Africa and Asia. There may be several reasons for this including low levels of fish consumption, preference for large fish species, relatively low population densities and thus comparatively low exploitation intensity, and possible differences in the nature of the fish communities.

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Brazil

Brazil represents the most fluvial country in the world with several large basins of great importance for fisheries. The most prominent is that of the Amazon River that extends 2 800 km from the tri-national border Peru – Brazil – Bolivia (Plurinational State of) to where it flows into the Atlantic Ocean covering a total area of 3.9 million km^2, followed in importance by the Paraná River basin with an area of 891 000 km^2, the Tocantins basin covering 757 000 km^2, the São Francisco basin with 634 000 km^2, the Paraguay basin with 369 000 km^2 (including the Pantanal wetland shared with Bolivia (Plurinational State of) and Paraguay) and the Uruguay basin covering 178 000 km^2.

Agostinho, Gomez and Pelicice (2007) estimate about 600 large reservoirs in the country and Paiva *et al*. (cited by Agostinho, Gomez and Pelicice, 2007) mention that there are at least 60 000 small reservoirs in the northeastern region alone. The total area flooded by reservoirs in Brazil is more than 35 200 km^2 (Agostinho, Gomez and Pelicice 2007).

The most recent fisheries statistics reported to FAO showed total landings of 235 527 tonnes from inland water for 2014, and an estimated catch of 225 000 tonnes in 2015, making it the thirteenth largest in the world. Catches have fluctuated over the years, but appear to be in a period of decline since 2008 when the highest catch of 261 280 tonnes was reported (FishStatJ). Considering the amount of waters available, catches appear to be very low or potentially seriously under-reported. FAO (1983), for example, estimated the country's fisheries potential to 700 000 tonnes, which still appears to be very conservative. Paiva (1976) estimated the fisheries potential of the 46 largest reservoirs in Brazil to be about 123 091 tonnes/year. In the public reservoirs of the northeast, potential capture was estimated at 130 000 tonnes/year (Paiva, 1983).

Brazil has made impressive progress with respect to the level of detail in their statistics and is now reporting more than 50 percent of the catch at the species level (more than 30 species) and another 27 percent of the landings at the generic level (FishStatJ).

The Amazon is the most productive basin with average annual landings of 141 000 tonnes divided among about 40 commercial species. This reported volume has been fairly stable for several decades, and corresponds to more than half of inland landings and about a third of overall fish catches in the country (Ruffino, 2016). The most important species are the large migratory pimelodid catfishes, and in the Central Amazon, migratory Characiformes particularly prochilodontids (Barthem and Goulding, 2007).

In the Paraguay basin average commercial catches in 2010 to 2015 were about 28 700 tonnes, of which the pimelodids *Pseudplatystoma corruscans* (32 percent) and *Pseudoplatystoma reticulatum* (23 percent) are the dominant species (Ruffino and Baigún, 2017).

The Brazilian Pantanal is shared between the two states Mato Grosso and Mato Grosso do Sul. In 1983, an estimated 7 505 tonnes were landed in the Pantanal, of which 2 069 tonnes came from Mato Grosso do Sul. However, commercial (artisanal) fisheries have now been severely restricted in the latter state and artisanal fishers have largely been pushed out by recreational fishers of which there are about ten times as many, and it is believed that the latter are responsible for more than 80 percent of the total catch (Resende, 2003). Commercial fishing is still prevalent in Mato Grosso state, but there are no recent estimates of catch volumes.

The Paraná basin is characterized by the presence of numerous dams. Petrere *et al*. (2007) reported that the Paraná basin is the most intensively dammed in South America, and that 70 percent of Brazilian reservoirs are concentrated here. Agostinho, Gomez and Pelicice (2007) provides quantitative data on landings in nine major reservoirs in the Paraná basin with a total annual yield of 2 447 tonnes of which 60 percent comes from the Itaipu.

However, the fisheries in the free-flowing parts of the rivers in the basin appear to be unassessed.

In spite of the size of the basin, it is hard to find any quantitative data on the landings from the São Francisco River. Menezes (cited by Ziesler and Ardizzone, 1979) mentions an annual catch of 4 980 to 5 304 tonnes in the period 1966 to 1968 before the big dams were built. At that time a potential yield of 18 000 tonnes was estimated (Ziesler and Ardizzone, 1979). The São Francisco River fishery has been severely impacted by the construction of several major dams. In the 1980s the basin supported about 25 000 professional fishermen, however, that number has decreased significantly since then. In the 1970s, catch per unit effort (CPUE) was about 25 kg/fisherman/day, whereas in the 1980s it was reduced to about 11 kg/fisherman/day in the central segment. The Sobradinho dam yielded 24 000 tonnes when catch peaked in 1980 but later catches declined to 3 000 tonnes. The Tres Marias and Paulo Alfonso dams yield about 500 tonnes and the Itaparica 4 000 tonnes.

According to FAO (2017), apparent consumption was 9.6 kg/cap/year in 2015. Using the household consumption model, Fluet-Chouinard, Funge-Smith & McIntyre. (2018) reach an estimated national catch for 2008/2009 of only 171 783 tonnes (range 141 308 to 201 280 tonnes). This is based on the fish consumption figures of the household survey, which averages 8.7 kg/capita per year.

The Brazilian government puts consumption at 14 or 15 kg/capita/year (Government of Brazil, 2017), which is still below the global average of about 20 kg/capita/year. Isaac and Almeida (2011) reviewed fish consumption studies in the Brazilian Amazon basin and extrapolated the findings to the entire region and concluded that annual consumption could be approximately 575 000 tonnes of Amazonian fish.

Generally people in the Amazon eat between 30 and 150 kg/person per year with major differences between urban and rural areas (with respectively lower and higher consumption rates). Near the border with Colombia, Fabré and Alonso (1998) found people who eat up to 0.8 kg fish per person per day or almost 300 kg/person/year.

For the Paraná basin, data on fish consumption are scarce. Available data indicate that 50 to 60 percent of the catches are eaten (Resende, 2003). Data from Pantanal show that children eat fish 4.6 to 7.8 times per week (Tavares *et al*., 2005) and Ceccatto *et al*. (2015) state that consumption among children, women of childbearing age and the rest of the population is respectively 51.1, 62.1 and 73.0 kg/person per year, however the authors do not account for how they arrived at these numbers.

Ruffino (2016) provides a consumption figure of 15 kg/capita/year for the eastern Atlantic basin and 5 kg/capita/year for the northeastern Atlantic part. The strong differences in freshwater fish consumption highlight that some communities have a strong fish eating tradition and arguably food security dependence on freshwater fish. This also highlights the variation that is often found in large countries, emphasizing that national catch figures and average (or apparent) fish consumption can be quite misleading with regard to local dependence and food security.

Sport fishing is an economically important activity and of growing significance both in terms of potential impacts on the resources, value generated, and competition with the artisanal fisheries for access and resources. In the upper Paraguay sector (Pantanal), sportfishing duplicates the volume captured by the artisanal fishery. Regulations in favour of recreational fisheries have resulted in significant declines in landings from almost 1 and 200 tonnes annually in 1998 to about 200 tonnes since 2007. In the Paraná basin, sport/recreational fishery is mostly practiced in reservoirs where *Cichla* sp. is the main captured species. In this basin the activity represents a movement of USD 305 million to USD 570 million per year, supporting the livelihoods of 4 000 people (Freire *et al*., 2012, 2016).

Ornamental fishing appears as the third economic activity in the Amazon basin representing an important source of work for 10 000 people (Chao, 1993) and involving 60 species (Beltrão dos Anjos *et al*., 2009). Between 2002 and 2005 about 100 million ornamental fish were exported representing USD 9.6 millions and USD 1.5 million revenue for local markets.

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Peru

The surface water resources of Peru can be divided in three main areas: coastal; Amazon basin; and montane (Autoridad Nacional del Agua, 2016).

The Pacific coastal region which has an area of 283 600 km^2 includes 22 percent of the territory of Peru and 62 basins with short rivers that often run dry during part of the year. There are also 3 896 mainly small lakes and lagoons in the Pacific coastal region. The Amazon basin has 84 river basins and 7 441 waterbodies. The area of the Amazon basin is 952 800 km^2, corresponding to 74 percent of the territory of Peru, and can be further divided into the highland and the lower jungle. The high Andes borders Bolivia (Plurinational State of) and shares with that country Lake Titicaca. Lake Titicaca itself has an area of about 8 300 km^2 of which 60 percent belongs to Peru. There are 13 river basins and 864 lakes in the montane area of the country.

Reported inland catches reached 37 499 tonnes in 2015, some 12 817 tonnes or 52 percent more than in 2014 when the landings were the smallest in 33 years (FAO FishStatJ, 2017). This figure for 2015 is slightly different from the 38 567 tonnes reported by Ministerio de la Producción (2016), which includes 1 817 tonnes from the highlands and 36 750 from the Amazon.

According to FishStatJ, fish landings peaked in 1995 with 54 175 tonnes, and has since experienced big fluctuations around a mean of 38 878 tonnes with a minimum of 24 882 tonnes in 2008. Using the household consumption model, Fluet-Chouinard, Funge-Smith and McIntyre (2018) reach an estimated national catch for 2003/2004 of 38 475 tonnes (range 29 781 tonnes to 48 894 tonnes). This is in excellent agreement with the reported figures above. It indicates that inland fisheries contribute 1.4 kg to per capita consumption of fish, but this in fact is far more concentrated in the Amazonian region of the country, so it would be relatively higher here.

The most important species (FAO FishStatJ) in terms of volume is the netted prochilod with almost one third of the landings. However, 60 percent of the volume is not identified and reported as nei. Much more detail is provided by Ministerio de la Producción (2016), which (reporting on 28 species) states that following the netted prochilod in importance are palometa, trahira, and zungaro catfish.

The rivers of the Pacific sustain local fisheries for native species, but it is mainly for own or local consumption (Ortega *et al*., 2012). The main resource in these rivers is freshwater shrimps (FAO, 1983). Because of the ephemeral nature of many of these rivers, fishing is probably a seasonal or occasional practice and there are no quantitative estimates of the volumes of fish and crustaceans landed.

The lowland fisheries are commercial artisanal activities and take place in the main rivers. The majority of the commercial fish is landed in the Department of Loreto where some 28 000 tonnes of fish, or 75 percent of total landings from inland fisheries at the national level was landed in 2015. Catches here were much lower in 2014, probably because of drought and flooding. The most important fisheries are concentrated in the vicinity of urban centres such as Puerto Maldonado, Pucallpa Ucayali, and Iquitos (Ortega *et al*., 2012).

Bayley (in Tello and Bayley, 2001) estimated the total catch in the Peruvian Amazon at 80 000 tonnes, of which 25 percent (20 000 tonnes) was from commercial fisheries and the rest from subsistence fisheries. These subsistence catches do not appear to have ever been fully included in official statistics. There have not been any more recent assessments done, however, commercial catches have remained at similar levels since the work of Bayley, and there is no reason to believe that the contribution by subsistence fishing is any different. FAO (1983) estimated a catch potential of 340 000 tonnes of the lowland Amazon in Peru.

The most important fisheries product in the mountains is currently the freshwater shrimps with a landed volume of more than 1 000 tonnes (Ministerio de la Producción, 2016). However, previously Argentinean silverside was very important with annual landings of up to 4 350 tonnes (1990) and for the period 1981 to 2010 a total of 46 178 tonnes of Argentinean silverside was landed corresponding to 43.4 percent of the total volume of finfish (Chura Cruz, 2012). In 2015 only 216 tonnes were caught (Ministerio de la Producción, 2016).

The 2013 inland fisheries census found 31 616 inland fishers (INEI, 2014) compared to 56 559 artisanal fishers in the marine environment (Medicina Di Paolo, 2014). The number of fishers around Lakes Titicaca, and Arapa and Umayo Lagoons in 2006 was 1 734 (Segura *et al*. cited by Chura Cruz, 2012).

Bayley and Petrere (1989) in their review found that the consumption of fish in the Amazon basin was up to 101 kg/capita/year in the lowlands and between 7 and 14 kg/capita/year in upland areas. Maco (cited by Cañas *et al*., 2017) found consumption levels of 180 kg fish per person per year in Saramiriza in the Loreto Department and 110 kg/capita/year in the Tahuayo basin.

Chura Cruz (2012) states that 95 percent of the catches from Lake Titicaca is consumed in the Puno region and in the area near Bolivia (Plurinational State of).

Fishing for ornamental fish is a major source of employment. Gertsner *et al*. (2005) stated that 3 000 families find employment in ornamental fisheries and that it benefits 100 000 people. In the period 2000 to 2010 between 5.8 million and 11.5 million fishes were extracted annually for ornamental purposes (García *et al*. cited by Cañas *et al*., 2017).

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Venezuela (Bolivarian Republic of)

The dominant feature among the surface water resources in Venezuela (Bolivarian Republic of) is the Orinoco River. The river mainstream is mostly located in Venezuela (Bolivarian Republic of) although it serves as a border with Colombia in parts of the Upper basin. The basin has an area of 1.1 million km^2 of which about 70 percent is in Venezuela (Bolivarian Republic of) and 30 percent in Colombia. The river has the third largest annual discharge of any river in the world, and the middle and lower sections of the basin include 97 000 km^2 of floodplains in Venezuela (Bolivarian Republic of) (Hamilton and Lewis, 1990). Along the 600 km from the confluence with the Meta to the delta, the Orinoco mainstream has a 7 000 km^2 fringing floodplains with 2 300 floodplain lakes (mean lake area 20 ha). When flooding is at its maximum, 79 percent of the floodplain is flooded forest (Hamilton and Lewis, 1990). In the Apure sub-basin an enormous internal delta of 70 000 km^2 is found (Welcomme, 1979). However, Lewis (1988) points out that only 4 920 km^2 are connected with the river and the rest is filled with rainwater. In the Orinoco delta there is a 20 000 km^2 floodplain (Welcomme, 1979).

In the southern part of the country an area of 53 000 km^2 is part of the Amazon basin (Lasso Alcalá, 2011).

Among the lakes, the most important is Lake Maracaibo and its basin. The lake, which is actually a giant brackishwater lagoon connected to the Caribbean Sea, has an area of 12 000 km^2 and its basin covers 90 000 km^2 of which 85 percent is in Venezuela (Bolivarian Republic of) (Ziesler and Ardizzone, 1979) and 135 permanent rivers end in the lake (Cressa *et al*., 1993). The endorheic Lake Valencia has an area of 350 km^2 and its basin, which includes many smaller rivers, covers 3 140 km^2 (Ziesler and Ardizzone, 1979).

According to Minea (undated), there are 108 reservoirs in the country; a total area is not provided, but Petrere (1996) mentioned that 82 reservoirs in 1990 inundated 7 000 km^2. The Guri dam, which was constructed on the blackwater Caroní River, is the largest with an area of 4 250 km^2 (Cressa *et al*., 1993). Cressa *et al*. (1993) also make reference to a large number of coastal lagoons along the Caribbean coast.

According to FishStatJ, fish landings peaked in 1995 with 54 175 tonnes, and have since experienced big fluctuations around a mean of 38 878 tonnes with a minimum of 24 882 tonnes in 2008. Official data only appears to include Orinoco catches where most inland fish is landed. Using the household consumption model, Fluet-Chouinard, Funge-Smith and McIntyre (2018) reach an estimated national catch for 2004/2005 of only 43 354 tonnes (range 39 320 to 47 748 tonnes). This is in very good agreement with the reported figures.

The Orinoco basin has an extraordinary species richness with about 1 000 fish species recorded, of which 60 have importance in commercial and subsistence fisheries. However, there is very limited species data available in FishStatJ for Venezuela (Bolivarian Republic of), and it does not allow for any analysis of trends. Nevertheless, Machado-Allison and Bottini (2010) and Machado-Allison (2013) present information and analysis of the official catch data by INSOPESCA for the Orinoco from 1996 to 2011. They arrive at the conclusion that there is a negative trend where catches have declined by 40 to 50 percent and with some of the key commercial species of catfish even disappearing. Landings of the pimelodid catfish *Pseudoplatystoma orinocense* in 1996 was for example 8 815 tonnes, whereas in 2011 only 1 537 tonnes were landed (a decrease of 80 percent). The commercial fishery for prochilodontids now mainly occurs in the lower portions of the tributaries (Duque, Taphorn and

Winemiller, 1998). This is in spite of efforts by the government to strengthen the sector through loan facilities for engines and fishing gear etcetera (Machado-Allison and Botini, 2017).

Although there is no conclusive evidence for the reasons behind the decline in catches, it seems that it may be a mixture of overexploitation, environmental degradation and blockage of migration routes because of dike and dam construction. Agricultural development has led to extensive deforestation and the resulting erosion has led to increased sediment loads of the rivers draining the Andes. The drier climate and the reduced flows have allowed fishers to completely fish out smaller streams (Rodriguez *et al*., 2007). The palambra, a migratory characid, has suffered decline in abundance because of dams and other human impacts (Lilyestrom and Taphorn, 1983).

In the Orinoco delta, CPUE has actually increased in the last 35 years, however the large predators have disappeared or are caught at a much smaller size, and smaller detritivores and herbivores are more abundant (Rodriguez *et al*., 2007).

There is no recent data for other courses or waterbodies in the country, although they may be potentially significant. Ziesler and Ardizzone (1979) for example mention that between 9 800 and 17 195 tonnes were landed annually in Lake Maracaibo between 1973 and 1977 and FAO (1983) provides a landing volume of 25 000 tonnes for 1970.

FAO (1983) estimated that the fisheries potential for the country was 190 000 tonnes for inland fisheries. However, Petrere (2009) felt that the Orinoco basin with its vast floodplains could have a fisheries potential of 164 900 to 582 000 tonnes per year. Curra (cited by Cressa *et al*., 1993) indicated a potential of 13 500 and 9 300 tonnes of zooplanktivorous fish in the lagoons Unare and Píritu, respectively. Cressa *et al*. (1993) suggest that reservoirs in the country may have a fisheries potential of 30 000 tonnes per year. However, Novoa and Ramos (cited by Cressa *et al*., 1993) give a potential of 30 000 tonnes to 40 000 tonnes for the Guri reservoir alone, which appears optimistic considering the trophic status of the waters.

Based on a review of consumption studies, Lasso Alcalá (2011) concludes that indigenous people in the Venezuelan Amazon catch at least 367 tonnes of fish each year from subsistence fishing activities.

In the Upper Orinoco and the Amazon basin fishing is mainly for subsistence among indigenous people and local trade in the villages and towns in the region. However, in this part there are also important ornamental fisheries and sportfishing. Most sportfishing in Venezuela (Bolivarian Republic of) centres on the peacock bass (*Cichla* spp.), which is highly sensitive to overharvesting. In areas with good access for anglers and net fishers, the populations of this species are soon decimated such as happened in the Aguaro River and Las Majaguas reservoir where illegal fishing destroyed the stocks in just ten years. Another important sportsfish, the saltador (*Salminus hilarii*), a predatory characid, once common in rivers of the Andean piedmont, has now been nearly eliminated by overfishing, deforestation and siltation, and dam construction (Winemiller, Marrero and Taphorn, 1996).

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Colombia

About 26 percent of Colombia's land area is regularly flooded (Jaramillo *et al*., 2015). The country can be divided in four watersheds: Caribbean (373 904 km^2), Pacific (77 299 km^2), Amazon basin (341 994 km^2) and Orinoco basin (347 208 km^2) (Jaramillo *et al*., 2015, Jiménez-Segura *et al*., 2017) and more than 700 000 micro basins are found in the country (OECD, 2016). With the exception of the rivers in the Pacific catchment, the Colombian rivers have extensive floodplains with lakes that are important as nursery areas for commercial fish species (Jiménez-Segura *et al*., 2017). There are about 1 015 floodplain lakes (ciénagas) (3 976 km^2), 1 277 lagoons (1 836 km^2), 1 065 mountain (páramo) lagoons (68 km^2), 234 swamps (1 654 km^2) and 28 reservoirs (5 186 km^2) (IDEAM, 2010 and 2014).

Historically, the Magdalena basin has been the main contributor accounting for 30 to 90 percent of inland catch. However, over the last 50 years, catches in this basin have declined 97 percent or from 72 000 tonnes per year to just 2 400 tonnes now (Jiménez-Segura *et al*., 2017). In 2010 landings were still 39 040 tonnes (Valderrama, 2015). Kapetsky (1978) established a fisheries potential of 80 000 tonnes to 120 000 tonnes/year for the Magdalena basin with an optimal level of extraction of 65 000 tonnes. The Magdalena basin is densely populated and is home to 80 percent of the population. It is considered that the decline stems from habitat degradation and fragmentation in synergy with pollution and species introductions (Barletta *et al*., 2016).

The southernmost Colombian city of Leticia in the heart of the Amazon is the regional centre for the fish trade, particularly of large catfish. It also receives landings from neighbouring Peru and especially

Brazil. From Leticia, fish are transported by plane to Bogotá, where demand is high. In 1993, commercial catches exceeded 13 500 tonnes (Anzola-Potes 1995 in Diaz-Sarmiento and Alvarez-León, 2004). Between 2004 and 2013 landings reached 56 165 tonnes of fish, mainly pimelodid catfishes (MADR and FAO, 2015). This data only includes commercial catches, and is basically based on records from packing plants and ports. It is considered that the commercial catches are likely to be under-reported (Diaz-Sarmiento and Alvarez-León, 2004).

The population in the region was 960 239 people in 2005 of which about 9 percent are indigenous people (DANE cited by SIAT-AC, undated) who traditionally consume large amounts of fish. Prieto-Piraquive (2006), studying consumption patterns in an indigenous community La Playa near Leticia, found that people eat from 200 g to 700 g of fish/capita/day depending on the season and the average was 450 g/day (164 kg/yr). It therefore seems likely that subsistence catches at least rival, and quite possibly are significantly higher than, commercial landings. The contribution of landings from Brazil cannot be separated out from these figures.

The Orinoco basin contributes 6 to 22 percent of national inland catch. According to available statistics, catches declined from 7 742 tonnes in 1995 to 1 024 tonnes in 2009 (Ramírez-Gil and Ajiaco-Martínez, 2011). However, the statistics obtained from 1999 to 2005 are not directly comparable to those of 2006 to 2011, because of a change in the data collection. In the latter period, catches varied between 1 062 and 1 436 tonnes (Jiménez-Segura *et al*., 2017). About 30 percent of the Orinoco basin is situated in Colombia, the remainder in Venezuela (Bolivarian Republic of), and considering that the Venezuelan catch is up to about 50 000 tonnes per year (see statistics cited earlier for Venezuela (Bolivarian Republic of)), Machado-Allison (2016) indicates an annual catch of 25 000 tonnes in the Colombian Orinoco, however he does not provide any source for this information. FAO (1983) suggests that the potential catch from the Orinoco system would be 10 000 tonnes. There are about 2 458 fishermen in the Colombian Orinoco and CPUE ranges from 5.7 to 60.0 kg/canoe per day (Ramírez-Gil and Ajiaco-Martínez, 2011).

The other Caribbean river basins Sinú and Atrato also have important fisheries, but like the Magdalena have suffered serious declines. In 1989, 2 000 tonnes of fish were landed in Sinú whereas in 2009 this was down to 242 tonnes (Jiménez-Segura *et al*., 2017). The Middle Atrato River produced 5 000 tonnes in 2001 and 1 600 tonnes came out of the floodplains (Gutiérrez-Bonilla, Rivas-Lara and Rincón-López, 2011).

The riverine fisheries are mainly targeting potamodromous fish species, eg. pimelodid catfishes and prochilodontids, and in the Pacific and Caribbean also several species of diadromous fish. Reservoirs are stocked mostly with exotic species such as *Cyprinus carpio*, *Oreochromis niloticus*, *Onchorhynchus mykiss*, *Coptodon rendalli* and *Micropterus salmoides*. There is no continuous monitoring by the government of success or failure of any of these programmes. The Urrá reservoir in the Sinu basin is an exception as it produces about 100 tonnes of native species per year. Since the dam started operation in 2002 it has been stocked with approximately 100 million fingerlings of indigenous species, and has been monitored with the objective of evaluating the efficiency of the stocking programme. The Porce II reservoir on the Porce River in the Caribbean basin, had an annual yield of 238 tonnes of six exotic species between 2011 and 2012 (López-Sánchez *et al*., forthcoming.).

The number of fishers in inland waters in Colombia has been estimated to about 150 000 (Gutierrez-Bonilla, Barreto Reyes and Mancilla Páramo, 2011) of which 74 percent are full-time fishers, 23 percent occasional and 3 percent seasonal (González *et al*., 2015). However, this is considered a significant underestimate (Jiménez-Segura *et al*., 2017).

The official employment in inland fishery reported to FAO (2014) is only 11 793 fishers. This figure is in the same order, but lower, than results of surveys. There have been conflicting results from various censuses, indicating that the estimates are not very precise. The National Fisheries and Aquaculture Authority (AUNAP) counted 4 370 economic fishing units at sampled landing sites in the Amazonas and the Caribbean, therefore if each unit corresponds to two fishers this corresponds to 8 740 fishers in the two basins (6 012 in Magdalena, and 2 728 in the Amazonas) (Altamar and Zuñiga, 2015). Cormagdalena (2016) carried out a census of the members of six of the eight fisher associations in the Magdalena basin (which unites a total of 156 fisher associations) and counted 7 796 fishers. If we consider that half of the fishers are organized (González *et al*., 2015), it is possible that there would be about 16 000 fishers in the Magdalena basin. This is still much lower than that indicated by researchers and agencies (Cormagdalena, 2008). Contreras (cited in Gutierrez-Bonilla, Barreto Reyes and Mancilla Páramo, 2011) mentions a figure of 46 000 fishers for the Magdalena basin.

Employment in the inland fishery is linked to the complexity of the value chain. In the Magdalena basin, Gutierrez-Bonilla, Barreto Reyes and Mancilla Páramo (2011) estimate that for each active fisher there would be eight others who would be economically dependent on his catch, playing roles such as intermediaries, primary or secondary retailers and wholesalers at the central markets. With a fisher population of 46 000, this indicates that more than 400 000 people depend on the fisheries for employment.

Inland fisheries in Colombia have contributed between 15 and 80 percent of total reported fish landings over the last 21 years (reported between 5 813 tonnes/year and 72 162 tonnes/year). The last year that Colombia reported inland catch to FAO was in 2011, since then FAO has estimated catches. In 2015 the FAO estimate was 18 554 tonnes.

Colombian catches appear to be either under-reported or exploited very lightly. A figure of 60 400 tonnes is obtained by combining the catch estimates of 56 000 tonnes of landings from the Amazonian region, 2 400 tonnes in Magdalena (down from 39 040 in 2010), over 1 000 tonnes from the Orinoco basin (although suggestions are this could be as high as 25 000 tonnes) and perhaps another 1 000 tonnes from the Caribbean basin.

Using the household consumption model, Fluet-Chouinard, Funge-Smith and McIntyre (2018) reach an estimated national catch of 103 197 tonnes for 2006-07 (range from 84 503 to 127 410 tonnes). It is higher than the combined figure above, it may be an overestimate, but does underscore that consumption of freshwater fish and therefore national catch is likely to be far higher than currently estimated (18 554 tonnes).

Colombia represents 5 percent of the global trade in ornamental fishes (OECD, 2016), with some 366 species traded (Ortega-Lara, 2015). Ornamental fisheries mainly take place in the Orinoco and Amazonas basins (80 to 85 percent), with a small contribution from the Caribbean basin (Jiménez-Segura *et al*., 2017).

Recreational fishing mainly takes place in the Carribean, Amazon and Orinoco basins and requires a licence issued by the fisheries authority (Jimienez-Segura *et al*., 2017). There are no available estimates of the value of this activity.

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Paraguay

Paraguay is situated entirely in the Plata River basin (Barberis cited by Quiros, 2004) and has an estimated 5 379 km² of surface waters in 15 basins, and 22 wetland regions. The main rivers for inland fisheries are the Pilcomayo (835 km), Paraguay (1 265 km) and Paraná (689 km). In the eastern part of the country, Aquidaban, Ypane, Aguaray guazú, Jejui guazú, Manduvira, Salado, Tebicuary and Tebicuarymi Rivers are important for fisheries and in the western part, it is the Monte lindo, Negro and Confuso Rivers. Important waterbodies are lakes Ypacarai (90 km²) and Ypoá with a surface area of 1 190 km², the Itaipú reservoir (1 350 km²), which is shared with Brazil, and the Yacyretá reservoir (67 km²) shared with Argentina. Other important reservoirs are the Acaray and Yguazú (Rios, 2017).

The Paraguay River has a floodplain covering 10 500 km², whereas the Paraná floodplain is much smaller and the flood regime less regular. Even though the Paraná has a smaller floodplain and a shorter and more erratic flood, the fauna is adapted to this pattern, and the river in its natural state presumably had equally productive fisheries.

The construction of hydropower dams has affected the productivity of the Paraná River basin by blocking migration routes for the most important commercial species and the catch of these has declined as a consequence (IIED and USAID, 1985 and Espinach Ros *et al*., 1991). Between the Itaipu and Yacyretá dams, catches are now only 3 to 4 kg/day, and in the Yacyretá reservoir itself catches are up to 60 kg per day (mainly low value fish), and below 20 to 40 kg/day (Rios, 2017). Dam corporations attempt to mitigate the impact on the population of indigenous fish species through stocking programmes further upstream and in tributaries. Catches from the Pilcomayo River vary between 250 and 2 000 tonnes per year (Payne cited in Espinach Ros *et al*., 1991).

Because of the lack of detailed catch statistics, it is difficult to say anything about the trends and status for individual species. However, some species appear to be at least locally overexploited and since most of the commercial species in Paraguay exhibit migratory behaviour they have been negatively affected by the construction of dams in the major rivers and are replaced in catches by smaller more fecund species with a shorter life cycle.

Commercial fisheries are mainly associated with the Paraguay and Paraná Rivers and are carried out by the riparian population. Subsistence fishing takes place in all waterbodies throughout the country (Rios, 2017). Currently, 7 877 fishers are registered as professionals, and the fishers work five days a week when fish are abundant (Rios, 2017).

The last year for which Paraguay reported fish catches to FAO was in 1992 when 17 925 tonnes reportedly were landed. Since then FAO has provided estimates (FishStatJ) of up to 28 000 tonnes from 1997 to 2000, but the most recent estimate for 2015 is now down to 17 000 tonnes. IIED and USAID (1985) stated that at least 28 000 tonnes are caught annually, of which 26 000 are consumed in Paraguay and 2 000 tonnes are exported to Brazil. Albiol-Flores (2007), based on the results of his study at Mariano Roque Alonso District along the Paraguay River, estimated that 9 000 fishers harvesting 20 kg per day and fishing 300 days per year would land 54 000 tonnes of fish per year. The total potential for the Paraguay floodplain was estimated as 40 000 to 60 000 tonnes (Espinach Ros *et al*., 1991; IIED and USAID, 1985). FAO (1983) estimated a potential yield for the country of 100 000 tonnes. These higher estimates may not take into account loss of fisheries from the effects of damming of rivers.

The Paraguayans are generally considered consumers of red meat, however studies carried out in the 1970s and 1980s show that there are major differences between the riparian population and people living away from the main watercourses (IIED and USAID, 1985). People living near the river and the lowest income groups in the capital would eat about 67 g fish/day or 24 kg/yr, whereas the rest of the population ate about 2 kg fish per year (IIED and USAID, 1985). The FAO apparent fish consumption is 3.9 kg/capita/yr (FAO, 2016), but this is based on the estimated catch. A re-evaluation of national inland fishery catch, based on household consumption might help to validate current catch estimates, in the absence of a national report since 1992.

There are about 8 000 recreational fishers for whom no catch statistics exist. The capture of wild fish for export as ornamentals is illegal.

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Argentina

The majority (90 percent) of inland fishery catch in Argentina is concentrated in the Plata basin, which is comprised of the upper, middle and lower Paraná, the Paraguay River (with the tributaries Bermejo and Pilcomayo) and the middle and lower Uruguay River. The associated wetlands cover an area of 229 000 km^2 (Minotti *et al*., 2013). These rivers are still in a good ecological state with a high degree of connectivity (Barletta *et al*., 2010). There is an estimated 20 200 km^2 of lakes, lagoons and reservoirs (Quiros *et al*., cited by Quiros 1988).

Reported inland catches since 2004 range from 12 283 tonnes in 2013 to 34 002 tonnes in 2005, the most recent reported landings in 2015 were 18 885 tonnes (FAO FishStatJ). This landing data appears to be somewhat underestimated, since Argentina exported a total of almost 130 000 tonnes of freshwater fish products between 2007 and 2014, whereas total reported catch for the same period was only 122 127 tonnes. It therefore appears that locally consumed fish and subsistence catches in particular (which likely add up to about 5 000 tonnes/year) are not included in official landings data. Eight species are exported, with the sábalo (*Prochilodus lineatus*) representing 87 percent, followed by carp with 4 percent. The export of sábalo peaked in 2004 with almost 40 000 tonnes, however, from 2006 the government introduced new management measures and landings decreased and have now stabilized between 10 thousand tonnes and 15 thousand tonnes per year. FAO (1983) estimated that the potential yield for Argentina could be 86 000 tonnes per year. Quiros (1988) estimated that the potential yield from lakes, lagoons and reservoirs could be about 50 000 tonnes per year.

Fishing communities are principally found along the large rivers in the Plata basin. It is estimated that between 7 000 and 10 000 fishermen are carrying out their activities in the Paraná-Paraguay corridor. It is likely that there is another 1 000 fishers along other rivers such as the Uruguay, Bermejo, etc. where commercial fisheries are less intense, but there is no census information available from here. Argentina reported 7 207 fishers to FAO (2015).

It is estimated that 3 million sport or recreational fishers practice their hobby in fresh and salt water in Argentina, of which about 1 million reside in the most important riparian cities in the Plata catchment and another 1.5 million in the Pampas region (Baigún and Delfino, 2001). In the lower Plata basin sportfishing generates about USD 15 million to USD 20 million per year, some parts of Patagonia could generate USD 7 million to USD 10 million per year (Vigliano and Alonso, 2000), Pampean lagoons USD 4 milion to USD 5 million and another USD 5 million in reservoirs and rivers in the northern part of the country (Baigún *et al*., 2003).

Fishing for live bait is an important source of employment that is practiced by about 1 000 families, many of them indigenous people working for intermediaries. This activity is not controlled and the volume of catch sold for this purpose is unknown (Baigun, 2017).

Available statistics do currently not permit distinguishing between ornamental fish from marine and freshwater environments. In 1996 when separate statistics were available, 14 tonnes of freshwater ornamentals were exported (this value possibly includes some of the water they are transported in). However, because of the competition from the Asian market export volumes are now down to 1 tonne to 5 tonnes per year.

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Bolivia (Plurinational state of)

Bolivia (Plurinational Stae of) features a high altitude plateau (Altiplano) and tropical lowland savannas (llanos), which cover more than two-thirds of the country. Hydrographically, the country is conveniently divided into three major basins, the Plata basin, Amazon basin and the high plateau. The Plata basin (Río Bermejo, Río Pilcomayo and upper Río Paraguay) with the lakes Cáceres and La Gaiba that are situated in the Bolivian Pantanal wetland, cover 15 000 km^2 to 22 000 km^2 (Roy, Barr and Venema, 2011). The Amazon basin with Río Mamoré, Río Madre de Dios, Río Beni and Río Iténez (or Guaporé) together form wetlands covering 100 000 km^2 to 150 000 km^2. This area is known as the Llanos de Moxos and consists of meanders, oxbows and other types of lakes with enormous fisheries potential (Lauzanne, Lobens and Le Guennec, 1981). With the exception of the Santa Cruz Department, the Llanos de Moxos has a low population density and it is mainly indigenous people who are engaged in fishing (Camburn, 2011). The high plateau has several endorheic lakes – Titicaca, Poopó and Uru Uru – that historically have been important fishing grounds, but where catches now have declined dramatically because of pollution, especially from mining. Fishery productivity decline is also driven by a drier climate that has led to severe reduction in size or drying up of waterbodies. There are several smaller highland lakes that are used for the stocking of rainbow trout.

The fisheries sector in the Amazon and La Plata basins have been little studied. The most productive fisheries are those of the lower Amazon where Van Damme *et al*. (2011) estimated the presence of 347 boats at the 11 most important landing sites. These authors estimated an annual catch of 3 000 tonnes whereas IPD PACU (2016) concluded that the annual catch was more than 4 000 tonnes. More than 80 percent of the catches consist of just 15, mostly large-bodied, species of high commercial value, including the introduced *Arapaima gigas* with 12 percent. Most fish is landed in the white water rivers Madre de Dios, Mamoré and Beni, whereas fish catch in the Iténez river basin with clear water is relatively low. Smaller sized species appear to be underexploited throughout the Amazon basin (Van Damme *et al*., 2011). Based on Welcomme's (1975) catch estimate for floodplains of 50 kg/ha, Lauzanne, Loubes and Le Guennec (1990) hypothesized that the fisheries potential of the Bolivian Amazon could be up to 250 000 tonnes. FAO (1983) has estimated the potential yield for the area to 50 000 tonnes.

For the La Plata Basin, it is estimated that between 100 tonnes and 700 tonnes of fish are extracted each year (with an average of 400 t/year) (IPD PACU, 2016). In this basin, the sábalo (*Prochilodus lineatus*) make up more than 75 percent of all landings. The fishery of this species is characterized by a very marked seasonality (with highest catches between May and August) because of the migratory habits of the species. FAO (1983) estimated a potential for the wetlands in the La Plata basin of up to 4 000 tonnes.

The catch data from the Altiplano are not very reliable. IDP PACU (2016) estimated a yearly catch of 5 000 tonnes from the Titicaca and less than 300 tonnes from Lake Poopó. As recently as the 1990s an annual catch of 2 550 tonnes to 3 600 tonnes of silversides (*Odontesthes* spp.) were reported from the latter lake (Zabaleta Cabrera, 1994), but in 2016 the lake dried up completely (Satgé *et al*., 2017).

According to the data reported to FAO, Bolivian catches have varied between 5 770 tonnes and 7 568 tonnes per year in the last decade with the highest recorded landings in 2009. The last year for which the country has reported landings to FAO was in 2014 with 6 990 tonnes. However, IPD PACU (2016) compiled the existing data on landings and estimated a fisheries catch of between 11 000 tonnes and 12 000 tonnes per year for the whole country, and about 10 000 fishermen working full time or part time in the sector.

The household survey catch estimate (Fluet-Chouinard, Funge-Smith and McIntyre, 2018) indicates that Bolivia (Plurinational State of) may produce as much as 61 198 tonnes of fish (ranging between 51 821 tonnes and 71 194 tonnes). This modelled figure may reflect a larger than expected catch of the Bolivian Amazon area, and is remarkably close to the FAO 1983 estimated potential yield of the Amazonian area (50 000 tonnes). It is also quite possible that the estimate is overestimated, especially if there are substantial hidden imports of fresh fish or contributions from aquaculture, although there are no clear reports to substantiate this. As these figures are substantially greater than reported catch, caution should be used in quoting them.

It is estimated that more than 80 percent of the fish caught in the country are destined for national urban markets and the remaining 20 percent is eaten locally. Fish markets in Bolivia (Plurinational State of) are also supplied by imports of fishery products (fresh fish, frozen fish, dry, salted or smoked fish, crustaceans, and molluscs) of 15 145 tonnes per year (FAO, 2016).

With an annual consumption of 2.2 kg/capita/year in 2013 based on reported data (FAO, 2016), Bolivia (Plurinational State of) is among the countries in the region (and the world) with the lowest level of apparent fish consumption. Realizing the importance of fish in the Bolivian diet, an ambitious Agricultural Sector Plan (2014–2018) has proposed an increase in fish consumption from 1.8 to 5.2 kg/person/year by 2018.

However, the precision of national consumption estimates depend on the accuracy of catch data, which do not include subsistence fishing as this is not registered anywhere. A recent review of fish consumption found that dwellers in large urban areas and indigenous people in the Bolivian Amazon together consume some 6 000 tonnes of Amazonian fish per year, and to that should be added the unknown consumption by *colonos* (indigenous highlanders) (Camburn, 2011). The Household Consumption and Expenditures Survey indicates this national consumption level may already be close to 4.5 kg/capita per year (FAO ADePT, 2009). Other studies of Santa Cruz area indicate consumption is approximately 5.6 kg/year.

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Uruguay

The majority of Uruguay (80 percent) lies within the Plata basin (Barberis cited by Quiros, 2004). The major riverine resources are the Plata River itself, the Uruguay River and its main tributary the Negro River. There are about 3 500 km^2 lakes and lagoons in the country and another 4 000 km^2 permanent or temporary wetlands (Cracco *et al*., 2007), and hydroelectric reservoirs with a total surface area of 2 273 km^2 (MVOTMA, 2017).

The main inland fisheries of Uruguay take place in the lower Uruguay River and the upper Plata River (which is shared with Argentina) and in the reservoirs on the Negro River. The lower part of the Plata River corresponds to the estuary. However, freshwater fishes such as *Prochilodus lineatus, Salminus brasiliensis* and some pimelodid catfishes, occur seasonally in the upper and middle Plata River according to the flow of the Uruguay and Paraná Rivers (Crossa, 2017).

In the Uruguay River, sábalo (*Prochilodus lineatus*) comprises the largest fresh water capture. Statistics provided by La Dirección Nacional Recursos Acuáticos (DINARA) indicate that this species accounts for an average of 63 percent of total inland captures for the country in the period 1990 to 2000. Average yearly capture was 742 tonnes, ranging between a minimum of 178 tonnes and a maximum of 1 262 tonnes (DINARA cited by Crossa, 2017). In 2012, 2013 and 2014 exports of sábalo were respectively 2 694 tonnes, 2 625 tonnes and 3 955 tonnes, growing to 6 611 tonnes in 2015 and then declining to 4 137 tonnes in 2016. In the same period catches of tarariras (*Hoplias* spp.) were estimated at between 432 tonnes and 1 296 tonnes (Crossa, 2017).

According to FAO FishStatJ, landings from inland fisheries in Uruguay in 2015 were the highest ever recorded with 3 434 tonnes, up from 2 425 tonnes in 2014. However, DINARA cited by Crossa (2017) mentions a catch of 3 954 tonnes. Commercial landings statistics indicate that fish catch from the Uruguay River is about 1 600 tonnes/year for the country, including 400 tonnes/year from the lower Plata River, 300 tonnes/year from the Negro River and the Rincón del Bonete reservoir, and 200 tonnes/year from the the Merín lagoon.

The potential sustainable catch has been estimated at 6 000 tonnes/year for the Uruguay River, 350 tonnes/year for the Negro River, 2 000 tonnes/year for the lower Plata River and 300 tonnes for the Merín lagoon (FAO/Fishcode 2004 and references therein). FAO (1983) has estimated that the reservoirs could yield 2 000 tonnes and the coastal lagoons could have a potential yield of 12 000 tonnes.

Although the artisanal fishery only contributes between 3 and 4 percent of the landings, more than 46 percent of sectoral employment is found in this subsector. In 2010 there were 1 250 full-time and part-time fishers, and 3 750 people, mainly from low income families, worked in associated activities (Crossa, 2017).

Changes in land use over the last 20 to 30 years have resulted in increased pollution with pesticides, higher nitrogen and phosphorus run-off causing algal blooms in marginal and coastal lagoons. These blooms of Cyanobacteria compromise human, animal and ecosystem health. The extraction of water for rice culture results in mass mortalities of larvae and juvenile fish in some wetlands (Crossa, 2017).

Most of the inland fisheries catch is exported (main markets are Brazil, Colombia, Nigeria and Cameroon). A smaller unreported volume is sold on the domestic market and along the Brazilian border (Crossa, 2017). Fish consumption in Uruguay is estimated at 7.5 kg per capita per year (FAO, 2016) consisting mainly of imported marine fish.

Recreational fishing is being promoted as an economic alternative to commercial fishing. However, the fast development of this subsector without clear rules, organizations and control mechanisms could compromise the sustainability of the sector and of the resources in the long term. Currently there are no statistics about the number of people involved or the impact the sector has on the economy (Crossa, 2017).

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Guyana

Guyana, in the Amerindian language means "land of many waters" and is rich in freshwater resources. The country has four principal rivers: the Courantyne River bordering Suriname, the Berbice River, the Demerara River, and the Essequibo River draining from the western highlands and southern uplands to the Atlantic coast. A few minor rivers are part of the Amazon watershed. The Essequibo River forms the country's largest river system, and its drainage basin (66 663 km^2) encompasses most of the country (United States Army Corps of Engineers, 1998). In the interior of the country, 40 000 to 50 000 km^2 of savannahs are flooded seasonally (Fisheries Department, 2006), of which 15 000 km^2 are found along the Rupununi tributary (NDS Secretariat, 2000). The northern Rupununi savannah is a giant wetland with 750 lakes and ponds (Fernandes, undated), the Rupununi River is a white water river, however most Guyanese rivers are black water rivers and therefore less productive (Mistry *et al*., 2004).

Despite this extensive environment, 90 percent of the country's total population is concentrated in the low-lying 3 to 15 kilometer-wide coastal plain (United States Army Corps of Engineers, 1998). Fishing is carried out in rivers, creeks, lakes and reservoirs, canals, and in savannah areas (NDS Secretariat, 2000).

Guyana reported 700 tonnes catch from inland fisheries in 2015. There have been only small variations in the reported landings 625 to 875 tonnes per year (FishstatJ). The national catch is still very modest considering the amount of water resources available and is an indication of the limited productivity of the black waters. Fisheries Advisory Committee (2007) mentions fisheries potentials of 90 tonnes per km^2 for flooded savannahs, but this appears to be an exaggeration. Even for white water rivers, this appears an order of magnitude too high and for black water rivers probably two orders of magnitude too high.

Guayana is the South American country with the highest level of fish consumption, with 31 kg/capita/year (FAO, 2016), but this is largely based on the availability of marine fish.

It is likely that the contribution by inland fish is not properly reflected, and consumption of freshwater fish is certainly higher, away from the coast. Mistry *et al*. (2004) for instance state about the most populous indigenous group in the Northern Rupununi, *"...* fishing is the mainstay of Makushi life comprising 60 percent of their diet." Fishing is done mostly by Amerindians living away from the coast (about 10 percent of the population) for subsistence, and fishing tends to interact dynamically with agriculture activities such as the harvesting of rice or sugarcane. Near larger logging and mining concessions there tends to be higher fishing pressure in order to feed the workers (Maison, 2007).

There is no species level information in the reports to FAO. However, overexploitation of arapaima caused the stock to become depleted, and the government banned fishing the species. However, as the activity happens in areas without efficient surveillance, the ban had no impact and most of the product was exported to Brazil where demand is high (Maison, 2007). The most pressing issue in inland fisheries is protecting fish habitats from destructive practices associated with the expansion of mining and forestry operations (NDS Secretariat, 2000).

In addition to fishing for food, about 4.2 million ornamental fish are exported annually (Watson, 2005).

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Suriname

FAO (2015) states that Suriname has 7 820 km^2 of surface waters and has an exceptional number of rivers (FAO, 1983) for such a small country. There are seven large river systems of which the Corantijn (67 600 km^2) and the Marowijne (68 700 km^2) river basins are the largest (Mol, 2012). Most rivers are nutrient poor (classified as either clear or black water rivers) and without large floodplains. This points to a relatively low productivity and thus fishing potential.

There are no true lakes in the country, and the largest waterbody is the Brokopondo reservoir (1 560 km^2) built on the Suriname River (Mol *et al*., 2007). Richter and Nijssen (1980) estimated the potential yield of the Brokopondo reservoir at 3 500 tonne/year, very similar to the 3 000 to 4 000 tonnes estimated by FAO (1983). However, several brackishwater lagoons may have fisheries of some significance (Mol, 2012).

The last time Suriname reported an inland fisheries catch to FAO was in 2013 (650 tonnes) and this is also the maximum amount reported by the country (FishStatJ).

Mol *et al*. (2000) mention that commercial fisheries have been taking place in the lagoons of the Bigi Pan area for more than 60 years and that these fisheries employ 150 fishers and produce 6 to 12 tonnes of fish per month with the most important species being snook, Mozambique tilapia, mullet and tarpon. About 95 percent of the population resides along the coast, and most of the fish consumed are consequently marine. Apparent annual fish consumption is 16.5 kg/person (FAO, 2016). Only the Amerindian and Maroon populations depend on inland fisheries for subsistence (Mol, 2012).

El Niño related droughts are frequent but unpredictable in Suriname and severely affect fish communities in streams, swamps and coastal lagoons and fisheries (Mol *et al*., 2000).

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Ecuador

The inland waters of Ecuador can be divided into three regions, namely the western lowlands, the Andean region and the eastern lowlands.

The western lowlands between the Andes and the Pacific coast is dominated by the rivers of the Guayas basin and the Esmeralda and Santiago Rivers, which are characterized by their fast and short flood cycle. The Andean region has hundreds of small lakes most of which are less than 2 ha and with low productivity. The eastern lowlands (east of the Andes) corresponds to the Amazon basin with the Putumayo, Napo, Pastaza, Santiago and Marañón Rivers, and is characterized by floodplains with highly productive lakes (Meschcat, 1975).

There are 16 major reservoirs mostly located in the Pacific watershed, but only one mega dam is located in the Amazon basin (Finer and Jenkins, 2012).

Fishing takes place in rivers of all sizes situated from the lowlands up to more than 4 000 m in altitude, and in many small mountain lakes. Mesckat (1975) mentioned that there were more than 1 000 people exclusively dedicating themselves to fishing in lakes and rivers, and several thousand fishing occasionally or for subsistence. He adds that it was impossible to provide more exact figures because of the lack of staff and transportation. Although this was more than 40 years ago, the situation does not appear to have changed. Willan (2010) in a survey found 613 organized fishers in Los Rios Province in the Pacific watershed, which at least at the time of Mesckat (1975), had almost no fishers compared to the Amazon lowlands.

Ecuador reported a catch of 105 tonnes of fish from inland fisheries in 2015. Since 2008, landings have fluctuated between 101 and 338 tonnes. The highest catches reported were 994 tonnes in 1984 (FishStatJ). Burgos (2011) estimated an annual catch of 236 tonnes in the Napo River. In the Chogón reservoir 105 tonnes were landed in 2015 (Pacheco Bedoya, undated). Sirén (2011), by extrapolating results of consumption studies among indigenous people in the Amazon basin, found that this group alone potentially consumes 8 362 tonnes of Amazonian fish per year, considerably more than the official report.

The absence of territorial management is a threat to the fisheries. The health of the riverine ecosystems in Ecuador is under growing pressure from the abstraction of water for the rapidly growing Andean cities, and the hydroelectric projects in the same region threaten biodiversity in both the Pacific and Amazonian basins (Barriga, 2017).

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Chile

Chile is a 4 200 km long narrow strip of land bordered on the west by the Andes and to the east by the Pacific Ocean. Parts of the country have low temperatures and it is extremely dry with less than 2 mm precipitation per year. The country has many short torrential rivers that originate in the Andes and run to the Pacific Ocean, and, the central part has many lakes. Brenner (1994) states that 4.9 percent of the provinces of Valdivia and Llanquihue are covered with lakes (a total of 3 000 km^2). However, the fish fauna is relatively poor with only 34 indigenous species.

No catches have been reported to FAO since 1998 when 4 tonnes were landed. The highest catch ever reported was 32 tonnes in 1990. Catches have mainly consisted of common carp and freshwater prawns (FishStatJ).

FAO/FishCode (2004) reported a very small-scale inland fishery in a coastal lagoon to the south of the country, where indigenous communities were involved in subsistence fishing, and artisanal extraction of river shrimp in some altiplano lagoons and rivers. However, it is not known if this is still extant as

Chile has now prohibited commercial fisheries in inland waters (Valbo-Jorgensen, Soto and Gumy, 2008).

Brenner (1994) calculated a potential of 1 500 tonnes in the lakes in the central part of the country, and FAO (1983) estimated a potential of 4 000 tonnes for the same area.

Most inland bodies of water are used for recreational or sportsfishing and about 50 000 fishers have been registered in the national territory (FAO/FishCode 2004) where they target the salmonid species that has been introduced successfully generating about USD 10 million/year (Valbo-Jorgensen, Soto and Gumy, 2008).

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French Guyana

French Guyana is drained by by eight river basins flowing south–north and many small coastal creeks (Lointier and Gaucherel cited by Merona, Tejerina-Garro and Vigouroux, 2012). The largest basins are the Maroni (66 000 km^2) and the Oyapock (27 000 km^2), and the rivers have only small floodplains (Mérona, Tejerina-Garro and Vigouroux, 2012). The Petit-Saut dam with an area of 350 km^2 has been created on the Sinnamary River (Mérona, Vigouroux and Tejerina-Garro, 2005).

French Guyana has never reported any inland fisheries catch to FAO (FishStatJ), and available information about inland fisheries in French Guyana is very scarce and is mostly limited to taxonomic research. However, Anonymous (undated) mentions that there are 17 small-scale vessels registered in inland fisheries, and 34 persons employed. Fréry *et al*. (2001) researched the impact of mercury among indigenous groups and found a high dependency upon fish with average consumption levels of up to 115 kg/year among 26 to 45 year olds and indicated that seasonally people may eat up to 600 g/day.

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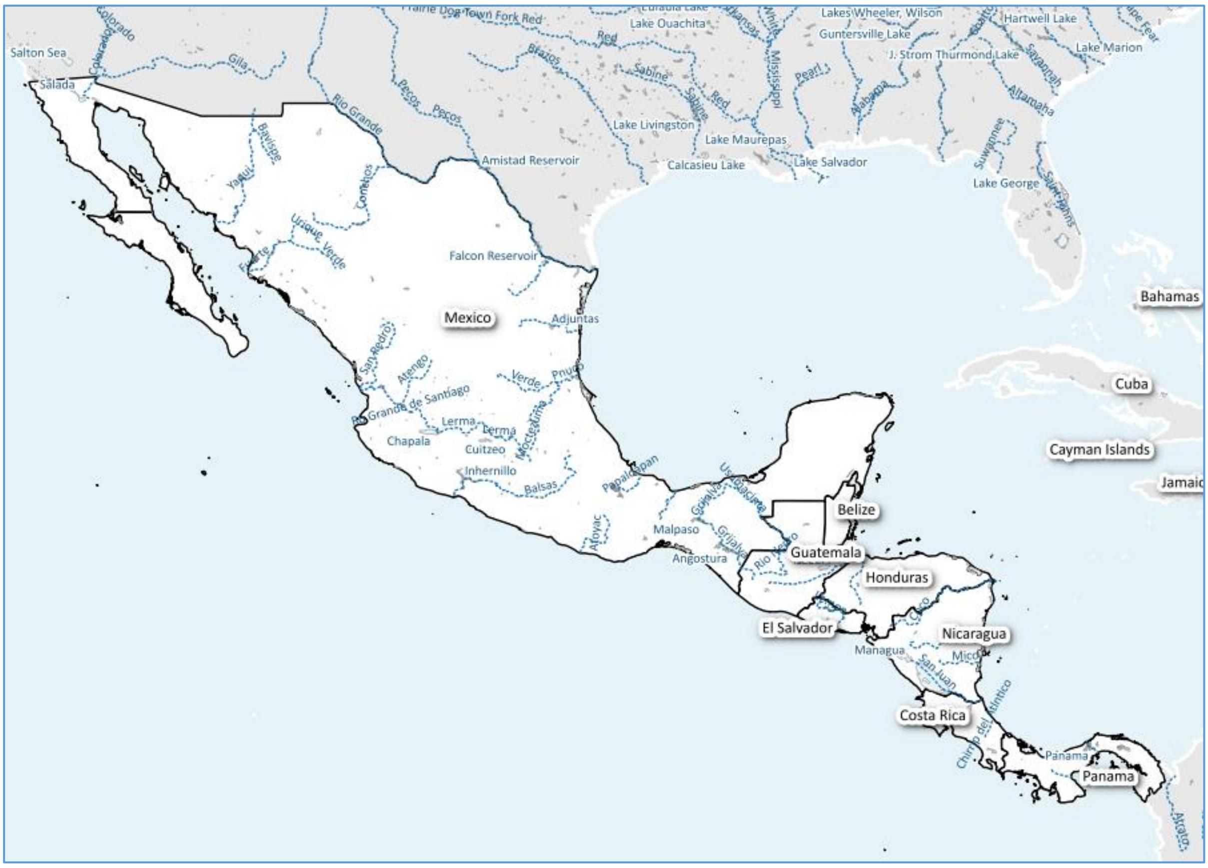
2.5.2 CENTRAL AMERICA



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	% of Global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km3/yr)
Mexico	151 416	122 332 000	0.95	1.32	403	376
Guatemala	2 360	15 468 000	0.15	0.02	119	20
Costa Rica	1 000	4 872 000	0.21	0.01	113	9
Nicaragua	606	6 080 000	0.12	0.01	161	4
El Salvador	458	6 340 000	0.27	0.00	23	20
Panama	405	3 864 000	0.17	0.00	136	3
Honduras	100	8 098 000	0.01	0.00	83	1
Belize	0	332 000	0	0.00	22	0

Mexico contributes the majority of inland fishery catch accounting for nearly 97 percent of the total. The Mexican inland fisheries are mainly based on the numerous reservoirs in the country, many of which are enhanced through stocking. Of the other Central American countries, roughly 1.5 percent comes from Guatemala with the remaining fraction (1.6 percent) shared between Costa Rica, Nicaragua, El Salvador, Panama and Honduras.

Central America has an estimated 2 303 waterbodies in Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama, with a total surface area of 16 011 km^2 (PREPAC, 2005). In 276 of the waterbodies identified by PREPAC (2005), fisheries were considered the main activity. The fisheries resources of Central America are based on the Usumacinta–Grijalva–San Juan River system and its associated reservoirs. This is the largest river system in Central America and supports important subsistence fisheries (Inda-Diaz *et al*., 2009). There are also lakes, with the biggest being Lake Nicaragua. The number of inland fishers identified in these countries in 2005 was estimated at 36 303, with an estimated annual catch of 37 964 tonnes (PREPAC, 2005).

Reporting of catches to taxonomic category is generally good (but dominated by the catch of Mexico). Catches are a mixture of North American and South American species with the exception of tilapias (84 052 tonnes) and common carp (35 779 tonnes), which together make up 77 percent of the catch. The predominance of the introduced tilapias, rather than native cichlids indicates the importance of stocked lake fisheries in the region. The introduced common carp is used for stocking cooler reservoirs and dams.

OSPESCA (2012) estimated 27 510 fishers, corresponding to 21 percent of the fishers in the Central American countries (that is 1.7 fishers per square kilometre of waterbody) using 15 876 vessels and estimated a catch of 31 556 tonnes (1.1 tonne per fisher) or roughly 18 percent of the total artisanal catch in these countries. This estimate is almost four times the landing data in FishStatJ for 2010, which was just 8 328 tonnes (which in the absence of national reports is principally based on FAO estimates). Between 80 to 90 percent of the catch is consumed locally (PREPAC, 2005).

PREPAC (2005) found that 75 waterbodies had disappeared in Central America since the early 1990s, the causes cited are both anthropogenic and natural.

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Mexico

The Mexican National Water Commission has identified 731 river basins in the country (Conagua, 2016). The largest river basins are those of the Bravo River with an area of 225 242 km^2 in Mexico and another 241 697 km^2 in the United States of America, and the Balsas River with an area of 117 406 km^2. The total length of rivers in the country is 633 000 km (Conagua, 2016). The largest lakes are Lakes Chapala (1 116 km^2) and Cuitzeo (306 km^2), and the largest reservoirs are the Angostura (640 km^2), Presidente Alemán (500 km^2) and Vicente Guerero (468 km^2) reservoirs (Sugunan, 1997).

In the early 1990s there were 13 935 lakes and reservoirs (Hernández cited by Sugunan, 1997). There does not appear to have been any more recent attempts to quantify the number of waterbodies in the country, and some parts of the country were not properly assessed. The number cited by Sugunan is therefore an underestimate (Arce-Ibarra and Charles, 2008).

Mexico has one of the largest irrigation infrastructures in the world with 5 163 dams and embankments watering 33 percent of agricultural land (Conagua, 2011). There are 142 wetlands listed under the Ramsar Convention with a total area of 8.6 million ha.

With an annual catch of 151 416 tonnes in 2015, Mexico reported the highest catch since the late 1980s, corresponding to an increase of 22 percent since 2014. Inland fisheries now constitute about 10 percent of the national capture fisheries catch (FishStatJ). However, it is believed that there is under-reporting of up to 60 percent, which the local fisheries authorities seek to address by using indicators such as observations and knowledge by decentralized staff. The estimates therefore depend on the level of experience of the staff making the estimate. The statistics also do not include catches used for own consumption (Martínez-Cordero and Sánchez-Zazueta, 201; Pedroza-Gutiérrez, 2017).

In Mexico, inland fisheries is by definition considered artisanal and small-scale; it is carried out alone or together with family members. According to the Diario Oficial de la Federación (2000, 2004, 2006, 2010 and 2012) there are 21 241 registered inland fishers in the waterbodies covered by these documents using 13 251 vessels.

Reporting at the species or species group level has improved over the last decade with now only 5.6 percent of the species reported as nei. Catches of most species appear to be improving except snook (with catches as high as 3 296 tonnes in 2007), which has almost completely disappeared from the catches. Carp and tilapia (that make up 55 percent of landings) are no exceptions to the overall trend. Other important species are silversides and catfishes (FishStatJ).

However, according to Pedroza-Gutiérrez (2017), out of 93 waterbodies monitored, fisheries is in decline in 22 percent and 14 percent are considered to be exploited at the máximum sustainable level. Only 8 percent are considered to have a potential to further increase catch levels. Dwindling catches and lower prices force fishers to increase their effort to maintain their income levels (Pedroza-Gutiérrez, 2017).

Enhancement is the most important management practice applied in inland fisheries. In 2007, culture-based fisheries with about 40 species were responsible for 58 percent of the recorded catch (Martínez-Cordero and Sánchez-Zazueta, 2010). FAO (1983) estimated a catch potential of 340 000 tonnes for Mexican inland fisheries with 70 percent coming from coastal lagoons, and 26 percent from major reservoirs.

Fishing with illegally small mesh sizes targeting juveniles is considered a problem affecting fisheries. Also, pollution is a serious problem. Eutrophication leads to growth of water lilies that prevent fishers from accessing fishing grounds, and may generate bad odour and affect the taste of the fish (Pedroza-Gutiérrez, 2017).

Although the fishery is mainly based on introduced species, some exotics are having a seriously negative impact on fisheries. Mendoza *et al*. (2007) mentions that catches in the Infiernillo reservoir, which used to produce up to 20 000 tonnes of tilapia per year, has decreased by 70 to 80 percent because of the appearance of *Plecostomus* spp. in the waterbody causing 3 600 fishers and their families a loss of 36 millon Mexican pesos per year.

Average apparent annual fish consumption in Mexico is 13.2 kg/person (FAO, 2016). In 2007, about 10 percent came from inland fisheries (Martínez-Cordero and Sánchez-Zazueta, 2010). The estimates of apparent consumption depend on the reliability of the statistics of the level of catches, which as mentioned before, seem to be underestimated. Furthermore, it is likely that consumption of fish is much higher in coastal areas and near waterbodies as the families of fishermen are known to eat fish five times a week (Pedroza-Gutiérrez, 2017).

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Guatemala

The waterbodies of Guatemala cover an area of 1 339 km^2 including 7 lakes, 306 lagoons, 826 lagunetas and 15 reservoirs (data collected by PREPAC provided by OSPESCA). There are 38 important basins situated in three watersheds: the Gulf of Honduras with an area of 57 005 km^2; the Mexican Gulf with 50 803 km$^{2;}$ and the Pacific Ocean with 23 990 km^2. The main rivers in Guatemala have a total length of 2 944 km (Ixquiac Cabrera, 2017), and if smaller streams are included this adds up to 56 208 km (CONAP, 2009).

According to FAO statistics, 7 301 tonnes of fish were landed in 2000, which decreased to 2 360 tonnes in 2006. Landed volume has been estimated by FAO at the same level since then.

The fisheries authority's collection of statistical data on fisheries is directed at marine fisheries. However, estimates for inland fisheries have been provided by OSPESCA and PREPAC, and there have been case studies of some waterbodies such as Lago Atitlán, Lago Guija, Lago Izabal and Río La Pasión. The most recent estimate was by OSPESCA (2012) that found a total inland catch of 5 400 tonnes in 2010. PREPAC (2005) estimated an annual landing of 13 346 tonnes from Guatemalan waterbodies of which 90.6 percent came from lakes, 3.2 percent from lagoons 3.2 percent, 2.9 percent from ponds, 2.7 percent coastal lagoons and 0.6 percent reservoirs (that study did not take into account rivers). The most important lakes were Izabal, Atitlán, Amatitlán and Laguna de Güija. ATP SA (2004) estimated landings from Lake Peten Itzá, Dulce River with Lake El Golfete, and Lake Izabal with River Polochic as 7 135 tonnes per year. Most of the studies have not considered river fisheries that are also not covered by official statistics.

Using the empiric models developed by Welcomme for African fisheries (1976) and annual catch figures of 40 to 60 kg/ha based on catch data from Río La Pasión and Río San Pedro, Ixquiac Cabrera

(2017) arrive at a conservative catch figure of 1 170 tonnes for Guatemalan rivers. The rivers with the most important fisheries are Río San Pedro, Rio la Pasión, Rio Dulce, Rio Sarstún and Rio Motagua. Ixquiac Cabrera (2017) further estimates that the catch from waterbodies is 4 131 tonnes per year, which together with the estimated catch from rivers adds up to 5 501 tonnes, which is 2.2 higher than FishStatJ records.

The fisheries law of Guatemala reserves inland fisheries exclusively for subsistence, artisanal and small-scale fisheries. Inland fisheries, such as the small-scale marine fisheries, are strongly affected by rural unemployment and become an essential subsistence activity that supports food and nutrition security. Very few people have inland fisheries as their only activity and it is almost always combined with agriculture. PREPAC (2005) estimated a total of 5 341 fishers operating in waterbodies in the country (there was no data for rivers). They used beach seines (0.8 percent), gill nets (28.6 percent), hook (40.3 percent), castnets (29.4 percent) and traps (0.8 percent). OSPESCA (2012) found that inland fishing is practiced by 6 200 fishers in 55 communities.

Overall annual fish consumption in Guatemala is estimated at 2.96 kg/person of which 7.8 percent is contributed by inland fisheries. However, case studies have shown that in some areas close to lakes and rivers people may eat much more fish, for example in the community El Estor in the Izbal Department, which has an annual consumption rate of 77 kg/person (García cited by CONAP, 2003).

The large waterbodies in Guatemala are under high fishing pressure, and this is even more pronounced in the case of smaller reservoirs (smaller than 150 ha) (Díaz de Barrios, 2010). However, the most serious ecosystem impacts stem from industrial and domestic pollution, deviation of rivers, draining of lagoons, species introductions and fishing for juveniles. Mitigation of these impacts is, when done, usually limited to stocking mostly with exotic tilapia, which has been done regularly by the Ministry of Agriculture, Livestock and Food since the 1960s, but even when indigenous species are used the quantities are inadequate and the diversity far lower than in the natural ecosystem. There are currently three stocking programmes in the country:

1. the government's stocking of pez blanco (*Petenia splendida*) in Lago de Peten Itzá;
2. stocking with tilapia (*Oreochromis spp*) in most waterbodies in the country by the government upon the request by communities and municipalities; and
3. stocking with the native Mojarra Tusa (*Vieja guttulata*), Mojarra Balsera (*Amphilophus trimaculatus*), Mojarra Negra (*Amphilophus macracanthus*) and freshwater snail (*Pomacea* sp.) – this is a private programme by the companies that grow sugar cane in river basins in the southern part of the country (Díaz de Barrios, 2010; Ixquiac Cabrera, 2017).

In some instances, hydroelectric dams have been equipped by fish ladders to mitigate impacts on fish movements, however these have proved to be inappropriate for the species concerned (Ixquiac Cabrera, 2017).

Sportfishing is mainly undertaken in the San Pedro River, la Pasión River and Rio Dulce River. Most of the sportfishing events take place in waterbodies inside protected areas. Several species with potential as ornamentals have been identified, however, there are no data on the quantities extracted for these purposes (Ixquiac Cabrera, 2017).

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Costa Rica

Costa Rica is a geographically diverse country with lakes, lagoons and floodplain rivers. The subregional inventory by PREPAC (data provided by OSPESCA, personal communication) counted 510 waterbodies with a total length of at least 682.3 km^2. However, most waterbodies are relatively small and so are the river basins. Nevertheless, fishing takes place in all aquatic ecosystems wherever fish or shrimp are present. Rivers are fished from the shore or from bridges and people only use boats in large lakes and reservoirs. The only legal gear is hook and line. Illegal fishing with dynamite and poison used to be common, and castnets and harpoons continue to be used (Segura, 2017).

There is no collection of statistics on inland fisheries by government institutions. Costa Rica has not reported any inland fisheries catches to FAO since 1997 when catches were reported as 840 tonnes, since then FAO has estimated catches at a constant level of 1 000 tonnes. The maximum catch ever reported was 1 090 tonnes in 1996. There are no species level information available in FishStatJ. It appears that landings consist of several exotic and indigenous species (some purely freshwater species and other marine or brackishwater species that migrate upstream), but there is no knowledge of their status.

Food fisheries are utilized for own consumption and limited local trade. There are important recreational fisheries, particularly in some reservoirs, but there are no quantitative data available on this.

The Comprehensive Agricultural Marketing Program (PIMA) estimates annual fish consumption at 7.17 kg/person (Sánchez and Cambronero, 2016), an impressive increase from just 1.83 kg/person in 2012. However, consumption of fish from inland fisheries is not accounted for.

Habitat destruction, and the use of agrochemicals by the expanding pineapple industry together with the extraction of materials from the riverbeds, dam construction, and the canalization and construction of dykes have all impacted negatively on freshwater ecosystems and the possibility to develop fisheries.

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Nicaragua

Nicaragua is the richest Central American country in terms of water resources with two-thirds of all surface water in the subregion. The total area is 10 506 km^2, of which 8 144 km^2 corresponds to Lago Cocibolca (Lake Nicaragua) (approximately the size of Lake Titicaca). PREPAC (data provided by OSPESCA, personal communication) counted 86 waterbodies, of which 68 were used for fishing. Among the rivers the most important is the San Juan River, the outlet of Lake Cocibolca, whose basin has a total area of 29 824 km^2 (PREPAC, 2006).

Commercial artisanal fisheries mainly take place in Lakes Apanás, Xolotlán (Lake Managua) and Cocibolca, all the people around these lakes and nearby areas including the San Juan River participate.

Fishing in other waterbodies is mainly for subsistence. However, there is some recreational fishing in the major lakes and San Juan River including some organized by tourist operators. In addition, there are two companies with legal permits to fish for ornamental fish (Sanchez, 2017).

Nicaragua has reported their catches to FAO every year since 1950. In 2015, 606 tonnes were landed, a decrease of more than 300 tonnes from the year before. The highest catch on record was in 1973 when 2 600 tonnes were landed. The catch levels appear to be very low considering the amount of water resources, and since data is mainly recorded at storage centres and processing plants, and as there are many communities that trade fishery products, locally and informally traded fish and subsistence catches are probably not accounted for.

Based on data from the national fisheries administration and the data collected by PREPAC, about 1 200 tonnes of fish are landed annually in Lake Cocibolca. Nevertheless, PREPAC (2006) estimated that lake catch is likely three times more than what was reported officially. OPESCA (2012) estimated that 6 300 tonnes (13 percent of total national landings) were caught in inland fisheries. INPESCA (1986) calculated the potential harvest of the lake to 7 830 tonnes (not including any of the tributary rivers). However, FAO (1983) estimated a potential catch of 50 000 tonnes from Lake Cocibolca and another 10 000 tonnes from coastal lagoons.

The high number of people working in inland fisheries also gives an indication that catch levels are underestimated. According to OSPESCA (2012), there were 4 200 fishers (13 percent) employed in inland fisheries in 2010. However, recent data indicate that many people have left inland fisheries because of the impacts of climate change (Rocha, personal communication).

The most important species are tilapias, tropical gar, and machaca; however, more than 20 percent of the landings are only identified as cichlids.

In addition, in 2015, 150 000 ornamental inland fish were exported from the country (Sanchez, 2017).

Illegal fishing and trade occurs mostly in the San Juan River, where effort is directed at fresh water prawns (*Macrobrachium carcinus*) and freshwater gar (*Atractosteus tropicus*). In Lake Cocibolca, Laguna de Masaya, and Tiscapa lagoon, not to mention Lake Xolotlán, which is extremely contaminated, there are serious problems with organic and inorganic waste, including sewage, industrial pollutants and pesticides (Sanchez, 2017).

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El Salvador

The regional inventory of waterbodies PREPAC (information provided by OSPESCA, personal communication) found 422 km^2, of which 45 percent were reservoirs, 33 percent lakes, 21 percent lagoons and 1 percent lagunetas. The Ministry of Environment and Natural Resources reports 139 permanent rivers with a total length of 5 690 km (Sampson and Hernández, 2010).

In spite of the relatively low importance of inland fisheries compared to the marine (about 6 percent of the landings), El Salvador has been reporting inland fisheries statistics to FAO very regularly since 1950 and data is only missing for 2009 and 2012; although in some cases it appears to be estimates since the same numbers are repeated for several years in a row. The last report for 2015 was just 458 tonnes, whereas the highest recorded catch in 1992 was 5 136 tonnes (11 times as much). OSPESCA (2012) estimated landings at 3 700 tonnes in 2010 whereas the official landing reported to FAO that year was 2 326 tonnes.

The most productive waterbody used to be the Cerrón Grande reservoir with catch levels almost reaching 3 400 tonnes (1992) (Sampson and Hernández 2010).

There are no proper landing sites in inland waters in El Salvador and fishers are selling their product to middlemen directly from the shore with minimal processing. The middlemen then bring the fish to the national markets. This complicates the collection of reliable catch statistics (Oquelí-Otero, 2017). The fisheries are based almost exclusively on exotic species, i.e. various carp species, tilapia and other cichlids (Sampson and Hernández, 2010). The only two fishes reported to FAO at the species level are Nile tilapia (the most important) and jaguar guapote; the remaining species are lumped together in groups at a higher taxonomic level.

There are 8 400 inland fishers organized in 42 cooperatives, which corresponds to more than 30 percent of all artisanal fishers in the country (OSPESCA, 2012), or approximately 20 fishers per square kilometre of waterbodies. However, most of the fishers only work part time or occasionally in fisheries and their main occupation is in agriculture, and the amount of time spend fishing is unknown (Oquelí-Otero, 2017).

Apart from the high fishing pressure, environmental degradation appears to be responsible for the decline in fisheries. In fact 95 percent of surface water is affected by pollution or eutrophication (Pohl cited by Oquelí-Otero, 2017).

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Panama

Panama has 52 river catchments, with about 500 rivers, 70 percent of which are in the Pacific watershed and 30 percent in the Atlantic. PREPAC (in Abadía, 2010) identified about 188 waterbodies, of which 47 are natural lakes and 141 artificial lakes. The total area of surface water was 1 232 km^2, with about 70 percent being reservoirs. The three major reservoirs are Gatun (423 km^2), Bayano (185 km^2) and Alajuela (59 km^2) (Centro Regional Ramsar para la Capacitación e Investigación sobre Humedales para el Hemisferio Occidental, 2009). In the major reservoirs both subsistence and commercial fishery take place, however, in smaller reservoirs catch is limited. In rivers, fishing is only for own consumption (Abadía, 2010).

Panama started reporting inland catches to FAO in 1984, and has mostly provided data since then. In 2015, the reported catch was 405 tonnes, and the highest was reported in 2006 with 3 555 tonnes. Statistics collection in most inland waterbodies is deficient and catches likely to be seriously underestimated. OSPESCA (2012) estimated an inland fisheries catch of 13 300 tonnes in 2010, which is 6.6 times the officially reported catch for that year and 39 percent of total artisanal catches in the country. PREPAC estimated an annual catch (mostly of tilapia) of 4 731 tonnes inland fish of which 82 percent came from Lake Bayano (Morales, 2006; Abadía, 2010).

Reported catches only consist of tilapias (97 percent) and peacock bass (3 percent), two species that have adapted well to the reservoirs in the country. Most of the tilapia comes from Lake Bayano where the species was introduced by accident in 1980. It is now exploited mainly by the indigenous people living there (Morales, 2006; Abadía, 2010). Ninety-eight percent of the fish coming out of Lake Bayano is fileted and exported and 2 percent is consumed in the country (PREPAC, 2005). Since 2009, the catch of tilapia has decreased because of conflicts over access to the resource and overexploitation, which has led to smaller sizes and falling demand (Abadía, 2010). The peacock bass comes from Lake Gatun and Lake Alajuela, and most of the tilapia is caught in Lake Bayano. A number of other species have also been introduced, but less successfully and includes various carps and *Colossoma* (Abadía, 2010).

PREPAC (in Abadía, 2010) identified 173 inland fishing communities and a total of 6 077 fishers and 1 806 vessels 356 landing sites. OSPESCA (2012) estimated 4 800 fishers in inland waters.

Chapman (1985) calculated a theoretical yield of 3 755 tonnes per year for the three major lakes based on the morphoedaphic index. However, the fisheries in Lake Gatun and Alajuela at that time were almost exclusively peacock bass and Bayley (1986) felt that Chapman's estimate was too high and suggested that 150 to 300 tonnes and 20 to 50 tonnes respectively were more realistic for the two lakes. FAO (1983) suggested a theoretical yield of 2 502 tonnes per year and Briceno and Goti (1983) estimated the fisheries potential for Lake Bayano to about 2 000 tonnes per year.

The fisheries authority (ARAP) has a stocking programme in some reservoirs (mainly Alajuela, Fortuna and Yeguada reservoirs), however the impact of this is unknown because of inadequate monitoring and analysis (Abadía, 2010; Van Eijs, 2016). There is a management plan for Lake Bayano that could be adapted to other reservoirs too (García Rangel, 2017).

Bayley (1986) studied fish consumption around Lakes Alajuela and Gatun, and found that annually people ate 7 and 15 kg fish/person, respectively; the latter figure almost twice the national average at that time.

There is a considerable recreational fishery in some reservoirs, particularly Lake Gatun, where a mixture of local residents who own boats and tourists who rent boats with captains participate. There are also people selling small fishes for use as live bait. Abadia (2017) mentions that there are 25 boats, 68 fishers and 25 to 30 tour operators that are mainly dedicated to this activity in Arenosa. There have been no attempts to quantify the size of this fishery or its contribution to the local economy.

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Honduras

There are 237 waterbodies with a total area of 1 598 km^2 in Honduras (OSPESCA cited by FAO, 2015). Commercial inland fisheries are limited to Lake Yojoa and the hydroelectric reservoir Francisco Morazán (Morales *et al*., 2007).

Honduras has not reported any inland catches to FAO since 2001, when 111 tonnes were landed. Since then FAO has estimated landings of 100 tonnes. The highest volume ever reported was for 1981 with 228 tonnes. FAO (1983) suggested that catches from rivers and Lago de Yojoa could add up to 4 000 tonnes, with an additional potential of 15 000 tonnes from coastal lagoons.

Current estimates of inland fish catch do not correspond to more recently reported estimates of fish catch. Morales *et al*. (2007) estimated the annual catch as 3 882 tonnes, and OSPESCA (2012) estimated that 2 856 tonnes was caught in 2010.

Morales Rodriguez (2017) provides estimates for the country total as 7 167 tonnes caught by artisanal fisheries. There was an additional 67 tonnes caught by recreational fisheries. The central part of the country with Lago de Yojoa and Francisco Morazán reservoir is considered the most productive area with 3 078 tonnes per year. The Caribbean (northern) region, with several lagoons and river mouths is estimated to produce 2 559 tonnes. The Pacific (southern) region has a lagoon complex producing 1 530 tonnes.

PREPAC (cited by Morales *et al*., 2007) identified 3 775 fishers and 1 411 vessels operating in inland fisheries. OSPESCA (2012) estimated 3 910 fishers operating in inland waters (i.e. about 10 percent of the total number of fishers in the country). Anonymous (2017) estimated 8 128 artisanal fishers and 575 recreational fishers, implying a total annual catch of less than 1 000 kg/artisanal fisher, which is very modest as each recreational fisher could catch 117 kg.

One reason for underestimation of inland catch is that catches from coastal lagoons are likely to be reported as marine catch, or possibly unrecorded. As there is no systematic data collection and no central database of inland fishery information, inland fishery catch recorded at the local level is not separated from marine catch leading to its inclusion in marine catch figures. As 98 percent of national inland fish catch is consumed in the country and mostly locally (Morales Rodriguez, 2017), much of the catch is not formally recorded. The only official data is for Lago de Yojoa with a catch of about 100 tonnes per year, so even these records appear to seriously underestimate landings (Morales Rodriguez, 2017).

The only species mentioned in reports to FAO is the giant freshwater prawn, a species, which according to Morales Rodriguez (2017), is no longer recorded in inland fisheries in the country. Morales Rodriguez (2017) mentions a range of native and indigenous cichlids, common carp and various catfishes from the Central Zone, whereas euryhaline species dominate coastal lagoons in the north and south.

The main threats to the sustainability of inland fisheries in Honduras are illegal fisheries. This can be at least partly explained by the limited presence of the fisheries authority and weak organization of the fishers. Also, pollution and water hyacinth growth are considered problems by the fishers. There are no stocking programmes in any waterbodies in the country (Morales Rodriguez, 2017).

As mentioned above catches by recreational fisheries are significant, but there has never been any attempt to quantify its impact. There is also a certain unexploited potential for catching ornamental fishes.

The value of the annual catch is about USD 17 million and it benefits about 40 000 people, if the families of the fishers are included.

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Belize

PREPAC (2006) mentions that Belize has 95 waterbodies and the northern Belize wetland in particular provides abundant fish habitat.

Belize has not reported any inland catches to FAO in recent years. The highest catch recorded was in 1981 with 40 tonnes. A few cichlids species (including tilapia) are known to be targeted in rivers and lagoons, together with tarpon, catfishes and freshwater turtles and there is limited local trade in these (Gillett and Myvette, 2008).

Inland fisheries are gaining more importance not only for food, but also from sportfishers in the country. However there is no system for recording statistics in inland waters and therefore the country does not have any data on inland fisheries (Zapata, 2017). Moreover, there is no published information on the status of any inland fish stocks.

It is noted that tilapia has spread to almost all waterbodies throughout the country, with many Belizeans believing that the species has been responsible for the decline of endemic species (Zapata, 2017). It is worth noting that the construction and operation of three major hydropower dams has severely affected inland ecosystems. Belizeans are advised not to fish in the reservoirs resulting from dam construction because of health risks from accumulated heavy metals (Zapata, 2017).

Sportfishers fish for tarpon and common snook in a few lagoons and rivers, including the Belize River and the New River lagoon. Other sportfishing activities occur on estuaries, inlets or mouths of rivers where fishing is done for bonefish, tarpon and barracuda (Zapata, 2017).

Most inland fishing is done in central Belize, where people along the Belize River fish for black tilapia, common snook and hicatee for family consumption. It is estimated that a total of 200 people engage in inland fisheries, however, less than 50 fishers possess a license to fish in inland waters, and for 90 percent of them it is only a dry season activity and only for household consumption (Zapata, 2017). About 50 fishers are involved in fishing for tilapia, which is sold along the roadside within the local communities (Zapata, 2017).

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2.5.3 NORTH AMERICA

Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish production per unit of renewable surface water (tonnes/km^3/yr)
Canada	27 964	35 182 000	0.81	0.24	2 892	10
United States of America	19 392	320 051 000	0.08	0.17	2 913	7

United States of America

The inland fisheries of the United States of America are based on the extensive Great Lakes system in the north, the Mississippi River and tributaries centrally and to the south, and the west-flowing rivers. Numerous other rivers and lakes are situated throughout the country. Harvests from these systems are likely to be underreported based on preliminary results from a study by the United States Geological Survey (Kinney *et al*., forthcoming). The United States of America reported an inland fishery catch to FAO of 19 392 tonnes in 2015, although results from Kinney *et al*. (forthcoming) suggest the total inland catch exceeded 40 000 tonnes when underreported commercial finfish data are included. Reported catches of inland fish from commercial fisheries in the United States of America have declined steadily since the late 1950s. This can be explained by several factors including competition from global imports, aquaculture, and declining productivity (owing to efforts to reduce nutrient inputs) in historically productive fisheries such as the Great Lakes.

Efforts to manage inland fisheries sustainably for recreational and commercial fisheries have increased through time, especially since the mid-1900s when overfishing occurred in some of the systems. According to the data reported to FAO, a wide range of fish are caught, particularly coregonids (21.6 percent) and percids (black bass, walleye and sunfishes, 18.9 percent), which form the mainstay of the Great Lakes fisheries, and salmonids, which are important in the west-flowing rivers. Salmonids used to form up to 19 percent of the total catch in 1988. When data are broadened to include inland fishery harvest unreported to FAO, carp and catfish species make up the most dominant fisheries (Kinney *et al*., forthcoming).

In contrast to the modest commercial fishery catch reported to FAO, Cook and Murchie (2013) estimate that the total harvest in the inland waters of North America (United States of America and Canada) may be in excess of 480 000 tonnes per year, if retained recreational fishery catches are included. Cooke *et al*., (2017) estimate that retained recreational catch in freshwaters of the United States of America is in excess of 396 000 tonnes. Adding this retained recreational catch to the reported catches of the country, plus the preliminary unreported inland commercial fisheries would give a total inland fishery catch for the United States of America in excess of 436 000 tonnes.

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Canada

The northern part of Canada has considerable lake resources, including the large Great Slave and Great Bear Lakes, however low population densities mean that exploitation levels are low. The inland capture fisheries of Canada reported to FAO amount to 27 964 tonnes. The predominant species are walleye and coregonids (whitefish).

Catch has declined steadily from its highest levels of about 60 000 tonnes in the 1960s to its current level of 29 964 tonnes. This decline of the commercial fishery may be misleading, as the indications are that retained recreational captures are somewhat similar (22 758 tonnes, Cooke *et al*., 2017). Total inland catch may be estimated at 50 722 tonnes if Cooke *et al. (*2017) estimates are used. This is close to the maximum reported catch of 60 000 tonnes.

The estimate of recreational catch is probably an underestimate, as the assessment of recreational fishing catch was 40 million angler days with an average catch of 4.3 fish per angler day (Post *et al.*, 2015), thereby suggesting the average weight of fish caught was 172 g.

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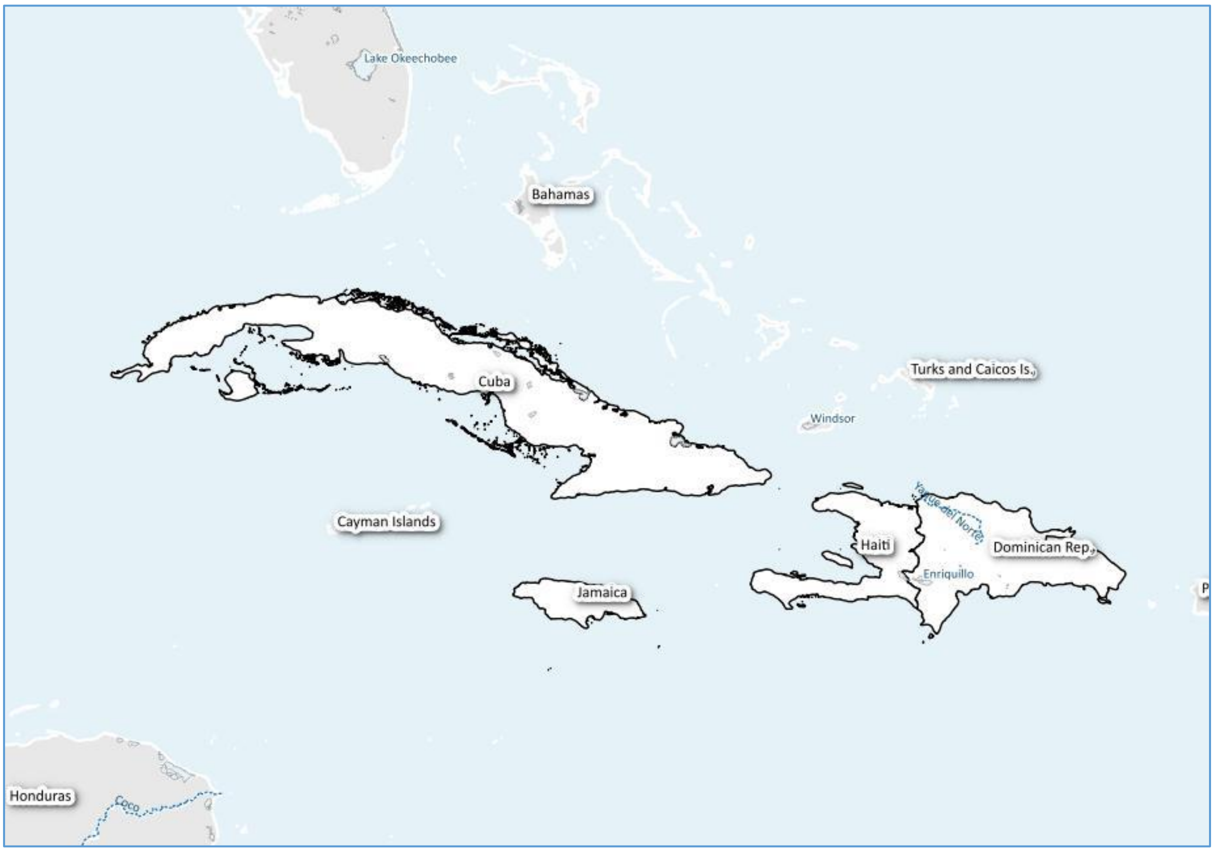
2.5.4 ISLANDS OF THE AMERICAN CONTINENT



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km³/yr)	Fish production per unit of renewable surface water (tonnes/km³/yr)
Cuba	1 800	11 266 000	0.15	0.02	32	57
Dominican Republic	1 234	10 404 000	0.05	0.01	24	53
Jamaica	698	2 784 000	0.14	0.01	9	77
Haiti	600	10 317 000	0.06	0.01	12	51
Falkland Islands (Malvinas)	1	3 000	0.33	0.00		n.a.

The inland fish catch of the islands of the American continent are understandably quite small, reflecting the limited freshwater resources and considerable greater access to marine fisheries. From the middle of the 1980s to early 1990s Cuba had developed an important fishery in the numerous reservoirs of the country under a government supported stocking programme, and reported a catch of 16 000 tonnes (1990). This has now declined substantially as support to hatcheries for stocking has been reduced or withdrawn. The Dominican Republic and Jamaica also stock reservoirs to provide a modest supply of inland fish.

Cuba

Cuban rivers are all small and short (62km to 343 km) flowing directly to the coast. There are 30 south-flowing and 11 north-flowing rivers in Cuba with a total length of 3 932 km (Sugunan, 1997). The country does not have many natural lakes, but there are some swamps and a network of lagoons along the coast. With respect to inland fisheries, 2 large, 6 medium and 228 small reservoirs, and several thousand small impoundments are most important (Sugunan, 1997). It is estimated that the total area of reservoirs is 1 460 km^2 (Coto, 2010).

Cuba has reported inland landings to FAO very regularly since 1956. The most recent statistic is from 2014 with 1 838 tonnes. Inland fisheries catch have experienced a substantial decline since the middle of the 1990s when catches were still close to 10 000 tonnes every year. The highest recorded catch was in 1990 with 15 143 tonnes (FishStatJ). There are some discrepancies with other published (and much higher) catch figures. For example, Coto (2010) mentions a total harvest of 16 374 tonnes in the first nine months of 2010 whereas the corresponding figure in FishStatJ is 2 028 tonnes for the whole year; the discrepancy is probably because of landed fish being classified as production from aquaculture rather than capture fisheries.

Since the 1970s inland fisheries have been managed through semi-intensive (feeding and fertilization) and extensive stocking (in reservoirs larger than 500 ha) programmes using a variety of exotic species, mainly tilapias and Chinese carps. In this extensive system, management includes regular stocking, mesh size restrictions, effort regulations and closed seasons. The average yield is 138 kg/ha (Sugunan, 1997). As this is arguably culture-based fisheries, it might be reported as aquaculture catch.

The very dramatic decline in catches probably results from a scarcity of fingerlings and a change in stocking policies with the country reserving more fingerlings for aquaculture. Quiros (1999) and Quiros and Mari (1999) made the observation that where there is adequate natural recruitment, light stocking of the reservoirs has no impact, particularly with regards to tilapia. Further, poaching and violation of fishing restrictions during closed season have increased. Similarly, there are problems regarding the availability of essential fishing implements such as nets and boats (Sugunan, 1997).

Since 2005, all reported landings have consisted of blue tilapia (FishStatJ). The native freshwater fish fauna in Cuba is rather poor, with 54 native species of which 36 are truly freshwater, the rest being either anadromous or catadromous. Until about 1980 there was a small riverine fishery for indigenous cichlids that yielded about 60 tonnes per year (FAO 2015) or some 4 to 7 percent of the catch. However, these species have now almost disappeared and non-enhanced fisheries are almost nonexistent.

The total number of fishers in the state and private sector is 2 593 (Coto, 2010).

Fish consumption is low with 5.5 kg/capita/year in 2013 (FAO, 2013). Traditionally, the Cubans may have been used to eating marine fish, however, nowadays most of the marine production is exported, and the production from aquaculture and inland fisheries is mostly supplying the domestic market (Adams, 1998).

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Jamaica

Jamaica has ten hydrological basins in which there are over 100 streams and rivers. The largest basin corresponds to the Black River with 1 638.8 Km² (NEPA, 2013). Fishing is mostly for mullets and crustaceans and increasingly also tilapia (O. mozambicus) that have been stocked with these. In addition, FAO (2005) states that land crabs are harvested during the rainy season and there is some collection of sea moss (Gracilaria spp.). CRFM (2015) mentions that most of the main rivers are fished by the local population. River fisheries are particularly important as a traditional activity for the Maroon communities. The Maroons use spear and traps and also biodegradable poisons (see Kimberly (2007) for more details). However, there are reports of pesticides being used for fishing, particularly in the Rio Grande, thus threatening the traditional practices of the Maroons (Kimberly, 2007).

Jamaica resumed reporting to FAO in 2012 after a long period when catches were estimated by FAO. In 2015, 698 tonnes were landed but there is no species detail in the report.

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Dominican Republic

The inland waters of the Dominican Republic consist of 108 river basins, and 270 waterbodies including Lake Enriquillo, which at 256 km^2 is the largest lake in the Caribbean, Cabral Lagoon with 30 km^2, and Oviedo Lagoon with 28 km^2 (Colón-Álvarez, 2017). Lake Enriquillo is hyper saline, but still habours a population of tilapia. The most productive fisheries are in Boca de Yuna and Higuamos wetlands with 132 tonnes and 127 tonnes respectively. In the former there are 981 fishers, which is the highest number of fishers recorded. However, there is only data for 13 waterbodies, which is less than 5 percent, and no data for the largest Lake Enriquillo (Colón-Álvarez, 2017).

National inland catches amounted to 1 234 tonnes in 2015. The highest catch ever reported to FAO was landed in 1994 with 3 774 tonnes, and Colón-Álvarez (2017) mentions that the estimated catch for 2017 is 1 173 tonnes. FAO (1983) estimated a potential yield of 2 088 tonnes per year.

The most important species are tilapias, American eel and common carp (FishStatJ), prawns are caught also and, increasingly, exotic invasive catfishes (Colón-Álvarez, 2017).

Jackson (cited in Marmulla, 1985) conducted fishery assessments of rivers and reservoirs in the Dominican Republic. Annual fishery yield estimates for reservoirs ranged from 29 kg/ha to 75 kg/ha. Prior to the construction of dams, river fisheries focused on crabs and marine fishes. In tandem with dam construction, exotic species such as largemouth bass and tilapia were introduced, and now form the basis for recreational, artisanal and subsistence fisheries. Primary challenges were, and remain, access to ice, transportation of the catch, and safety concerns from fishermen encountering standing dead timber while fishing in small craft.

There is a partly illegal and highly controversial fishery for eel larvae for export (Crook and Nakamura, 2013).

Dramatic changes in the availability of water resources by the year 2100 are foreseen as a consequence of lower precipitation levels (MARENA cited by Colón-Álvarez, 2017).

Annual fish consumption in the country is 8.7 kg/capita (in 2013), and as national catch is only capable of meeting 25 to 30 percent of the demand the rest is met through imports (FAO, 2017).

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Haiti

The total area of inland waters is estimated at 220 km^2, of which about 85 percent is constituted by four main waterbodies including the brackishwater Lake Azuéi, which is the largest with an area of 113 km^2, and the Péligre reservoir, which is the second largest with 48 km^2. In addition, there are numerous small waterbodies (Vlaminck, 1990). The waterbodies are greatly affected by periodic droughts that cause significant fluctuations in water level (Miller, 2015). There are 31 permanent or almost permanent rivers in Haiti, and most rivers are small and dry up during the dry season (JICA, 2011). The only river with some fishing potential is the Artibonite River which is the largest in Haiti with a basin area of 8 908 km^2 (Vlaminck, 1990).

Haiti has only reported inland catch data once since 1970, and that was in 2009 with 600 tonnes. No alternative estimates have been found and no species detail is available. Vlaminck (1990) estimated a total potential for the four largest waterbodies of 1 500 tonnes.

Inland fisheries are carried out by small-scale fishermen living around the waterbodies, using boats and basic fishing techniques. The most important management intervention is the occasional stocking by the fisheries department. However, there is less need to stock where the local population is organized to manage the fish resource (Ministère de L'Agriculture des Ressources Naturelles et du Développement Rural, 2010). According to the Ministry of Environment there is an estimated 1 071 fishers in inland waters (Ministere de l'Environnement, 2001), although Felix (2012) suggests that the number is 800. Hargreaves (2011) suggests 3 000 fishers around Lake Azuei of which 60 percent depend solely on fisheries for their income and 33 percent rely on a mixture of livestock raising and fishing.

During the 1990s when FAO supported a stocking programme with tilapia (*O. mossambicus*) in Lake Azuéi the catch was at 140 tonnes per year, but when the programme and regular stocking stopped catch decreased to 45 tonnes (Ministère de L'Agriculture des Ressources Naturelles et du Développement Rural, 2010). Tilapia reproduction and recruitment in the lake is limited by salinity and the lake has been stocked with tilapia twice since 1999. The lake also hosts a native cichlid, *Cichlasoma hatiensis* and bigmouth sleeper (*Gobiomorus dormitory*) (Hargreaves, 2011).

The marketing of fish is provided by some small merchants who buy directly from fishermen, or with an intermediary and is marketed fresh or dried (Ministère de L'Agriculture des Ressources Naturelles et du Développement Rural, 2010).

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Falkland Islands (Malvinas)

A variety of freshwater bodies occur in the Falkland (Malvinas) Islands, including coastal barrier ponds, oxbow ponds, glacial tarns and erosion hollows, and slump features in peat. There are six species of fish in freshwater and brackishwater in estuaries and in the lower reaches of rivers (Otley *et al*., 2008). The two indigenous fish species the inanga (*Galaxias maculatus*) and the zebra trout (*Aplochiton zebra*) and the introduced sea (or brown) trout (*Salmo trutta*) (McDowall, Allibone and Chadderton; Otley *et al*., 2008). These three species all follow a diadromous life cycle, but can survive in landlocked waterbodies. Three marine species: Patagonian blennie (*Eleginops maclovinus*) and two species of silversides (*Odontesthes nigricans* and *O. smitii*) are also found in the lower reaches and estuaries of streams and rivers. There have been attempts to introduce rainbow trout (*Oncorhynchus mykiss*), brook char (*Salvelinus fontinalis*) and Atlantic salmon *(Salmo salar*), but none of them have become established (Otley *et al*., 2008).

Falkland (Malvinas) Islands have reported an annual catch of one tonne of sea trout from inland fisheries since 1996 (FishStatJ). This probably corresponds to the catches by the small company that supplies sea trout for people and restaurants (Otley *et al*., 2008). However, since 2000, artisanal fishers has been operating what appears to be a sustainable beach seine fishery for Patagonian blennie in creeks in the Goose Green, North Arm and Port Louis areas, with catch levels of about 10 to 61 tonnes per year, all marketed locally (Otley *et al*., 2008). In addition to the commercial operations, there is a famous recreational fishery for anadromous trout (McDowall, Allibone and Chadderton, 2001).

A number of threats to inland fisheries resources have been identified, and these include intensive grazing and associated damage to streamsides, changes to water quality because of pollutants such as effluent from homes, and livestock sheds, physical changes to watercourses such as installation of culverts, creation of dams, removal of water, introduction or transfer of exotic species and unsustainable fish catches (Otley *et al*., 2008).

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Antigua and Barbuda

FAO (2007) indicates that although there are no commercial inland fisheries, there is traditional harvest of freshwater and estuarine species in salt ponds and inland dams or ponds on a subsistence basis. Species harvested include mullets, tarpons, tilapia, cockles and crabs. Crabs are primarily hunted during the rainy season and are especially popular during festivals. Cockle is harvested year round and is marketed locally.

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Barbados

Freshwater shrimps occur in catchments in Barbados but there is no known extraction of these (CRFM, 2015).

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Dominica

There is a traditional fishery for goby fry in river estuaries. The fishery is governed by lunar phases and takes places for three days a month from July to April. There may also be some fishing of prawn postlarvae for grow out in culture ponds(FAO, 2002).

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Grenada

A small number of finfish and crustaceans are harvested in small streams on a subsistence basis mainly using handline and spear gun. Several rural families depend on this resource for the supply of valuable protein (FAO, 2007).

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Montserrat

There is a fishery for crustaceans in rivers and tilapia in ponds (Department of Fisheries Montserrat cited by CRFM, 2015).

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St. Kitts and Nevis

Tilapia and mullets are fished in ponds and lagoons (Department of Fisheries St. Kitts and Nevis, cited by CRFM, 2015).

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St. Lucia

Several species of shrimp were fished until 1994 when a moratorium was implemented (Department of Fisheries St. Lucia, cited by CRFM, 2015).

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St. Vincent and the Grenadines

There is a traditional fishery for goby fry in river mouths and estuaries of some economic importances (Fisheries Division St. Vincent and the Grenadines, cited by CRFM 2015).

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Trinidad and Tobago

Fish and crustaceans are harvested on a subsistence basis in rivers and streams. There is commercial exploitation of teta (*Hypostomus robinii*) as an ornamental (Alkins-Koo *et al*., 2004).

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Anguilla, Bahamas and Turks and Caicos

No inland fisheries have been identified at Anguilla, Bahamas and Turks and Caicos (CRFM, 2015).

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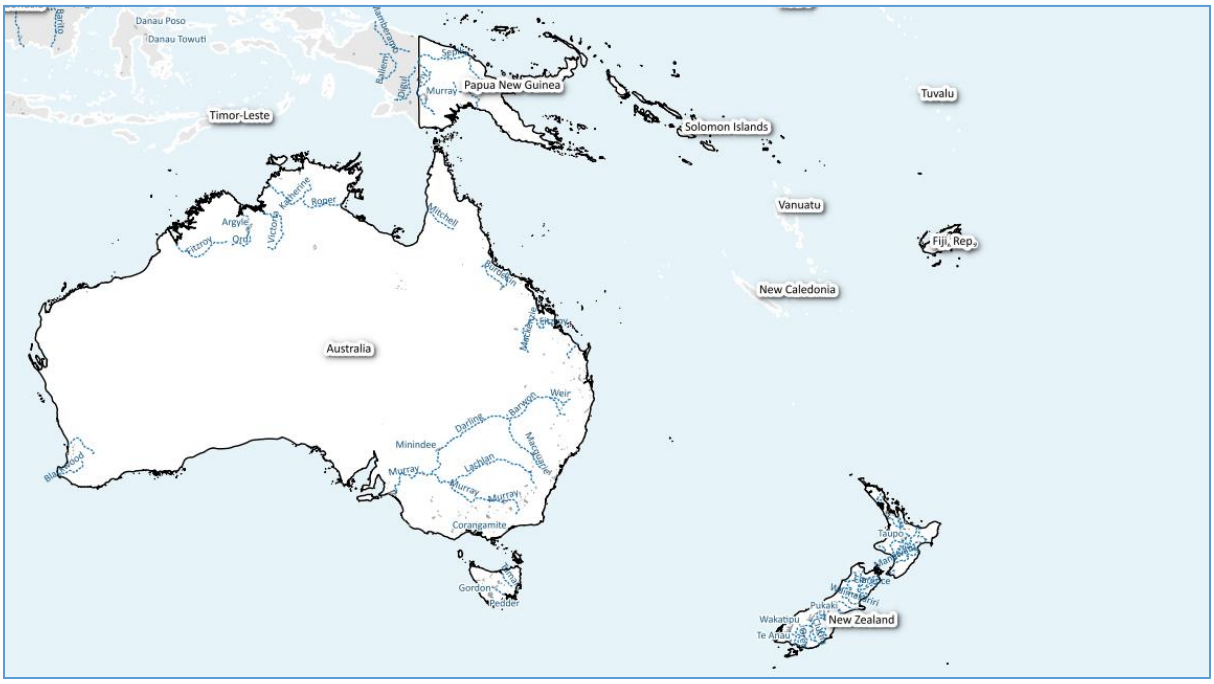
2.6 OCEANIA



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km³/yr)	Fish production per unit of renewable surface water (tonnes/km³/yr)
Papua New Guinea	13 500	7 321 000	1.84	0.11	801	17
Fiji	2 600	881 000	2.95	0.02	28.55	91
Australia	1 039	2 334 3000	0.05	0.01	440	3
New Zealand	832	4 506 000	0.3	0.01	-	-
French Polynesia	53	277 000	0.19	0	-	-
Federated States of Micronesia	5	104 000	0.05	0	-	-
Samoa	1	190 000	0.01	0	-	-
Solomon Islands	0	561 000	0	0	44.7	0

The Oceania region comprises many small island developing states (SIDS), the continent of Australia, New Zealand and Papua New Guinea. The main catch of inland water fish in Oceania comes from Papua New Guinea with 75 percent of the combined catch. Most of the smaller island states have limited freshwater resources and no appreciable inland fisheries.

Papua New Guinea

Papua New Guinea has water resources including the Fly (1 200 km) and Sepik Rivers (900 km) and corresponding basins. In addition there are over 5 000, mostly small, lakes. Over 87 percent of the human population of Papua New Guinea live inland and have no direct access to marine aquatic resources. Even in highland areas, where fish stocks are very poor, over 50 percent of the population engages in fishing activities in many areas, traditionally for eels, but more recently catches include a number of exotic species (Coates, 1996). FAO has been estimating freshwater catch since 1980. The current estimate of 13 500 tonnes has been unchanged since 1992. The 2001 to 2006 household survey figure gives an estimate of 25 572 tonnes of inland fish catch, which is is 89 percent higher than the FAO estimate for inland capture fishery catch (Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Gillett (2016) makes an extrapolated estimate of 20 000 tonnes in 2014, which is reasonably close to the household survey estimate.

Papua New Guinea's rivers and floodplains naturally have low productivity and this has been attributed to a depauperate fish fauna (Coates, 1989). During 1984 to 1997, six non-native species were introduced into the Sepik River: *Barbonymus gonionotus*, Pacu (*Piaractus brachypomus*), red belly tilapia (*Coptodon rendalli*) and *Prochilodus argenteus* were introduced to lowland floodplains and snow trout (*Schizothorax richardsonii*) and golden mahseer (*Tor putitora*) were introduced to higher altitude streams. All of these species have now established breeding populations and contribute to inland fisheries (Kolkolo, 2005). Before the introductions the inland fishery of the country was mainly based on the Fly River.

Papua New Guinea also has a commercial fishery (~170 tonnes) for sea bass (*Lates calcarifer*) a dominant species in the Fly River. A commercial gillnet fishery was developed in the 1960s in coastal and estuarine waters. Annual catch reached 330 tonnes in the 1970s. The fishery was closed in early 1990s after decline of the fishery from effects of mining, overfishing and drought. A management plan was implemented in 2004 and annual catch has now reached 170 tonnes from the middle Fly River. Several other species are considered to have some economic potential (Jellyman, Gehrke and Harris, 2015).

Coates (1989) estimated total freshwater catches before species introductions as being from 14 500 to 18 500 tonnes per year assuming that with the "right" composition of the species assemblage a catch of 100 000 tonnes could be attained. A re-estimation of national production, perhaps using household surveys, might indicate the extent to which the fishery has been enhanced by the stocking effort.

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Fiji

Fiji accounts for 14 percent of regional catch and 2 420 tonnes of this catch is freshwater molluscs (freshwater clams *Batissa violacea*), with an additional 140 tonnes of freshwater crustaceans. The kai (Batissa violacea) is found in all major river systems in Fiji, and is the basis of the largest freshwater fisheries in the country, and one of the top three in the Pacific region. Harvests of freshwater finfish consist mainly of eels and introduced fish such as tilapia and carps (FAO, 2014). Eels are taken in fresh water in Fiji. Nandlal (2005) reports that eels are an important source of protein for the rural population, but Richards (1994) states there is not a strong local demand for freshwater eels, and there is no organized fishery for them. The fish biodiversity in Fijian rivers has been significantly affected by a loss of catchment forest cover and introductions of tilapia (Jenkins *et al*., 2009). Gillett (2016) estimates inland fish catch at 3 731 tonnes in 2016.

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Australia

Australia's water resources include the Murray-Darling systems and a number of smaller rivers. Fish populations in the main Murray-Darling River system are severely stressed because of river regulations and desiccation of the river channel and riparian wetlands (Gehrke *et al*., 1995).

Reported catch in 2015 was 1 039 tonnes. Catches from Australia have always been relatively low (maximum catch 3 512 tonnes in 1992 (FishStatJ) and have declined from 1992 onwards. There was a minor fishery for the introduced common carp in the 1990s for cat food, but this later proved uneconomical. No species details are reported for 2015, although both crayfish (*Euastacus armatus*) and eels (*Anguilla* spp.) made important contributions in the past (FishStatJ).

Recreational fishing is predominant. There was a small commercial fishery in New South Wales with a catch of 344 tonnes. These trap fisheries in New South Wales targeted eel, yabby, Murray cod and carp (Grant *et al*., 2004). This inland commercial fishery in New South Wales had a mean annual catch of 344 tonnes (1965 to 1995), was worth USD 1.7 million per annum in 1995/96 (Reid, Harris and Chapman, 1997). The fishery was phased out in 2001. Commercial estuarine fisheries still exist in the north and northeast, targetting barramundi (*Lates calcarifer*) and mullet. Eels are also commercially harvested from southeastern coastal rivers (Jellyman, Gehrke and Harris, 2015). In Victoria State, commercial fishing existed for native species, eel and baitfish, however the commercial licences were all bought out in 2002 or all species were excluded except eel and baitfish.

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New Zealand

New Zealand had a total reported catch of 832 tonnes in 2015. Freshwater species caught include eels, trout and salmon. Also, some freshwater species such as eels and koura (a native freshwater crayfish) are important to the Maori for their spiritual and customary needs. The New Zealand commercial eel fishery has an estimated catch of 500 tonnes. The commercial fishery for eel started in 1960s reaching more than 2 000 tonnes by the early 1970s, after which it collapsed. Freshwater eels were brought into New Zealand's Quota Management System in the 1990s and the commercial eel fishery currently produces approximately 500 tonnes per year and 80 percent of this is *A. australis* (Jellyman, Gehrke and Harris, 2015).

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French Polynesia

There are a reported 37 species of freshwater fish and 18 species of decapod crustaceans (Keith, Watson and Marquet, 2002). The most important speices for inland fisheries are juvenile gobies (*Sicyopterus lagocephalus* and *S. pugnans*), *Macrobrachium*, tilapia, *Kuhlia* spp. and eels. No official estimate is made for inland fishery catch, however Gillett (2016) cites estimates by staff of Service de la Pêche that, on average, catches fluctuate around 100 tonnes per year.

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Samoa

ADB (2008) reports that 2 percent of all households in Samoa engage in at least some fishing in inland rivers and lakes. The annual catch of one tonne of freshwater fish is estimated by FAO. Gillett (2016) reports that main freshwater fishery species are tilapia, eels and freshwater shrimp and that the total annual harvest is unknown, but likely to be about 10 tonnes per year.

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Solomon Islands

The large islands of the country mean that a relatively large inland population have no direct access to marine food resources and there is a significant subsistence freshwater fishery (Gillett, 2016). Anecdotal information and survey reports focussed on single islands suggest that flagtails, gobies, eels, and freshwater shrimps are important native species. Tilapia, an introduced species, appears to be important, especially in small ponds and lakes. The Solomon Islands record an inland subsistence fishery landing some 2 000 tonnes per year, which do not appear in FishStatJ (FAO, 2009). Gillett (2016) estimates the 2014 catch to be 2 300 tonnes.

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Vanuatu

It is reported that the distribution of the various freshwater ecosystems is patchy throughout the Vanuatu archipelago, covering only one percent of the total land area. There are 18 families of local freshwater fish, three families of introduced fish, and several species of shrimps and crab. The most important taxa for fishery purposes are local species of fish: five genera of fish (*Khulia*, *Lutjanus*, *Gerres*, *Monodactylus, Scatophagus*), four species of mullets, and several species of freshwater eels; introduced species of fish: Cyprinus and two species of tilapia, and invertebrates: several species of *Macrobrachium* (Amos, 2007). Recent annual catch from freshwater fisheries in the country is about 80 tonnes per year, and is almost entirely for subsistence use, except for the *Macrobrachium* shrimp which is sold in urban areas (FAO, 2010). An estimate of recent annual catch from freshwater fisheries in the country is about 88 tonnes per year (Gillett, 2016).

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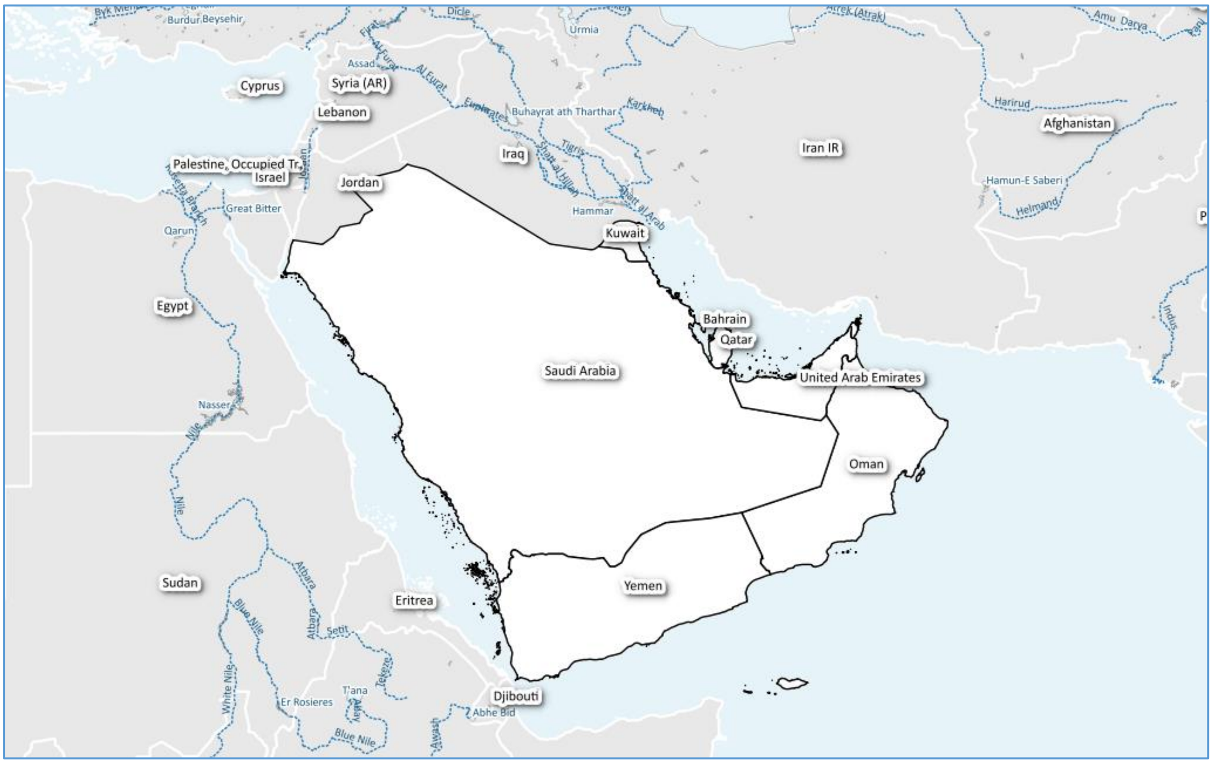
Other countries

Catches from some island groups do not appear in FishStatJ.

2.7 ARABIA



Country	Inland capture fishery catch (tonnes) (2015)	Population (2013)	Per capita Inland fishery catch (kg/cap/yr)	Percentage of global inland fishery catch	Total renewable surface water (km^3/yr)	Fish prodn. per unit of renewable surface water ($tonnes/km^3/yr$)
Bahrain	0	1 332 000	0	0	0.004	0
Kuwait	0	3 369 000	0	0	-	0
Oman	0	3 632 000	0	0	1.05	0
Qatar	0	2 169 000	0	0	0	0
Saudi Arabia	0	28 829 000	0	0	2.2	0
United Arab Emirates	0	9 346 000	0	0	0.15	0
Yemen	0	24 407 000	0	0	2	0

This region has minimal surface freshwaters and is almost totally arid. There is no reported inland catch to FAO from any of the countries.

3 THE CONTRIBUTION OF INLAND FISHERIES TO SUSTAINABLE DEVELOPMENT

Fiona Simmance and Simon Funge-Smith

SUMMARY

Small-scale inland fisheries catch tends to for local human consumption and plays an important direct role in food security. Ecosystem services from freshwater environments and inland capture fisheries influence human well-being by alleviating poverty and contributing to food and livelihood security. Inland capture fisheries and their ecosystem services provide a broad range of benefits for development and contribute directly to the Sustainable Development Goals (SDGs). Despite this, the inland fisheries sector is typically ignored or overlooked in policy and global debates on food security.

3.1 INLAND FISHERIES CONTRIBUTION TO THE SUSTAINABLE DEVELOPMENT GOALS

Inland capture fisheries produce immense social and economic value for millions of people globally (Béné *et al.*, 2016). In 2014, 11 898 482 tonnes of inland capture fisheries were reported with over 95 percent from developing countries, particularly in Africa and Asia, and 40 percent produced in low-income food-deficit countries (LIFDCs) (FAO, 2014). Small-scale inland fisheries catch tends to be almost entirely for local human consumption and hence plays an important direct role in food security. The primary value of inland capture fisheries is in providing fish as a nutrient dense food source and generating income and employment for tens of millions of people (Youn *et al.*, 2014; Béné *et al.*, 2015). In many countries, even countries with very small inland fisheries compared to the marine fisheries, employment in inland fisheries may rival that in the marine sector. Inland fisheries can provide livelihood opportunities in areas with few employment opportunities. It can be a primary or supplementary activity that can provide income all year round and act as a safety net such as during climate-induced agricultural lean months.

Fish is often an accessible, low-cost source of animal protein and essential micronutrients to remote rural communities. Inland capture fisheries are often located in remote rural areas where communities are highly dependent upon natural resources for their livelihoods. The sector thus has a critical role in supporting food security and poverty alleviation for many communities in developing countries. Several countries are also highly dependent upon inland fisheries as their main fish supply, such as landlocked countries, where fish can contribute an important source of animal protein intake and nutrients, as well as sustaining livelihoods (Youn *et al.*, 2014; FAO, 2003).

Inland capture fishing in industrialized countries is primarily directed at recreational fisheries, providing important cultural services and generating a billion-dollar industry through sale of licences and associated businesses (UNEP, 2010).

Despite the broad range of benefits for development that are provided by inland capture fisheries and their ecosystem services, the sector has been ignored largely in policy and global debates on food security. In comparison to the marine marine fisheries sector, inland fisheries have been paid comparatively little attention. This is reflected in the poor coverage of aquatic ecosystems and inland fisheries in the Sustainable Development Goals (Cooke *et al.*, 2016; Juffe-Bignoli *et al*., 2016). The social and economic value of the sector has largely been invisible because of inland capture fisheries being one of the most under-reported and undervalued sectors (Bartley *et al.*, 2015). Greater recognition of the value of inland capture fisheries is required to improve management of the sector at the national and local decision making levels (Béné and Neiland, 2003; Bartley *et al*., 2015; Lynch *et al*., 2016).

Through these contributions, inland capture fisheries have the capacity to support directly the achievement of the Sustainable Development Goals (SDGs). The direct and indirect contributions of inland capture fisheries to selected SDGs are presented in Table 3-1.

Table 3-1: Contributions of inland capture fisheries to selected Sustainable Development Goals

Sustainable Development Goal	Contribution of inland capture fisheries
1 NO POVERTY	Inland capture fisheries provide income and employment to over 60 million people worldwide. Inland fishers, who are dependent upon fishing for their livelihoods, are amongst the poorest and most vulnerable rural populations.
	Fisheries contribute to poverty reduction by providing food, income, and employment. However, small-scale producers often receive the least calculated benefits (Béné *et al.*, 2016).
	Fishery related livelihoods are particularly important in remote rural areas where there is a lack of alternative employment, and can act as a safety net during times of shocks, such as in agriculture, and for the landless poor.
	The inclusion of the fisheries agenda in a country's national poverty reduction plan depends on the interdependence between the fisheries sector and other industries (e.g. water industries), which permits action against common concerns (Thorpe, 2005; Thorpe *et al.*, 2006).
2 ZERO HUNGER	Contribute to dietary intake, food and nutritional security, which decreases malnutrition and improves health and well-being. Inland fisheries contribute a significant proportion of protein and micronutrients in a number to LIFDCs and for rural populations in at least 100 countries worldwide.
	Inland fish are accessible and often a low cost nutritious source of protein and minerals. Income from fish increases purchasing power for other food items. (Roos 2016; Lymer *et al.*, 2016a; Youn *et al.*, 2016).
	Women's participation in the inland fishery sector can also strengthen the link between fish and food security.
	Inland fishery related livelihoods can also act as a safety net during times of shocks.
3 GOOD HEALTH AND WELL-BEING	Inland fish provides a source of affordable proteins and micronutrients that through food and nutritional security improves the health of women during pregancy and child development.
	Fish nutrients help mitigate the impacts of disease among the poor and are essential for the effective use of drugs.
	Fish related income enables fisherfolk to access services such as healthcare and nutrition.
	Fishers are generally happy with their occupations in part because of the amount of income they receive, but also because of non-monetary factors such as the relative ease of obtaining food, the independence permitted by the job (Pollnac, Pomeroy and Harkes, 2001; Pollnac, Bavinck and Monnereau, 2012)
4 QUALITY EDUCATION	Income from fishing can pay for school fees.
	Indirect benefits through increased income for women and improved health of children.
	The impact of high quality nutrition from fish in the diet for pregnant women, and the first thousand days of children's development may have a significant impact on brain development and learning capacity.
	Number of women employed in inland fisheries >50 percent.
	Women's engagement primarily in the fishery secondary sector enables gains in income, independence and power.

Table 3-1: Contributions of inland capture fisheries to selected Sustainable Development Goals

Sustainable Development Goal	**Contribution of inland capture fisheries**
5 GENDER EQUALITY	Some fishing sector jobs (e.g. fish trading) are well-suited for female entrepreneurs, especially in sub-Saharan Africa and Southeast Asia.
	In general, women's contributions to the fisheries sector are undervalued (Béné *et al.*, 2016). Women in post-harvest jobs may be vulnerable to economic or sexual exploitation (Béné and Merten, 2008; Youn *et al.*, 2016; Belton and Thilsted, 2014).
6 CLEAN WATER AND SANITATION	The elimination of dumping, the reduction of pollutants, hazardous materials and untreated wastewater released to freshwater systems, as well as increase of wastewater reuse, can improve the quality of habitat supporting inland fisheries (Dudgeon *et al.*, 2006; Arthington *et al.*, 2006).
	Increased water use efficiency, sustainable freshwater withdrawals, and the implementation of integrated water resources management, will also help protect and restore freshwater ecosystems and fisheries (Bunn, 2016).
	An ecosystem-based approach to fisheries management can contribute towards sustaining freshwater ecosystem services.
	Inland fish also provide water quality regulating services.
7 AFFORDABLE AND CLEAN ENERGY	The inland fisheries sector must coordinate with the water and energy sectors to ensure that hydroelectricity projects do not harm inland aquatic ecosystems and fisheries (Poff *et al.*, 1997; Winemiller *et al.*, 2016).
8 DECENT WORK AND ECONOMIC GROWTH	16.8 million to 20.7 million rural people are employed in inland capture fisheries with another 8 million to 38 million rural people employed in the post-harvest sector. This represents ~2.5 to 6 percent of the global agricultural workforce.
	Inland fisheries are generally less dangerous than marine capture fisheries.
	Because of the general poverty of small-scale inland fishers, there are some risks from the use of child labour and unsafe operating practices.
10 REDUCED INEQUALITIES	Fish-related employment and income-effective governance of inland capture fisheries can prevent and reduce poverty for men and women.
13 CLIMATE ACTION	Inland capture fisheries are a highly efficient food production system.
	Inland capture fisheries can provide a low carbon footprint food source.
	Inland capture fisheries can also act as a safety net/coping strategy during times of climate-induced shocks.
14 LIFE BELOW WATER	Inland capture fisheries contribute to global fish supply and demand. Inland fisheries could contribute directly to this SDG if modified to include freshwater.
	Target 15.1 freshwater ecosystems : An ecosystem based approach to inland fisheries management can contribute to sustainable use of freshwater systems.

Table 3-1: Contributions of inland capture fisheries to selected Sustainable Development Goals

Sustainable Development Goal	Contribution of inland capture fisheries
15 LIFE ON LAND	Targets 15.5 and 15.8: Managing freshwater ecosystems to conserve inland fisheries contributes to sustained biodiversity; it may limit impacts of invasive species.
	Freshwater ecosystems cover only about 1 percent of the earth's surface, but aquatic ecosystems (inland and marine) represent the most biodiverse sources of food consumed by humans.
	Freshwater aquatic ecosytems provide habitat for over 40 percent (13 000) of the world's freshwater fish species. Another 2 000 species of fish can also live in brackishwaters.
	Rice field ecosystems are an important source of biodiversity >200 species of fish, insects, crustaceans, molluscs, reptiles, amphibians and plants.
	Many freshwater species are important to the aquaculture industry.

Source: Modified from Heck, Béné and Reyes-Gaskin, 2007

3.2 INLAND FISHERIES CONTRIBUTION TO THE AICHI BIODIVERSITY TARGETS

Sustainable management of inland capture fisheries and their freshwater environments are linked to the Sustainable Development Goals and the Aichi Biodiversity Targets. Some of the challenges that inland capture fisheries experience, such as competing demands for freshwater, can be managed through conservation goals in these global agreements, and sustainable management of inland capture fisheries can also make important relevant contributions to the success of these agreements.

Biological diversity also underpins ecosystem functioning and the provisioning of ecosystem services to human well-being. Under the Convention on Biological Diversity, the Strategic Plan for Biodiversity 2011–2020 aims to "take effective and urgent action to halt the loss of biodiversity in order to ensure that by 2020 ecosystems are resilient and continue to provide essential services, thereby securing the planet's variety of life, and contributing to human well-being, and poverty eradication". The Aichi Biodiversity Targets set to achieve this plan include conservation of freshwater ecosystems and fisheries: Target 6 – sustainable use of fisheries and Target 11 – at least 17 percent of terrestrial and inland water environments to be protected areas. In addition, the targets also aim to prevent the drivers of biological diversity change, such as habitat loss, that are also the biggest threats to inland waters.

For inland freshwater environments, Target 11 may have already been achieved with estimates that approximately 20 percent of inland waters are already protected (Juffe-Bignoli *et al.*, 2016), including 19.3 percent of total river lengths in Africa (Holland, Darwall and Smith, 2012). However, protection of inland waters is not typically directed at protection of inland fisheries, rather it is related to habitat complexes (e.g. wetlands) for protection of bird life, charismatic mammals and to some extent reptiles. The protection of inland freshwater environments is complex; there is difficulty in estimating the extent and status of freshwater inland areas, particularly in the tropics, and existing protection is often weak (Gardner *et al.*, 2015; Juffe-Bignoli *et al.*, 2016). The protection of wetlands is not necessarily protecting fisheries as they depend on a much more holistic approach to conservation taking into consideration connectivity and the dynamics of the system.

There is a need to ensure that protection is appropriately designed and located for overall protection of inland waters; including upstream sections. Thus, the sustainable use and management of inland capture fisheries and their freshwater ecosystems can help achieve many interlinked global agreements.

3.3 INLAND FISHERIES AS AN ECOSYSTEM SERVICE

In 2005, the Millennium Ecosystem Assessment (MEA) provided a comprehensive evaluation of the status and value of global ecosystems, the services they provide, and benefits derived for human society. The MEA (2005) found that 15 out of the 24 global ecosystems were degraded, with increased risk of non-linear changes and exacerbation of poverty for some groups. Freshwater environments have experienced alarming changes with the most rapid deterioration in terms of losses in species and habitat area.

Ecosystem services defined as "the benefits people obtain from ecosystems" are most widely categorized into provisioning, regulating, cultural and supporting services (MEA, 2005) (Figure 3-1). Provisioning services are the products obtained from ecosystems and include food, freshwater, fuel, wood and fibres. Regulating services are the benefits obtained from regulation of ecosystem processes such as climate regulation, water purification, flood control and the flushing of salinity. Supporting services include nutrient cycling, soil formation and primary production, which are the underlying services that are necessary for the production of all other services. Non-material benefits of cultural services obtained from ecosystems include spiritual fulfilment, recreation and tourism.

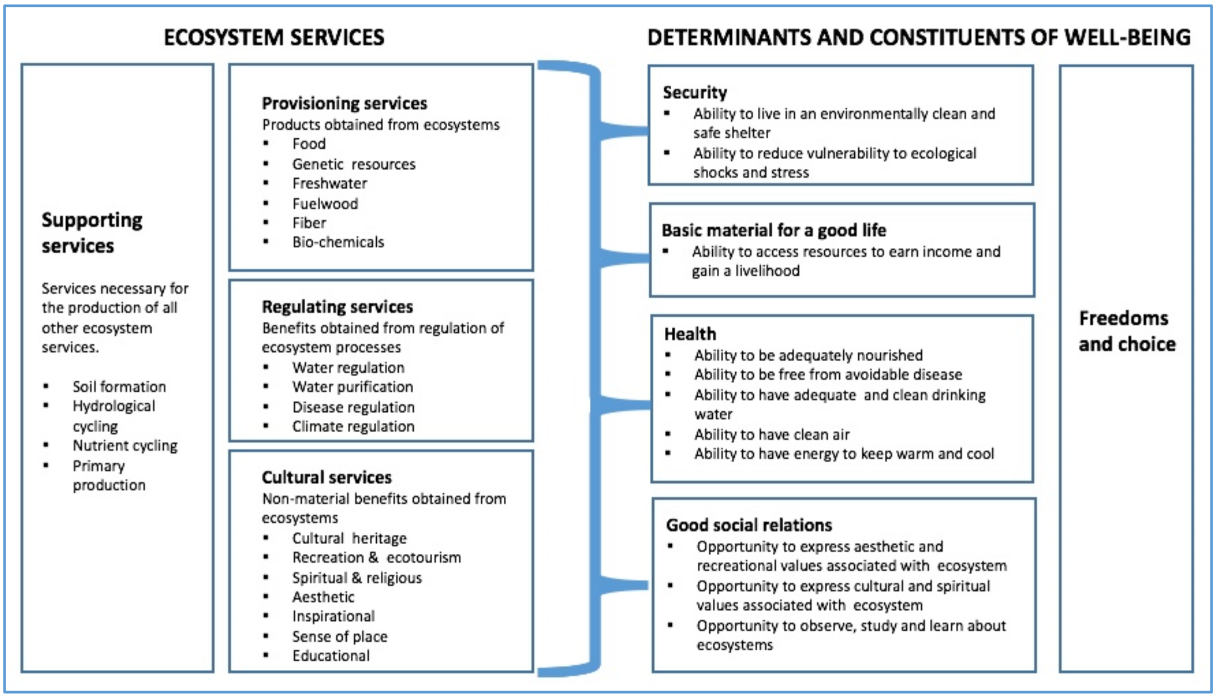


Figure 3-1: Ecosystem services and linkages with human well-being

Source: Adapted from MEA, 2005

The MEA (2005) found that in recent decades, ecosystems have provided provisioning services such as freshwater and food for the growing global population that has enabled human well-being and economic development to increase, thereby contributing to reducing malnutrition and improving health. Even so, these enhancements in provisioning services have come at the costs of other ecosystem services such as biodiversity and nutrient regulation.

Inland capture fisheries and their freshwater systems provide unique and diverse provisioning, regulating, supporting and cultural services that also support wider ecosystem services in terrestrial and marine environments (Table 3-2; Figure 3-1). Provisioning services of freshwaters, where inland fisheries occur, include fish and wild game as food, freshwater for drinking and agriculture use, and freshwater for transport and navigation. Regulating services include water purification and treatment and flood control, and freshwater environments also provide a habitat for terrestrial and aquatic organisms, thus also acting as supporting services. For thousands of years these environments have also been centres of social, cultural and recreation activities, being integral to cultural identity and having high aesthetic value even today.

These freshwater ecosystem services vary between habitats such as lakes, rivers, swamps, rice fields and floodplains (Table 3-2).

Table 3-2: Ecosystem services from freshwater and inland wetlands

Categories	**Ecosystem services from freshwater and inland wetlands and inland fisheries**
Provisioning	
Freshwater consumptive use	93 113 km^3 of surface water (used for drinking, domestic, agriculture and industrial purposes
Freshwater non-consumptive use	Hydro-electric dams and water turbines generate power for transport and navigation
Food, nutrition, food security	Approximately 11.5 million to 17 million tonnes of fish, wild game, fruits and grains produced from inland fisheries
Income and livelihood options/jobs	From fishing and other wetland associated employment
Aquatic species for non-food purposes	Ornamental and recreational species of plants and animals
Biochemical	Extraction of medicines and other materials from biota
Genetic materials	Genetic material for improving aquaculture broodstock for aquaculture; genes for ornamental species etc.
Fibres and fuel	Production of fuelwood, peat etc. Wood for building and energy
Skins and hides	Animals, including fish, provide material for clothes, shelter and other uses
Regulating	
Nutrient recycling and transport	Migratory fish such as salmon transport nutrients from marine to freshwater environments as they spawn
Water treatment and purification	The soil, microbes, plants and animals of wetlands remove particulate matter, nutrients and toxins from water Sedimentation, erosion and salinity regulation
Temperature regulation	Trees and floating and emergent vegetation help maintain shade and water temperatures for biodiversity of rivers and lakes
Natural hazard regulation	Flood control, storm protection
Carbon sequestration	Emergent plants and wetlands such as rice fields and peatlands are sinks for carbon – as long as they remain flooded and undisturbed
Pollination	Providing habitat for pollinators
Pest control and disease control	Predation of plant pests (e.g. in ricefields) and vectors of waterborne diseases e.g. snails and mosquito larvae)
Supporting	
	Soil formation
	Nutrient cycling
	Food chain dynamics (food web and trophic structures)
	Habitat
	Ecological balance
	Biodiversity
	Aquaculture
Cultural	

Table 3-2: Ecosystem services from freshwater and inland wetlands

Categories	Ecosystem services from freshwater and inland wetlands and inland fisheries
Recreation and tourism	Sport fishing and preservation of environments for fishery recreation
Sense of place	Spiritual and inspirational, cultural heritage and identity. People throughout the world often are strongly connected to nature and their ancestral areas, e.g. Tūrangawaewae ("a place to stand") in Maori culture
Biodiversity aesthetic values	Appreciation of fish, birds, amphibians, plants etc add to the quality of life or tradition in urban and non-urban areas, for example Ramsar Wetlands of International Importance. (See http://www.ramsar.org/sites-countries/the-ramsar-sites)
Existence value	Knowing that biodiversity exists, even if one can't see it, e.g. the giant Mekong catfish, the world's smallest fish in Indonesia, the diversity of cichlids in the African Great Lakes, the piranha of the Amazon, the sturgeon of the Caspian Sea and North America.

Source: Adapted from MEA, 2005; Brugere, Lymer and Bartley, 2015.

3.3.1 PROVISIONING SERVICES

In many developing countries, where the bulk of inland capture fisheries production occurs, the primary value is provisioning services of food, and associated income and employment from harvesting of fish products. Fish is one of the most valuable wild foods, providing an accessible and affordable nutrient dense food source, and a source of income and employment. The contribution of inland capture fisheries provisioning services to food and livelihood security are also amplified when considering that the fisheries are often in remote rural locations where communities have a lack of nutrient food sources and livelihood options.

3.3.2 REGULATING SERVICES

Freshwater ecosystems also indirectly influence valuable coastal and marine fisheries through freshwater flows, and the species and nutrients they contain (Table 3-3). Flows of freshwater into coastal areas also impact marine organisms through changes in salinity, habitat and nutrient availability and other changes in the physiochemical aspects of coastal and marine ecosystems (Kennedy and Barbier, 2016).

Table 3-3: Influence of freshwater flows on marine and coastal fisheries

Species	Scientific name	Location	Influence
Banana prawn	*Penaeus merguiensis*	Gulf of Carpentaria, Australia	+/-
Black drum	*Pogonias cromis*	Galveston Bay, North America	+/-
American lobster	*Homarus americanus*	Gulf of St. Lawrence, Canada	+
Anchovy	*Engraulis encrasicolus*	Northwestern Mediterranean	+
Barramundi	*Lates calcarifer*	Fitzroy River, Australia	+
Blue crab	*Callinectes sapidus*	Apalachicola Bay, North America	+
Blue shrimp	*Litopenaeus stylirostris*	Gulf of California, Mexico	+
Common sole	*Solea solea*	Gulf of Lions, Mediterranean	+
Eastern oyster	*Crassostrea virginica*	Apalachicola Bay, North America	+
Halibut	*Hippoglossus hippoglossus*	Gulf of St. Lawrence, Canada	+
Harbour crab	*Liocarcinus depurator*	Northwestern Mediterranean	+
Herring	*Clupea pallasi*	Strait of Georgia, Canada	+

Table 3-3: Influence of freshwater flows on marine and coastal fisheries

Species	Scientific name	Location	Influence
Mud crab	*Scylla serrata*	Logan River, Australia	+
Salmon	*Oncorhynchus* spp.	Strait of Georgia, Canada	+
Sardine	*Sardina pilchardus*	Northwestern Mediterranean	+
School prawn	*Metapenaeus macleayi*	Clarence and Hunter Rivers, Australia	+
Sea mullet	*Mugil cephalus*	New South Wales, Australia	+
Slinger	*Chrysoblephus puniceus*	KwaZulu-Natal, South Africa	+
White shrimp	*Litopenaeus occidentalis*	Buenaventura, Colombia	+
Common octopus	*Octopus vulgaris*	Gulf of Cadiz, Spain	-
Patagonian blenny	*Eleginops maclovinus*	Central-south Chile	-
Pink shrimp	*Farfantepenaeus paulensis*	Patos Lagoon, Brazil	-

Note: + indicates positive influence, i.e. increase in catch; - indicates a decrease in catch; +/- indicates both positive and negative influences

Source: Gillson, 2011

3.3.3 CULTURAL SERVICES

The Ramsar Convention on International Wetlands resolved in 2005 through Resolution IX.4, that traditional fisheries and aquatic biodiversity are suitable criteria for designation of a wetland of international importance, i.e. a Ramsar Site. The above Ramsar resolution also stated that “fishing is of great social, cultural and economic importance throughout the world.” Freshwater ecosystems are a means to connect people to nature, to their culture and to their ancestors. The cultural services provided by freshwater ecosystems are increasingly being recognized as important rights of indigenous people at both the national (Noble *et al.*, 2016; Lumley *et al*., 2016) and international levels (e.g. Article 8j of the Convention on Biological Diversity[3]).

The cultural services of recreational freshwater fishing are extremely valuable in the industrialized countries of North America, Europe, Russian Federation, China and Australia, as well as in a growing number of non-industrialized countries. Recreation is seldom reported in statistics although periodic surveys and assessments are made in some countries. From this review, it is estimated that more than 174 million people participate globally and generate more than USD 108 billion to USD 122 billion annually through direct and indirect expenditure such as income from fishing licences, equipment and associated businesses. (see Chapter 8 in this publication)

Freshwater fish provide significant cultural services to many people that contribute to human well-being, a sense of place, cultural identity and spiritual fulfilment. These may be especially important for indigenous peoples as certain freshwater species are specifically valued culturally and act as “cultural keystone species”.

Eels and lampreys are a valuable food source for indigenous communities that have also had high cultural value across the Pacific.

In North America, the Pacific lamprey is sacred to elders in the Native American community and is utilized in ceremonies and celebrations. The American eel increases social capital and provides spiritual fulfilment through harvesting practices that strengthens community bonds, and connects communities through ceremonial gatherings that coincide with eel migrations.

In Australia, the Murray cod was once an important component of the diet of Australian Aboriginal communities, and recognized as a cultural totem that played a role in the creation of the Murray River. The communities in the basin continue to have strong cultural connections with the species.

[3] https://www.cbd.int/convention/text/

In Cambodia, the *Bon Om Tok* festival celebrates the reversal of the current in the Tonle Sap, heralding the migration and annual fishery for the Trey Riel, a major local fishery resource. Recognition of the cultural values of freshwater environments and cultural keystone species can enhance management approaches and help sustain cultural stability and ecosystem services. These roles help provide wider ecosystem services, and ultimately support the well-being of communities dependent on the ecosystem.

3.3.4 ECOSYSTEM SERVICE VALUATION

Inland capture fisheries and freshwater environments are facing alarming threats and competing demands. Their value and the trade-offs that result from other activiites within the ecosystem can be revealed through ecosystem assessments. The use of ecosystem services valuations can help inform conservation and management of freshwater environments and inland capture fisheries, helping to improve ecosystem health and sustain the future supply of benefits. The complex socio-ecological nature and under-reporting of inland capture fisheries does present methodological challenges in capturing the multidimensional nature of the role of inland fisheries to food security and resilience (Béné and Neiland, 2003). The Economics of Ecosystems and Biodiversity (TEEB) project of the United Nations conducted ecosystem service valuation on a number of inland capture fisheries to reveal their hidden value and highlight their economic importance (Box 3-3).

Box 3-3: Examples of ecosystem assessments of inland capture fisheries and their systems

The Economics of Ecosystems and Biodiversity (TEEB) project of the United Nations undertook one of the first comprehensive ecosystem assessments of inland fisheries. The study evaluated the full range of ecosystem services, estimated the economic value of the services, and made visible trade-offs under management scenarios for inland capture fisheries and their systems.

In the lower Mekong basin in Southeast Asia and in Lake Victoria basin in East Africa, freshwater environments and their fisheries provided important provisioning, regulating, supporting and cultural services. Inland capture fisheries were valued as one of the most important ecosystem services and their systems positively contribute to other ecosystem services. Fish provide a nutritious food source, medicinal products, income and livelihood options that improve health and food security, particularly for developing countries. Fish also support the functioning of the freshwater environment through regulating services such as biological and sedimentation regulation; supporting services such as playing a role in food web dynamics and supporting ecological balance; and cultural services such as being a cultural keystone species for cultural and spiritual identity and providing recreational fisheries. However, the production of fisheries is dependent upon the functioning of its freshwater environment, which is increasingly under competition from other water users such as hydropower and agriculture expansion.

In the lower Mekong basin in Southeast Asia, inland fisheries that included capture and aquaculture were valued at USD 4.85 billion per year in 2014. Under development scenarios for hydropower and dam construction, fish catch would reduce by 340 000 tonnes causing a loss of USD 476 million per year. Fish play an important role in food and nutritional security of many communities in the lower Mekong basin. Under hydropower development scenarios, losses in fish and their nutrients such as protein could not be replaced by current levels of livestock production.

In Lake Victoria, provision of fish is also highly valued at USD 846.9 million per year as provisioning services through commercial and small-scale fisheries. Its wetlands regulating services in terms of nutrient cycling and buffering where found to be highly valuable and comparable to provisioning services. Management scenarios that prioritize agriculture and promote wetland conversion would cause a loss in the nutrient buffering services and require payments of 35 percent of crop value to replace them.

In both regions, local communities primarily depend on ecosystem services for their livelihoods where functioning of the freshwater environment enables livelihoods of farming, fishing and livestock rearing. Local communities will bear the costs of changes to ecosystem services from water management and development programmes.

Source*:* Brugere, Lymer and Bartley, 2015.

The project showed that fish is the most important provisioning service of inland capture fisheries and their systems, and that loss in ecosystem services cause social and economic impacts that often effect poorer groups in communities (Brugere *et al.*, 2015). Inland capture fisheries are often in competition with other water uses, such as hydropower and water abstraction for irrigation. The project found that these uses have a negative effect on inland fisheries and the benefits derived from them, and create ecosystem services losses that cannot be readily replaced (Brugere, Lymer and Bartley, 2015).

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4 CONTRIBUTION OF INLAND FISHERIES TO FOOD SECURITY

Fiona Simmance and Simon Funge-Smith

SUMMARY

Global inland fishery production is reported at 11.47 million tonnes of fish in 2015. This is equivalent to the full dietary animal protein of 158 million people.

At least 43 percent (4.9 million tonnes, 2015) of the world's inland fish capture harvest comes from 50 low-income food deficit countries (LIFDCs). At least 11 percent of global inland fishery production (1.3 million tonnes, 2015) comes from landlocked countries

Inland fish provides nutritional quality to countries where there are otherwise poor diets, due to poverty and limited access to other forms of quality food.

Inland fisheries are efficient producer of food, as inland fishery production also has a far lower resource use footprint when compared with livestock or other protein dense foods. In low GDP countries with inland fisheries, the per capita supply of fish food produced from inland waters is greater than than that of marine capture fisheries or aquaculture.

The Sustainable Development Goals agenda makes achieving food security and ending malnutrition a global priority (see Table 3-1). Food security occurs "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996). Despite progress towards meeting international development goals over the past decade, the status of global food insecurity remains unacceptably high with 795 million people globally having insufficient food energy (calories) (FAO, IFAD and WFP, 2015).

Inland capture fisheries can contribute to food security in a myriad of complex pathways (HLPE, 2014). These are dependent on a number of factors including: the productivity of the fishery and the degree of stress placed upon the system; the vulnerability of populations dependent on fish for income, revenue or nutrition; the nature of involvement in the fishery; as well as cultural norms and relations between men and women (Unsworth *et al*., 2014). The main contributions are illustrated in Figure 4-1 and are identified as:

- directly through direct home consumption which contributes to food and nutrition intake;
- indirectly through sale of fish for cash which lowers market value of fish and increases purchasing power for other foods; and
- via employment in ancillary activities for women who are linked with spending more income on household food and nutrition (Kawarazuka and Béné, 2010).

These contributions of fish to household food and nutrition security are based on the pillars of food security: availability, access, utilization (preferences) and stability (Beveridge *et al.,* 2013). There have been few in-depth studies exploring the role of fisheries in food security, particularly for the under-reported and undervalued inland capture fisheries sector (Béné *et al.,* 2016).

With respect to inland capture fisheries, studies around Lake Victoria have shown that participating in fishing as a livelihood was not associated with household fish consumption or food security directly, but rather was associated with higher incomes and assets (Fiorella *et al.,* 2014; Geheb *et al.,* 2008).

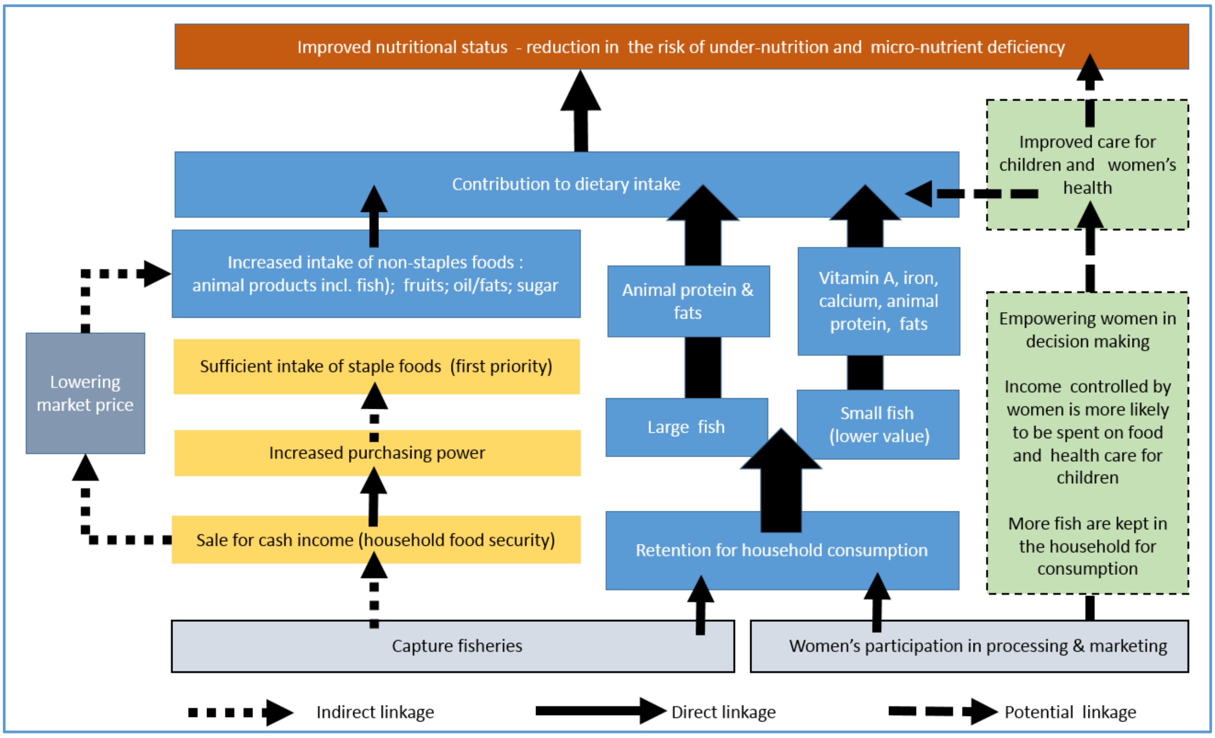

Figure 4-1: Pathways through which small-scale fisheries can contribute to nutritional status

Note: The figure portrays the direct pathways in blue, indirect pathways in orange, and the contribution explicitly from women in the supply chain in green.

Source: Adapted from Kawarazuka, 2010

In terms of supply of fish for food, inland capture fisheries provide nearly 16 percent of global food fish from capture fisheries (In 2015, the figures were: inland – 11.5 million tonnes; total marine capture – 81.5 million tonnes). Although 16 percent may seem rather modest, this aggregate figure disguises the importance of this fish to a subset of countries that have a far higher dependence on inland fisheries than the rest of the world.

Many of these countries are landlocked or countries with limited access to marine fishery resources. They are also predominantly developing countries that have substantial freshwater resources and large rural populations. The notable exception here is Finland, where the freshwater fish catch is substantial, but largely part of a recreational livelihood activity.

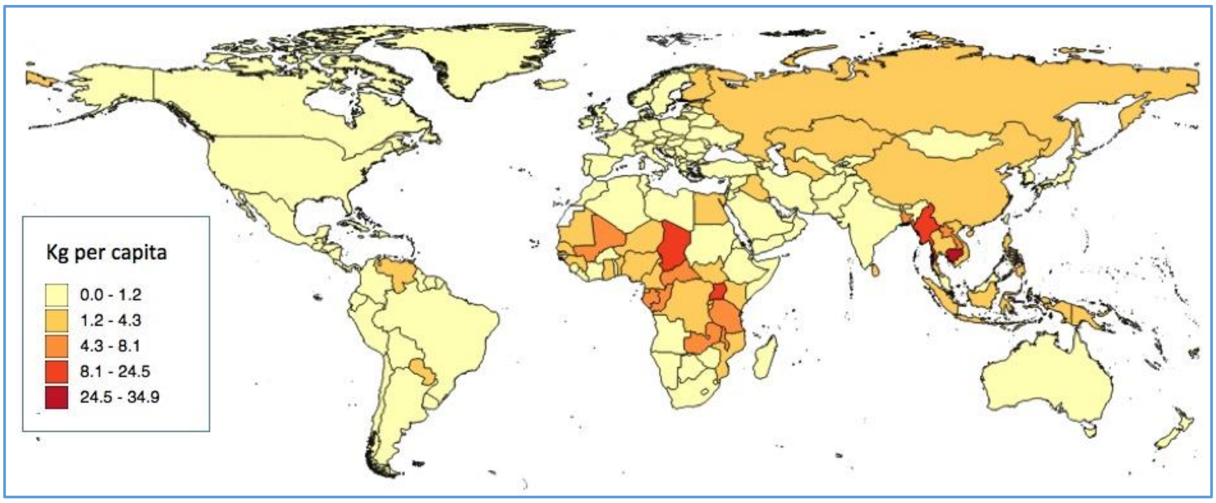

Figure 4-2: Inland fish catch per capita of population

Figure 4-2 (Table 4-1) illustrates the catch of inland fish as a proportion of the total population. It is immediately apparent that a number of countries that may not produce globally significant amounts of inland fish, may still have a production level that is important to the population of that country. The importance of inland fish in Africa and Southeast Asia is also clearly revealed when viewed as catch per capita.

Table 4-1: Inland fishery catch per capita population (2013)

Kg catch per capita of population	Country name
10 to 35	Cambodia, Myanmar, Uganda
5 to 10	Chad, the Congo, Malawi, Gabon, Central African Republic, Mali, Tanzania UR, Bangladesh, Lao PDR, Zambia,
2 to 5	Finland, Mauritania, Kenya, Ghana, Cameroon, Congo DPR, Mozambique, South Sudan, Sri Lanka, Thailand, Egypt, Fiji RO, Turkmenistan, Benin, the Niger, Paraguay, Gambia, Senegal, Estonia, Viet Nam, Kazakhstan, Philippines
1 to 2	Nigeria, Rwanda, Guinea, Papua New Guinea, Russian Federation, China, Indonesia, Iraq, Venezuela BR, Armenia, Montenegro, Equatorial Guinea, Burundi, Namibia, Burkina Faso, Suriname, Brazil, Iran IR, Sweden, Madagascar, Guyana
0.1 to 1	India, Mexico, Peru, Canada, Nepal, the Sudan, Angola, Zimbabwe, Togo, Pakistan, Bolivia (Plurinat. State), Hungary, Ukraine, Uruguay, Iceland, Albania, Uzbekistan, Serbia, Liberia, Sierra Leone, Poland, Lithuania, Turkey, Morocco, Ethiopia, Colombia, Côte d'Ivoire, Slovakia, Czechia, Falkland Is.(Malvinas), New Zealand, Argentina, El Salvador, Japan, Switzerland, Botswana, Costa Rica, Korea (Dem. People's Rep), Malaysia, Germany, French Polynesia, Panama, Macedonia (Fmr Yug Rp of), Latvia, Guatemala, Cuba, Korea (Republic of), Jamaica, Tajikistan, Syrian Arab Republic, Spain, Romania, Nicaragua, Netherlands

The top 24 countries (listed in Table 4-2) represent 11 percent of the global population and comprises 17 African countries with five from Asia. Cambodia has the highest per capita of inland capture fisheries with 28.2 kg exceeding Chad, second in place, by a factor of more than three. Inland capture fisheries are particularly important in African landlocked countries (Chad, Uganda, Mali, Zambia, Central African Republic, Malawi) with a range from 3.3 to 9.7 kg per capita (FAO 2003; Kolding and van Zwieten, 2006). Fifteen of the countries with a high per capita catch of inland fish are also categorized as LIFDCs.

Table 4-2: The top 24 countries with high per capita catch of inland fish

Country	Inland fish catch (tonnes) (2013)	Population (2013)	Kg inland fish produced per capita of population	LIFDC
Cambodia	528 000	15 135 000	34.89	
Myanmar	1 302 970	53 259 000	24.46	
Uganda	419 249	37 579 000	11.16	Yes
Chad	120 000	12 825 000	9.36	Yes
Congo	35 990	4 448 000	8.09	Yes
Malawi	112 248	16 363 000	6.86	Yes

Table 4-2: The top 24 countries with high per capita catch of inland fish

Country	Inland fish catch (tonnes) (2013)	Population (2013)	Kg inland fish produced per capita of population	LIFDC
Gabon	11 300	1 672 000	6.76	
Central African Republic	30 000	4 616 000	6.50	Yes
Mali	99 353	15 302 000	6.49	Yes
Tanzania UR	315 007	49 253 000	6.40	Yes
Bangladesh	961 458	156 595 000	6.14	Yes
Lao PDR	40 165	6 770 000	5.93	
Zambia	75 187	14 539 000	5.17	
Finland	23 549	5 426 000	4.34	
Mauritania	15 000	3 890 000	3.86	Yes
Kenya	154 257	44 354 000	3.48	Yes
Ghana	90 000	25 905 000	3.47	Yes
Cameroon	75 000	22 254 000	3.37	Yes
Congo DR	223 596	67 514 000	3.31	Yes
Mozambique	84 860	25 834 000	3.28	Yes
South Sudan	37 000	11 296 000	3.28	Yes
Sri Lanka	66 910	21 273 000	3.15	
Thailand	210 293	67 011 000	3.14	
Egypt	250 196	82 056 000	3.05	

4.1 THE EFFICIENCY OF INLAND FISH AS A SOURCE OF FOOD

One aspect of inland fisheries production that may not be immediately obvious is its relative efficiency compared with other fish production systems (e.g. marine fisheries and aquaculture). When taking into account the per capita availability of fish and the GDP, it was found that each tonne of inland catch supported the total annual consumption of animal protein by 157 people. This is 72 percent and 43 percent higher than marine fisheries and aquaculture respectively. As 81 percent of nutritional dependence on freshwater fishes occurs in nations below global median gross domestic product (GDP) (less than USD 4 800 purchasing power per capita annually) the impact of this fish supply is even more important (Mcintyre, Liermann and Revenga, 2016).

4.2 NUTRITIONAL IMPORTANCE OF INLAND FISH IN LOW INCOME FOOD DEFICIT COUNTRIES

As stated earlier, 15 of the countries where inland fish is important are also categorized as LIFDCs. These LIFDC's contribute 40 percent of the total global inland fish catch (Figure 4-3). Furthermore, there are 23 LIFDCs in the top 40 countries with a high per capita inland fish catch. This highlights the importance of the inland fish catch as a contributor to nutritional security in these countries.

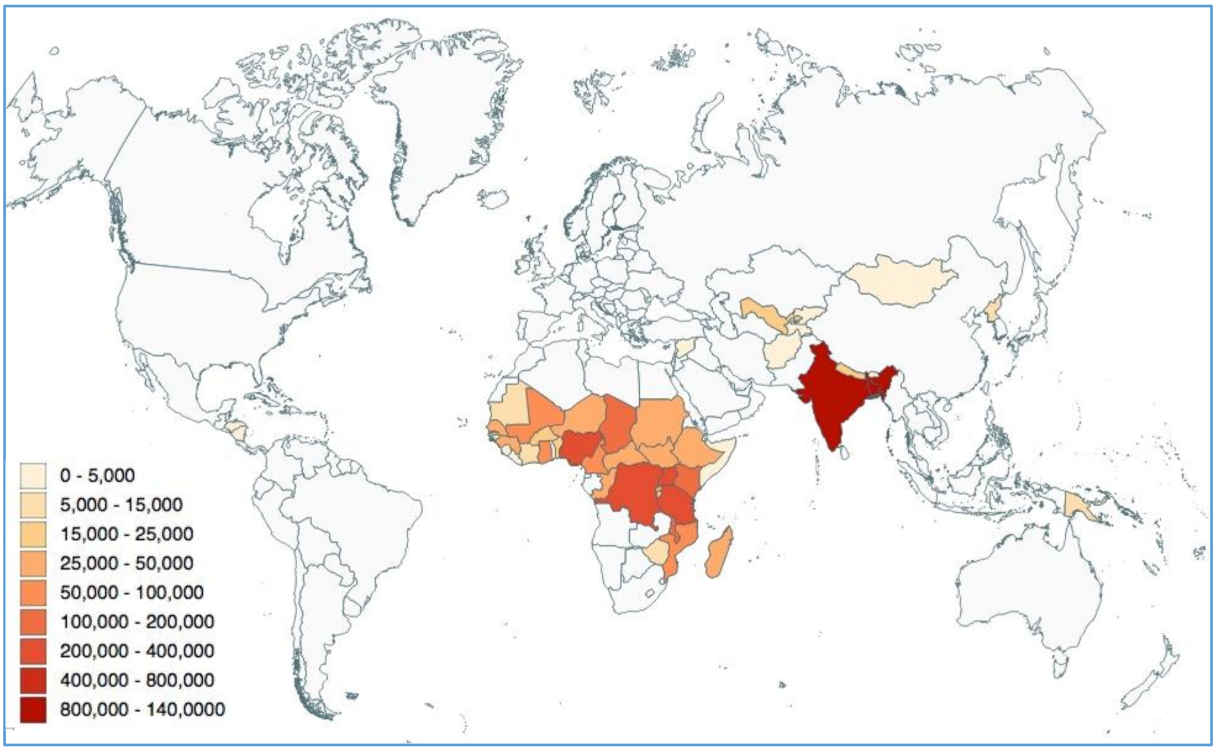

Figure 4-3: Forty percent of inland fish catch comes from LIFDCs (indicated by shading according to tonnes of inland fish catch).

4.3 ROLE OF INLAND FISH IN NUTRITION

Fish is a nutritious food source and the fisheries sector has been recognized as playing an essential role in tackling food and nutrition security worldwide (HLPE, 2014; Béné *et al.*, 2016). In the context of inland capture fisheries, the distribution of fish production is worldwide with over 90 percent being directed for human consumption. As a food source, kept for home consumption by fisherfolk or purchased, fish also provide important nutrients that contribute to a diverse diet, nutritional security and health. Small fish have also been shown to be particularly nutrient dense and an affordable food source for low-income consumers (Kawarazuka and Béné, 2011; Béné *et al*, 2015). In many communities, inland capture fisheries can provide a valuable and affordable source of nutritious fish that contributes to tackling food and nutrition security at local and regional levels (Bogard *et al.*, 2015; Youn *et al.*, 2014; Lymer *et al.*, 2016b). Freshwater fish has been reported to be a rich source of protein for human health, particularly for the most poor and vulnerable (Belton and Thilsted, 2014; Lymer *et al.*, 2016a). This nutritional contribution of inland fish to seasonal and annual food security is being increasingly recognized in the global debate on food security (Taylor and Bartley, 2016; HLPE, 2014).

Micronutrient deficiencies are well-documented in food-insecure populations and the importance of maintaining a diverse diet to tackle malnutrition is well known (Arimond and Ruel, 2004; Roos, 2016). Micronutrient deficiencies, notably vitamin A, iron and iodine, affect more than 2 billion people primarily in developing countries (Allen *et al.*, 2006). Globally, over 25 percent of all children under the age of five are stunted and approximately 30 percent suffer from vitamin A deficiency (World Bank, 2006; Roos, 2016). Efforts to tackle malnutrition must ensure that access to nutritious food is maintained crucially in early life, especially during the first 1 000-day period – from conception, through pregnancy and the first two years of a child’s life (Bogard *et al.*, 2015; Roos, 2016).

4.4 FISH NUTRITIONAL QUALITY AND HUMAN HEALTH BENEFITS

A healthy diet must comprise sufficient concentrations of bioavailable minerals and vitamins, essential fatty acids and animal protein (Roos, 2016). Provided the nutritional quality is preserved, fish in the human diet can provide a rich source of these nutrients and numerous benefits to human health.

The actual measure of the importance of inland fisheries to nutritional security remains poorly understood (Miao, daSilva and Davy, 2010; Youn *et al.*, 2014), largely because of the lack of comprehensive global assessments. So far, studies of fish and nutrition relationships tend to be limited to case studies and specific to a locality, country, continent or species. A summary description of nutrients and their contribution to human health is provided in Table 4-3.

Table 4-3: Summary of evidence regarding the beneficial role of fish to human health

Nutrients from freshwater fish	Importance to human health	Citation
PROTEIN		
Protein	Source of amino acids	Delgado and Mc Kenna (1997)
	Growth	
	Muscle mass	
Lipids		
Omega 3 fatty acids, Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA)	Brain development	Moths *et al.*(2013); Guler *et al.*(2008); Pottala *et al.*, (2014); Imhoff-Kunsch *et al.*, (2012); He *et al.*, (2004); Horrocks and Yeo (1999)
	Reduced risk of early preterm delivery	
	Reduction of several human diseases (e.g. Alzheimer's disease, cardiovascular disease, arthritis)	
MICRONUTRIENTS		
Vitamin D	Cardiovascular health	Ostermeyer and Schmidt (2006); Craviari *et al. (*2008); Lu *et al. (*2007)
Calcium	Bones	Roos *et al. (*2007); Chan *et al. (*1999); Hansen *et al. (*1998).
B vitamins	Energy production Brain function Nervous system maintenance	Steffens (2006); Thilsted *et al. (*2016); Rayman (2000).
Vitamin A	Vision Tissue growth	Roos *et al*. (2007)
Iron	Formation of haemoglobin and myoglobin	Steiner-Asiedu, Julshamn and Lie (1991)
	Component of many proteins	Lazos, Aggelousis and Alexakis (1989)
Zinc	Cellular metabolism	Gibson *et al. (*1998)
Lysine	Amino acid	Adeyeye (2009)
OTHER FUNCTIONS		
	Enhances uptake of micronutrients from plant-source foods	Michaelsen *et al. (*2009); Sandström *et al. (*1989).

Source: Adapted from Youn *et al.*, 2014

Overall, fish can help to reduce the risk to vulnerable women and children of malnutrition and non-communicable diseases, particularly during critical life stages (HLPE, 2014). Fish nutrition is particularly important for lactating women and for the physical and cognitive development of infants and young children. Calcium and omega-3 fatty acids found in fish are particularly important in this respect (Youn *et al*., 2016; Roos, 2016).

The nutritional profile of freshwater capture fish species, aquacultured species and some terrestrial animal sources based on a review of available literature is summarized in Annex 4. The development of a comprehensive database of the nutrient content of inland capture fish species is an important first step in trying to synthesize and understand the potential of inland fisheries to improve nutritional security (Roos *et al.,* 2007; Youn *et al.,* 2016). The table highlights the higher levels of micronutrients that are available in small, whole fish (Roos, Islam and Thilsted, 2003; Roos *et al.,* 2007; Bonham *et al.,* 2009).

4.4.1 PROTEIN AND AMINO ACIDS

Protein in fish has been found to be 5 to 15 percent more bioavailable than plant-based protein sources (HLPE, 2014). Fish in relation to all sectors has been found to contribute 20 percent of average per capita animal protein intake for one third of the population and can exceed 50 percent in some countries such as Gambia, Sierra Leone and Ghana (Kawarazuka, 2010; HLPE, 2014). For inland capture fisheries, Tables 4.1 and 4.2 show that some countries have a high reliance on freshwater fish as protein in their diet. In addition to this trend in animal protein consumption, fish can further contribute to the overall protein intake through increased digestibility of protein, particularly in food-insecure regions (WHO, 1985).

4.4.2 LIPIDS AND FATTY ACIDS

Fish are also a unique and important source of essential n-3 and n-6 fatty acids and provide the valuable long-chain polyunsaturated fatty acids (LCPUFA), docosahexaenoic acid (22:6n-3), and eicosapentaenoic acid (20:5n- 3). Fish provide fatty acids in the form of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in greater quantities and are more biologically usable compared to plant sources of omega-3s (Nettleton, 1991; Youn *et al.,* 2014). Intake of these fatty acids has been associated with a variety of health benefits including:

- adult health and child development (Thilsted, Roos and Hassan, 1997; Richardson and Montgomery, 2005);
- maintenance and growth of normal brain function (Pottala *et al*., 2014);
- reduction of several human diseases (e.g. Alzheimer's disease, cardiovascular disease, arthritis) (He *et al.,* 2004; Horrocks and Yeo, 1999); and
- reduced risk of early preterm delivery (Imhoff-Kunsch *et al.,* 2012).

4.4.3 MINERALS AND VITAMINS

Fish, especially small fish, also provide essential micronutrients (vitamins D, A, and B), and minerals (calcium, phosphorus, iodine, zinc, iron, and selenium) (Kawarazuka and Béné, 2011; HLPE, 2014; Lymer *et al.,* 2016a; Roos, 2016). Micronutrients are concentrated in the bones, heads and viscera of fish species and thus what part of the fish consumed plays a key role in determining the intake of these nutrients. Micronutrients and minerals can provide many human health benefits: vitamin B12 can enhance brain and nervous system development and calcium and vitamin D are important for improved bone health and neuromuscular function (HLPE, 2014; Youn et al 2014). Fish can therefore add diversity to diets and be beneficial in tackling micronutrient deficiencies, particularly in developing countries (Kawarazuka and Béné, 2011; HLPE, 2014).

4.4.4 THE NUTRITIONAL QUALITY OF SMALL FRESHWATER FISH

There is considerable variation in the nutrient composition of fish, and an important factor is which species and which parts of the fish are actually eaten (HLPE, 2014). Although all fish species provide a valuable source of animal protein, fatty acids, micronutrients and minerals (Beveridge *et al.,* 2013), the intake of these nutrients is often determined by cultural perceptions and individual preferences influencing what parts of the fish are considered edible.

In much of the developing world, inland fish, particularly small native fishes, provide the main and an important source of animal protein and micronutrients particularly where other sources of these nutrients are difficult to obtain (Youn *et al.*, 2014). Small fish when eaten whole (bones, organs, and head) provide greater potential intake of essential minerals and vitamins to the human diet (Roos, Islam and Thilsted, 2003) compared with larger fish which are often consumed in fillet portions. For example, in Bangladesh and Cambodia, the small indigenous fish species *mola (Amblypharyngodon mola)* provide a very important source of vitamin A because of the head and viscera of the fish being consumed (Roos, 2016). Nutrient composition can also vary by fish species, however the nutritional profiles of fish species, particularly those from inland capture fisheries, are poorly understood (Bogard *et al.*, 2015).

In relation to fatty acids, although marine fish species typically contain high levels of long-chain omega-3 fatty acids, some freshwater fish species can contain very high amounts of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Youn *et al*., 2014). For example, intake of fresh water fish by women provided a vital source of DHA and above sufficient levels of DHA in breast milk (Kawarazuka, 2010).

The consumption of freshwater fish is increasingly reported to provide beneficial human health impacts with respect to micronutrients. For example, in Zambia the consumption of small freshwater fish has been reported to provide positive health benefits by reducing infections and promoting chronic wound healing with vulnerable populations living with HIV/AIDS (Kaunda, Chizyuka and Phiri, 2008). In addition, in parts of Bangladesh and sub-Saharan Africa, calcium intake from freshwater fish has been shown to contribute to the prevention of rickets in children (Craviari *et al.,* 2008). Furthermore, intake of freshwater fish species has been reported to provide health benefits to lactating women and to young children in Bangladesh, Cambodia and Kenya (Longley *et al.,* 2014).

4.5 POST-HARVEST LOSSES IN INLAND FISHERIES

Yvette Diei-Ouadi

Post-harvest fish losses occur globally in all fisheries, from the point of production to the final sale to the consumer, but the magnitudes and types vary. The assumption that the greater the structural shortcomings of any fish supply chain, the higher the losses, if equally applied between marine and inland fisheries, signals the magnitude of the loss challenge in the inland fisheries, commonly known for their comparative disadvantage and this is of great concern. This pattern is deep-rooted in their invisibility, hence lower attention for policy making and investment, as catches tend to be poorly recorded, and the operations more dispersed and remote, which of course contributes to the occurrence of losses.

Three types of losses have been established in Ward and Jeffries (2000): physical, quality and market force. (i) physical losses are defined as fish not used after capture/harvest or landing – totally lost from the supply chain and not consumed or utilized); (ii) quality losses relate to products that are spoiled or damaged, but not to the extent that they are thrown away, for example they may still have some nutritional value, but they are products of lower quality); and (iii) market force losses are a type of loss resulting from market reaction affecting the selling price to such an extent that, irrespective of quality, the fish sells for a lower price. This latter loss is not necessarily a fish food loss in the first instance, but it can later lead to quality or physical loss, and influence supply stability.

A model on the simultaneous occurrence of these three types and the intricate dimension of market force losses is illustrated for a tilapia value chain in Lake Victoria (Figure 4-4).

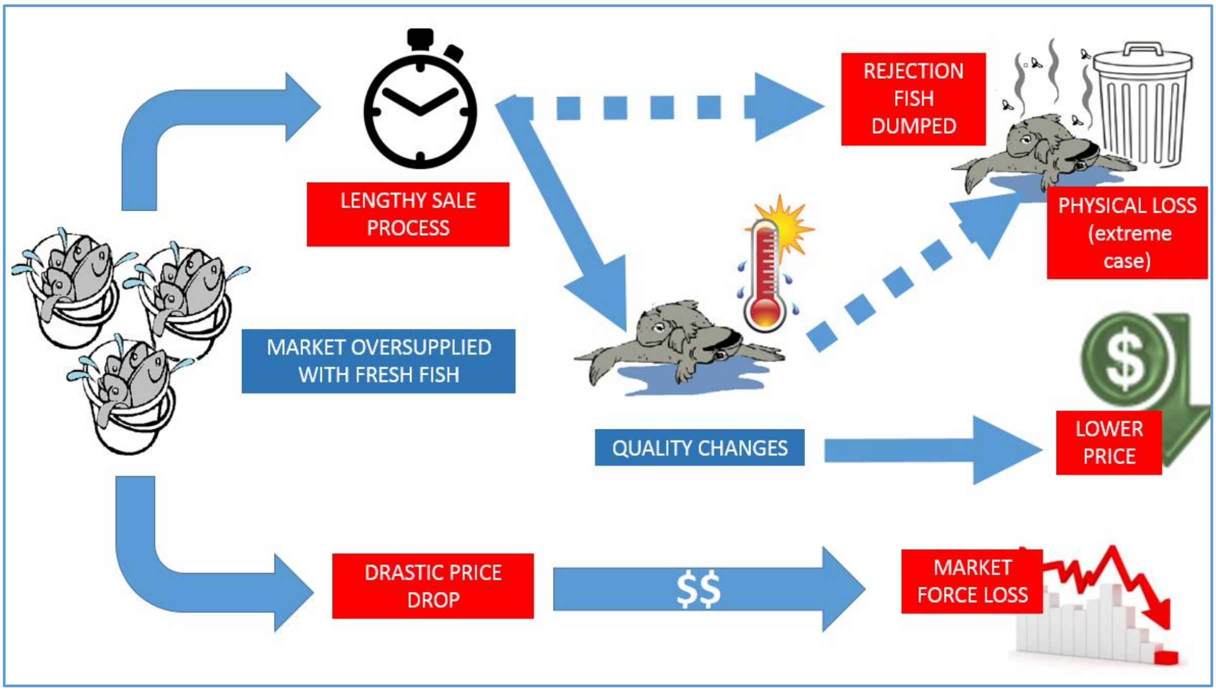

Figure 4-4: Causes of fish loss in inland fisheries

4.5.1 ASESSING THE MAGNITUDE OF FISH LOSSES

Much of the early data on post-harvest fish losses in inland fisheries, especially loss levels, have been derived from limited and ad hoc observations and studies. In many cases the method of data collection and interpretation is not clear. This has often prevented the clear identification of the cause of the fish loss. These estimates have also been based on qualitative estimates and have sometimes involved substantial extrapolation (e.g. from single landing sites to whole countries and even regions!). The result of this has been that fish loss in inland fisheries has been quoted at up to 75 percent in some extreme cases.

Using an established methodology for assessing post-harvest losses validated on the basis of case studies mostly on inland fisheries (Lake Victoria and major production areas in Mali (Akande and Diei-Ouadi, 2010; Diei-Ouadi and Mgawe, 2011), substantial systematic assessments have been conducted mostly in Africa, but also recently in Asia. These cast some consistent light on the extent of the losses phenomenon, be it for an individual country or for a shared waterbody. Such assessments are also guiding preliminary observations in an ongoing initiative on raising the understanding of losses linked to gillnet and trammel net operations in riparian countries of the Amazon River basin.

Concurring data from assessments in inland fisheries put the post-harvest losses between 13 and 45 percent, with an average 27 percent of total catches. These reflect the general trends so far in terms of distribution among the three types of losses in the small-scale fisheries assessed. Although physical losses from the supply chain range from less than 5 percent to 10 percent, quality losses are much higher and can account for up to 70 percent of total losses in a given value chain, which may reflect a loss in high quality protein (readily digestible, with essential amino acids) and long-chain polyunsaturated fatty acids and micronutrients. Likewise, physical removal of fish from the food chain reduces the contribution of fish to food and nutrition security, as consumers have access to smaller quantities or low quality fish/fishery products, and value chain actors receive less income, hence meagre opportunities for bartering or purchasing other nutrient-rich foods. As a standalone or a precursor of these two types of losses, market force losses have been found to be higher than physical losses, as it is frequently ranked second after quality related losses. However, the findings from assessments of the Lake Victoria sardine (*Rastrineobola argentea*) fishery indicate that much higher physical losses are occurring during the rainy season when poor drying conditions prevail; in this fishery they can account for more than 20 percent, sometimes higher during the main fishing season. At the Kirumba-Mwaloni wholesale fish market in the United Republic of Tanzania, quality losses made up the bulk of the more than USD 40 million to USD 60 million in Lake Sardine losses annually.

These figures are in line with others under different geographic contexts. A study in Orissa, India observed that a proportion of catch of commercial fishes in inland reservoir gillnet and hook-and-line fisheries was lost because of catch falling out of the gear (FAO, 2014, FAO, 2017). Adverse weather has also been identified as a cause of spoilage in inland gillnet fisheries, because of the heavy inputs of muddy water. For example, between 6.5 percent and 8.9 percent of catch of commercial fishes in inland reservoir gillnet and hook-and-line fisheries of Orissa, India was lost because of spoilage from the inflow of muddy water, too long gear soak time, and catch being damaged because of poor handling practices (FAO, 2017).

FAO (2014b) estimated the loss in inland fisheries for omena and tilapia in three counties of Kenya through a literature review, fisher interviews and observations of supply chain operations. An estimated 4.5 percent of the value, and USD 1 100 per vessel per year of tilapia is lost in Kenyan inland fisheries (in Migori, Homabay and Siaya counties) because of spoilage from too long a gear soak time (FAO, 2014)

Recent data from the Barotse floodplain fishery in Zambia indicate that total post-harvest losses averaged 29.3 percent, with physical losses at 6.4 percent and quality losses at 22.9 percent, with the processing node of the value chain experiencing the highest percentage of losses compared to fishing and trading nodes, and women processors experiencing three times more losses than men processors (Kefi *et al*., 2017).

4.5.2 CAUSES OF FISH LOSS AND SOME SOLUTIONS

Assessments have demonstrated that post-harvest losses are caused by multiple intertwined underlying factors stemming from technical, technological and/or infrastructure deficiencies, and weaknesses in knowledge and skills. These account for 65 percent of the factors undermining the availability of food. Whereas, 35 percent of the drivers of losses are linked to value chain actors (VCA) and consumers' social and cultural dimensions of vulnerability, the lack of responsible governance, regulations and their enforcement. Case studies in the Volta basin riparian countries draw a comprehensive picture that links the loss drivers to poverty (Figure 4-5).

The complexity of the loss factors calls for holistic thinking in terms of effective sustainable solutions, i.e. following a value chain approach that caters to the contextual occurrence and dynamics of these losses and keeping in mind the opportunity for different entry points. Table 4-4 compiles some examples driven from experiences in addressing losses in inland fisheries using the "from the net to the plate" rationale.

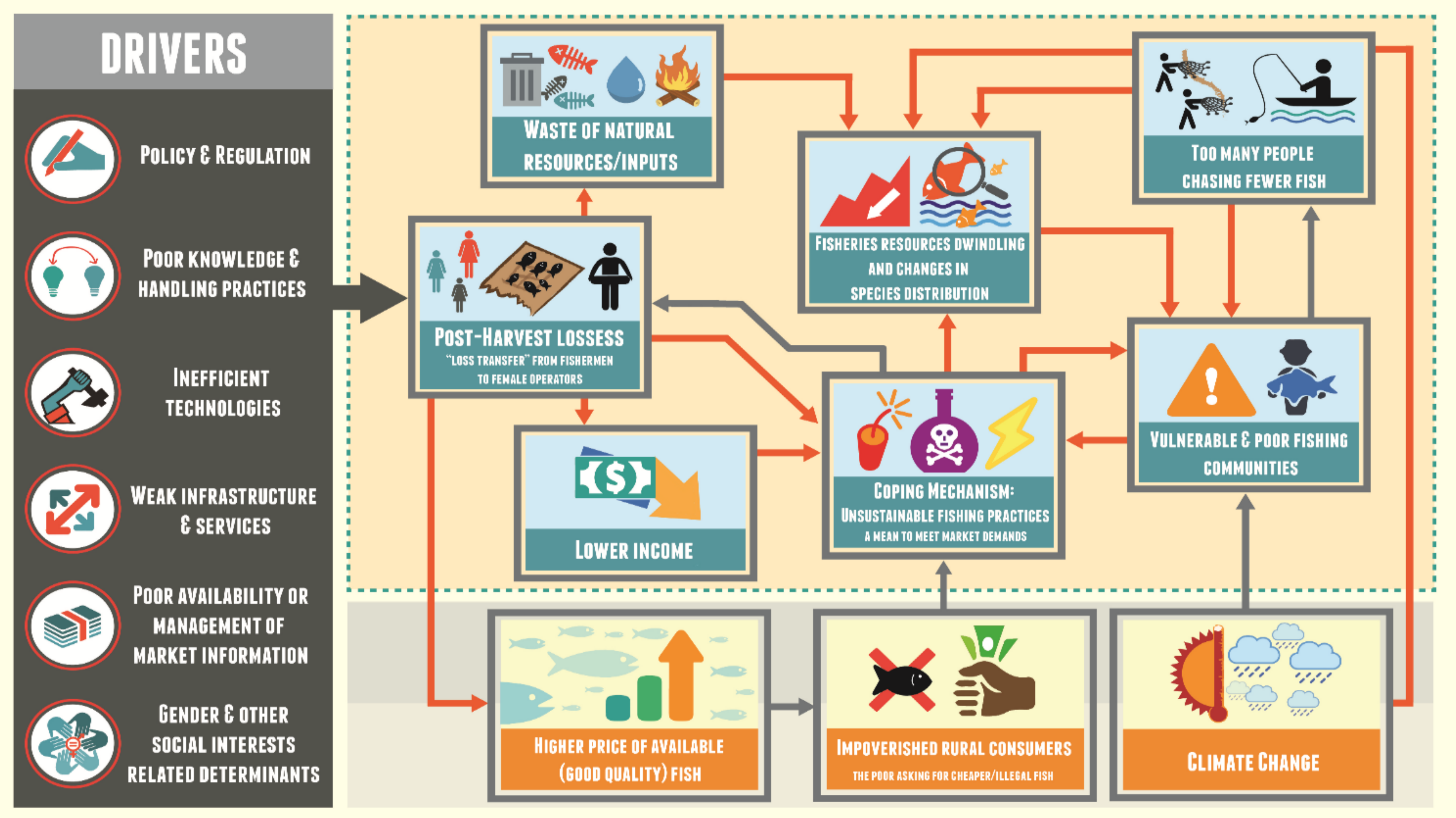

Figure 4-5: Linkages between fish loss and poverty in Volta basin riparian countries

Source: Diei-Ouadi *et a*l., 2015

Table 4-4: Using a value chain approach to identify post-harvest solutions in inland fisheries

Value chain stage (Activities)	Causes of fish loss	Examples of proven loss reduction solutions
Primary production *Catch (capture)*	– Water pollution (pesticides) from shore side human activities (agriculture, industry, and domestic) – Use of harmful fishing techniques (chemicals, dynamite, mosquito nets etc.) – Fish spoilage and physical loss because of long soaking time and hauling back of nets – Fish falling from nets while hauling – Damage while removing from nets and handling/stowage on board – Discarding – Absence of chilling or inadequate cooling system (ice/fish ratio, insulated container) on board	Regulations and enforcement to deter illegal fishing practices Shorter soaking time and haul back times Well-equipped landing site with handling and cold chain facilities Improved fishers' knowledge of basic fish handling
Post production *Landing, handling, storage, transport conditions*	– Landing conditions – Lack of appropriate storage Infrastructure and services (including cold storage) – Absence of chilling or inadequate cooling system (ice/fish ratio, insulated container) – Delays in sales/price negotiations – Fish falling from containers during handling	Well-equipped landing site with handling and cold chain facilities Improved fishers' knowledge of basic fish handling
Processing *Gutting, drying, fermenting, salting, smoking, filleting, packaging*	– Poor quality raw materials – Inadequate water quality for cleaning fish (especially high microbial loads) – Inefficient/traditional processing techniques (e.g. drying on bare ground) with climate variability adding more uncertainty to the efficiency of the drying process – Low processing capacity – infestation/predation by insects, birds and rodents – Poor packaging and storage of product	Use of raised racks for fish drying gives 50 percent reduction in post-harvest losses in two years (Lake Tanganyika riparian countries) FAO-Thiaroye processing technique improves product quality and increases income, reducing post-harvest losses, and negative environmental impacts (used in African countries, recently introduced to inland fisheries in Sri Lanka).
Distribution *Retail, transport*	– Excess supply (gluts)/lack of buyers/ weak access to and control of market information – Delays in packing, loading, transport – Insecurity along transport routes largely involved in what is known as "artificial glut" that undermines competitive trade – Poor quality packaging – Careless handling/stacking – Poor roads and transport facilities – Physical status of the market facilities	Electronic market information system Peers to peers information sharing Adequate market and transport facilities Development of low-cost fish retailing facilities, (including adequate design of pushcart and display) has played an important role in the rapid

Table 4-4: Using a value chain approach to identify post-harvest solutions in inland fisheries

Value chain stage (Activities)	**Causes of fish loss**	**Examples of proven loss reduction solutions**
	– Misguided or mismanaged imports of fish products can weaken the position of domestic small-scale fishers where they coincide with periods of glut or bumper seasons	increase of small-scale and medium-scale fish commercialization in urban cities
Consumption *Storage, preparation, table*	– Discards (over purchase e.g. because of poor planning, celebrations/ and loss generation situations such as weddings, Christian Lent, baptisms, confirmations, end-of-year celebrations) – Excess preparation because of inadequate knowledge – Spoilage (poor preservation of purchase) – Poor consumers' preference for small portion size (heaps of immature fish), meeting such demand encourages the capture of juveniles/IUU fishing – Quality blind consumers or consumers that lack of appreciation of quality create no incentives for fishers to sustain best practices)	Communication and education for consumers' behaviour change

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5 THE ECONOMIC VALUE OF INLAND FISHERIES

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SUMMARY

The economic value of inland freshwater fisheries catches (as reported to FAO) is estimated to be approximately USD 26 billion. The major contributions to this come from Asia (66.1 percent) and Africa (22.2 percent).

It is acknowledged that a significant proportion of the inland catch is "hidden" and unreported, however as a result of improved reporting, this proportion is likely to have reduced over the past few years. Including this hidden component gives a projected estimate of the total use value of inland freshwater fisheries of USD 38.53 billion. This value is increased to USD 43.53 billion if the value of freshwater molluscs and crustaceans is included.

The value of capture fisheries is somewhat dwarfed by the use values generated by recreational fishing. With a 2015 non-market use value (NMUV) of recreational fishing estimated to lie somewhere between USD 64.55 billion and USD 78.55 billion. The United States of America and Canada account for almost 72 percent of this value. It is considered that the NMUV is almost certainly an underestimate because of the lack of data from Africa and limited data from Asia and Latin America, despite their burgeoning recreational fishing activity.

Aggregating the NMUV of inland recreational fisheries and the UV of inland capture fisheries indicates that the total UV of the inland fishery sector is worth an estimated USD 108 billion to USD 122 billion annually. If the costs of capture, that is the value added ratio (VAR), are discounted, the gross value added (GVA) of inland capture and freshwater recreational fisheries is still between USD 90 billion and USD 100 billion.

5.1 INTRODUCTION

The global human population of 7.5 billion is utterly dependent upon freshwater for drinking and sanitation needs and the economic value of the ecosystem services provided by global inland/freshwater resources is beyond quantification. Global freshwater resources also play a central role in food supply. According to FAO-AQUASTAT (2012), 1 500 km^3 are extracted annually to irrigate over 307 million hectares of farmland, with the proportion of water withdrawn for agricultural purposes ranging from 4.1 percent in Sweden to 98.6 percent in Afghanistan. The IUCN (undated) estimate that over one million species (including mammals, plants, fish, reptiles, molluscs, and insects) rely on freshwater habitats, and many of the most abundant of these are harvested for food. This importance is recognized in global environmental accords including the Ramsar Convention, which identifies 1 827 inland wetlands (81 percent of total sites) of international importance, covering an area of 201.6 million hectares (92 percent of total area). The World Network of Biosphere Reserves identifies 669 reserves spanning 120 countries, 221 of which are located contiguous to inland waterbodies and habitats, and intended to promote environmental, economic and social sustainability.

To better harness global water resources for agriculture and power generation, hydropower and irrigation dams have been built. Nilsson *et al.* (2005) noted that about 15 percent of total global river run-off (>6 500 km^3) was retained by more than 45 000 dams above 15 metres high, with 172 out of 292 of the world's largest river systems modified by damming. Dams are important in terms of hydroelectric power, with 16.6 percent of global electricity (70 percent of all renewable energy) coming from hydropower sources in 2016. Paraguay is wholly dependent upon it, and China derives over one-fifth (1 126 terawatt-hours) of its annual electricity requirements from hydropower (IHA, 2016). As an integral component of aquatic ecosystems, inland fisheries have generally been impacted negatively by the creation of dams.

The formation of artificial reservoirs and impoundments has provided new waterbodies that can be both stocked and fished. Downing *et al.* (2006), for example, estimated there were 515 149 manmade structures (99.7 per cent with a surface area of 1 km^2 or less) encompassing 258 570 km^2 of water across the planet. Nevertheless, their water storage and releases are dictated by agricultural and hydroelectric requirements, requirements that typically run counter to the biological needs and reproduction cycles of most riverine and floodplain fish species. Moreover, dams alter upstream and downstream freshwater habitats and hinder passage (in the absence of fish ladders/passes), and can lead to the extinction or extirpation of fish species (Nehlsen, Williams, and Lichatowich, 1991; Layman et *al*., 2007; Roscoe and Hinch, 2010). The introduction of alien species into inland waterbodies has also impacted catches, diversity and abundance of endemic species. Classic examples of this are: the introduction of the Nile perch (*Lates niloticus*) into large African lakes; the Lake Sevan trout (*Salmo ischchan*) into the waters of Lake Issyk Kul in Kyrgyzstan; Asian silver carp into North American waterways and non-indigenous fish introductions into Yunnan, China (Thorpe and Bennett, 2004; Thorpe and van Anrooy, 2009; van Zwieten *et* al., 2016; Vermeij, 2015; Yan *et al.*, 2001).

Despite the continuing and growing impact of water management on fish habitats, inland capture fisheries are still an important source of economic value, and also contribute substantially to food security (Chapter 4), employment (Chapters 6 and 7) and resilient livelihoods (Chapter 9) in many lake and riverine and floodplain communities.

In the FAO *Report of the state of world fisheries and aquaculture*, it was reported that inland capture production had reached 10.2 million tonnes in 2008 and was worth an estimated USD 5.5 billion (FAO, 2012). However, this value of inland capture fisheries was overshadowed by freshwater (inland) aquaculture, which in the same year generated treble the volume (33.8 million tonnes) and twelve times the value (USD 61.1 billion).

The purpose of this chapter is to revisit this 2012 FAO valuation of inland capture fisheries in the light of more recent catch figures and estimates of hidden inland fishery catch. Section 5.2 explains how total economic value is estimated, distinguishing between use and non-use values, within an inland fisheries context. Section 5.3 provides an overview of past attempts to compute the economic value, at either the regional, national or river basin level, of inland fisheries/waters and Section 5.4 provides an estimate of the use value of the world's inland fisheries. Separate sections focus on the contribution of diadromous species (5.5), brackish waters (5.6), unreported "hidden/lost" catches (5.7), and recreational fisheries (5.8). A fifth, concluding section links these subsections so as to provide an estimate of the total use value of the world's inland fisheries. Recommendations for further research in this area are also put forward.

5.2 MEASURING TOTAL ECONOMIC VALUE WITHIN AN INLAND FISHERIES CONTEXT

Although Cowx *et al.* (2004) highlight that the benefits of inland fisheries can be assessed across three domains (economic, ecologic and social), the emphasis in this chapter is solely on the first of these domains: the economic.

The **total economic value (TEV)** of inland/freshwater resources can be disaggregated into two subcomponents: use value and non-use value.

Total use value (TUV) is the economic value of products extracted from an inland fishery that are either directly utilized (e.g. for consumption or processing, used as aquaculture broodstock or seed material, or for ornamental purposes) or extracted for sporting/recreational purposes.

In general, **non-use value (NUV)** is less tangible and relates to the intrinsic value that resides in a particular resource and which is typically unexploited, or unexploitable.[4] Non-use value takes three forms: existence value; option value; and bequest value (Krutilla, 1967; Peters, Gentry and Mendelsohn, 1989; De Groot *et al.*, 2006; Bennett and Thorpe, 2008).

[4] The term "resource" is used in its broadest context – to refer to anything from species to habitat (eco-system).

Existence value relates to the value people derive from the knowledge that the resource exists, even if they presently have no intention of actually using/consuming it. Peirson *et al.* (2001), for example, estimated that the existence value of a salmon fishery in the River Thames (United Kingdom) catchment area was worth as much as GBP 12 million a year.

Option value is the benefit derived from maintaining/preserving the resource in a particular condition so that, at some future time, it may be used to an individual's/societal advantage (i.e. at some point in the future it will be transformed into a use value). The current option value attached to recreational sea angling in Scotland, for example, was computed using contingent valuation techniques (CV) to be worth GPB 957 664 (Riddington, Higgins and Radford, 2014).

Bequest value captures the desire to preserve the resource for the benefit of future generations. An example, is the estimate that the bequest value of a traditional fishing ground on the Fijian coral coast was approximately USD 106.91 to each local fishing household annually, a figure comparable to household expenditure on durable goods, clothing and footwear (O'Garra, 2009).

One of the most comprehensive studies in the arena of non-use value in the inland fisheries context used **contingent value (CV) and willingness to pay (WTP)** techniques to establish annual existence (USD 8.59 million), bequest (USD 8.03 million) and option (USD 3.6 million) values for residents proximate to the Chinese Sturgeon Natural Reserve in Yichang (Gan *et al.*, 2011). This type of study is rare and the Worldfish Center's study on tropical fisheries valuation points out: "*Existing studies estimate direct use values but rarely indirect use values, let alone non-use values."* (WorldFish, 2008).

The reason is simple, NUV are unpriced, and so appropriate evaluation methods are required to quantify such values. The problem is that the principal technique (CV/WTP) employed to assess NUV is "complicated, lengthy, and expensive"[5] generally relying on the application of survey-based techniques to capture the stated preferences of a substantive and clearly defined representative sample of the affected population. Without a WTP/CV survey, there can be no estimate of the NUV value.

Although CV/WTP techniques will be considered later in this chapter (see section 5.8) for the assessment of the worth of recreational freshwater fisheries, this chapter only focuses on use value, both marketed use value (MUV) and non-marketed use value (NMUV). In the case of inland fisheries, NMUV refers to fish caught for self-consumption, as baitfish (unless this is sold to others, when it becomes a MUV), or for sporting or recreational purposes (Bennett and Thorpe, 2008). Over twenty years ago, for example, it was suggested that the annual value of freshwater (cultured and/or extracted from the wild) baitfish use in the United States of America and Canada alone, could be "conservatively estimated at USD 1 billion" (Litvak and Mandrak, 1993). The NMUV of inland sport and recreational fisheries is examined in more detail in Sections 5.8 and Chapter 8.

Assessing the economic value of fish caught for home consumption is problematic on two counts. First, it is very difficult to identify and estimate the volume of inland fish that bypasses the market. As Welcomme *et al.* (2010) state, "much of the catch from inland fisheries is unrecorded ... because much of the catch goes directly to domestic consumption." According to the World Bank (2012), as much as 90 to 95 percent of small-scale landings is destined for self-consumption and, therefore implicitly, does not pass through some form of reporting system. Second, even if it were possible to accurately assess the level of self-consumption, what shadow/surrogate prices should be applied (imputed) for the value of this consumption? Fish prices can vary sharply by species type and across locales and this, linked to the unpredictability of catch, means that the estimation of the value of self-consumed fisheries products is highly imprecise.

Economic valuations are more easily quantified when using market use value (MUV). MUV refers to the capture and sale of fish and fish products through local, national and international markets, whether for food or ornamental purposes. Prices reflect what consumers are prepared to pay for a given product, and so express product value.

[5] http://www.ecosystemvaluation.org/contingent_valuation.htm#case5

In the case of the ornamental fish trade, FAO (2017a) estimate inland fisheries contributed USD 328 million annually,[6] although more than 90 percent of inland ornamental fish are bred in captivity, as opposed to trapped in the wild (Monticini, 2010). In the African case, NEPAD (cited by Chimatiro 2012) estimates a first sale value of approximately USD 4 861 million, with annual resource rents equivalent to between 30 and 70 percent of this first sale value. Unfortunately, the value of global capture (marine or inland) fisheries, unlike aquaculture, is not routinely monetized, and this study is reliant upon a small number of national/regional case studies to provide some insights into this area.

More correctly, as Cowx *et al.* (2004) and Tuan *et al.* (2009) indicate, MUV is a net value, and so the cost of extraction should be deducted from the gross fishing income, in order to identify the resource rent.[7] This is extremely pertinent in the case of marine fisheries, for example, where annual subsidies have been estimated to account for 20 to 25 percent of the total value of landings (USD 35 billion in 2009), thereby severely distorting the true costs of fishing activity (Sumaila and Lam, 2013) and, therefore, MUV.

In the case of inland capture fisheries, detailed research on the topic is absent to date, but there is some documentation on subsidization:

- The EU Fisheries Fund (EFF) assigned EUR 4 billion to support inland fishing between 2002 and 2006.[8]
- The Indian government provided subsidies (capped) of 20 percent for craft, gear, landing stages, and fish rearing units and dedicated to supporting inland capture fisheries.[9]
- Brazil requested that the inland capture sector remained outside the scope of the WTO Framework for disciplines on fisheries subsidies.[10]
- China assigned USD 580 million for fuel subsidies to aquatic production and its nearshore and inland fishing fleet in 2006.[11]

The transformation of fish into a fish product (through drying, smoking, processing, transportation etc.) also generates additional value, which can be directly attributed to the underlying extracted resource. (NEPAD cited by Chimatiro 2012), for example suggest that by including these “substantial market-based gains”, African fish rent resource generation rises from USD 2 billion to USD 3.8 billion. Although we recognize the importance of this value-added sector, most particularly in terms of the (gendered) employment it generates, this chapter concentrates on the value of inland fisheries at point of first sale value (FSV).

In practical terms, Welcomme *et al.* (2010) are correct when they assert that “... in most parts of Africa and Latin America, and to a lesser extent in Asia, it is extremely difficult to make any accurate and up to date assessment of the economic value of small-scale fisheries activities.” In the next section (Section 5.3) some of the major regional studies that have sought to do just this are reviewed. This is to give some understanding of the challenge, before moving to estimate the total economic value of the world’s inland fisheries.

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[6] In contrast, the value of the marine ornamental trade was about USD 44 million the same year (2011).

[7] Resource rent is the difference between total revenue (catch times price) and the total cost of the fishing effort (including the opportunity cost of fishing time) expended in landing the catch.

[8] WWFN, 2011.

[9] DAHDF, undated.

[10] WTO, TN/RL/GEN/79/Rev. 4, 2007, cited by Cho (2015).

[11] Pacific Islands Forum Fisheries Agency (Forum Fisheries Agency, 2013).

5.3 PAST STUDIES ON THE ECONOMIC VALUE OF INLAND FISHERIES

Worldfish (2008) estimated an annual tropical inland fish catch of about 5.5 million tonnes to have a gross market value of USD 6 billion, equivalent to 20 percent of the value of fish exports from developing countries at the time. The same paper also acknowledged "... the realisation that we still have some way to go before reliable estimates of total economic value will be available to all stakeholders" (p.1).

Yet, a decade later, although there is a growing number of studies detailing the economic impact of the inland fisheries sector (in terms of its effect on food security, employment, incomes and livelihoods – as presented in Chapters 3, 4, 6 and 7 in this publication), there are still relatively few studies that focus on the economic wealth/value of the world's inland fisheries (Grantham & Rudd, 2015[12]; Table 5-1).

The extensive study by De Graaf and Garibaldi (2014) on the value of African fisheries was intended to estimate the contribution of fisheries to GDP and employment within the region, as opposed to the economic value of either inland or marine fisheries. A survey questionnaire, distributed to two experts based in 23 different African countries for completion, captured data on fishing (inland and marine), aquaculture (pond), post-harvest processes (inland and marine) and licencing. This enabled the authors to compute the gross production value (GPV = total catches × fish price) and the gross value added (GVA = GPV × value added ratio[13]) of the inland fisheries surveyed as being worth USD 3 296 million and USD 2 415 million respectively.[14]

In a similar fashion, aquaculture generated a GPV equivalent to USD 2 189 million and a GVA of USD 2 054 million. More problematic was calculating the GVA of the post-harvest sector given the additional requirement to convert live weight to processed product, and the wider range of post-harvest products, production methods, markets and prices encountered. Despite these challenges, de Graaf and Garibaldi estimated a post-harvest GVA of USD 767 million across the 23 sampled countries in 2011. In comparison, the revenue generated from the sale of inland fisheries licences was relatively modest (USD 3.64 million), with Tanzania (USD 1.5 million), the Democratic Republic of the Congo (USD 1 million), and Mali (USD 0.56 million) the main contributors.

In total, the gross value added of African inland fisheries in 2011 was estimated to reach to USD 3 186 million (2 415 + 767 + 3.64), or USD 6 275 million if these findings were extrapolated across the whole continent. Concerns voiced by the authors regarding the reliability of their findings included: the considerable time and effort required to complete the study; the lack of national data on the production costs of different types of fishing and post-harvest operations (which militated against the construction of precise value added ratios); likely discrepancies in the fish prices provided (being a mix of ex-vessel and market prices, rather than just the former) and the very limited data on post-harvest activities.

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[12] Grantham and Rudd (2015) sourced articles on the economic value of inland capture fisheries from the bibliographic databases Econlit, Greenfile, Scopus, Science Direct and Web of Science using the search terms freshwater/inland, fisher*/fishing, and socioeconomic. They found 3 939 articles, but subsequently dropped 3 889 of these from their analysis (on the grounds that no economic values of inland capture fisheries had been generated via the use of primary data). The remaining 44 articles were supplemented with a further 31 articles encountered via the snowballing technique (total =75). Of these, 61 percent (46) related to recreational fisheries (examined in more detail in section 4.5), and just 39 percent (29) to subsistence and/or commercial fisheries. Although most made some reference to productivity or income, very few actually sought to estimate the costs of extracting the resource. We updated the research of Grantham and Rudd to end July 2017. This disclosed an additional 132 articles, though only three of these expressly involved primary research and the generation of economic values.

[13] Where the value added ratio (VAR) is defined as (1 – production cost [fuel, fees, maintenance etc.]/GPV).

[14] More than a decade earlier Neiland and Béné (2004) had estimated the potential production value of river fisheries in Central and Western Africa at USD 749.1 million, compared to current production of USD 295 million. UNEP (2010) reported research suggesting the beach value of catches from the Lake Victoria basin was worth USD 350 million each year.

Table 5-1: The market use value (MUV) of inland capture fisheries: selected research to date

Region Authors (Year)	**Countries/ regions covered**	**Estimated MUV (USD million unless otherwise stated)**	**Sectors covered**
Africa De Graaf and Garibaldi (2014)	23 countries	3 186 (survey) 6 275 (all Africa)	Harvest (74.5%) Post-harvest (25.3%) Licences (0.1%)
Americas Almeida, Lorenzen and McGrath (2003)	Brazilian Amazon	54.7 (subsistence) 26.6 (commercial) 65.4 (market and processing)[1]	Harvest and post-harvest
Asia Baran, Jantunen and Chong (2008)	Mekong River basin	1 478 to 2 000	Harvest
Asia Hortle (2009)	lower Mekong River basin	3 600 to 6 500	Harvest
Asia So Nam *et al.* (2015)	lower Mekong basin	11 000	Harvest
Europe Mawle and Peirson (2009)	England and Wales	GBP 1 billion (angling) + GBP 350 million (salmon loss)	Recreational
Oceania Baker and Pierce (1998)	South Australia	AUD 3.5 million to 6.1 million	Harvest (Commercial)
Subregional studies			
Norton, Brown and Richards (1969)	Columbia River, USA	4.69 to 5 (sport) 3 (commercial)	Commercial and sport
Radtke, Carter and Davis (2004)	Columbia and Snake Rivers, USA	3.6 to 8.6	Sport-reward
Gan, Du, Wei and Fan (2011)	Chinese Sturgeon National Reserve, Yichang/ Yangtze, China	1.62	Harvest

In South America, Almeida *et al.* (2003) interviewed stakeholders involved in the fishing inputs, fishing, marketing and processing, and service (restaurants) sectors along the Amazon-Solimões River corridor, scaling up their findings to encompass the 49 small and three large cities in the corridor. The value of these fisheries was estimated at USD 81.3 million, with the subsistence catch (valued at market prices) alone valued at USD 54.7 million. The value of the commercial fisheries sector is understated however, as the authors removed the value of the fish the sector sold on to processing plants and fish markets – where USD 65.4 million (at market prices) was generated – so as to avoid double-counting. Bennett and Thorpe (2008) also report data from the Floodplain Resources Management Project (FRMP-Provárzea) (since closed) in Brazil indicating a first-sale value of USD 21.4 million across 17 municipalities along the Amazon-Solimões corridor, with two municipalities (Belém and Manaus) accounting for 54 percent of this value. They also highlighted the wide variation in fish prices across Amazonas ports, citing the case of Apapá (*Pellona castelnaeana*, where prices ranged from BRL 0.5 to BRL 2 per kg) and Mapará **(***Hypophthalmus marginatus*, where prices ranged from BRL 0.37 to BRL

2.56 per kg), which demanded detailed and continued data collection if TEVs were to be computed with any degree of certainty in the region.

In Asia, Baran *et al*. (2007) reported estimates for both the Mekong basin, and for the countries bordering the Mekong from a number of authors. Fish consumption data was used to estimate an annual riverine and wetland capture fisheries yield of 1.5 million tonnes which, when multiplied by an average first-hand sale price of USD 0.68, produced a value of USD 1 478 million (Sverdup-Jensen, S., 2002).[15] Later research by Van Zalinge *et al.* (2004) and the Mekong River Commission (MRC, 2005), valued the fishery at USD 1 700 million and USD 2 000 million respectively. At the national level, values of USD 48 million to USD 100 million (Lao People's Democratic Republic, the latter figure including "other aquatic animals), USD 157.5 million (Thailand), USD 150 million to USD 300 million (Cambodia) were reported, although no values were reported for Viet Nam. Subsequently, Hortle (2009) undertook a rapid appraisal of the "worth" of the lower Mekong basin fishery, based on total yield for the catchment (3.6 million tonnes), first-sales (USD 1 to USD 1.8 per kg) and retail market prices (USD 2 to USD 3.60 per kg). This yielded a FSV "crude yardstick" figure of USD 3.6 billion to USD 6.5 billion, excluding production costs. More recently the MRC (Nam *et al*., 2015) estimated, a 2012 FSV, for inland capture fisheries in the region of USD 11 billion (USD 6.4 billion in Thailand, USD 2.8 billion in Cambodia, USD 1.3 billion in Lao People's Democratic Republic, and USD 0.8 million in Viet Nam) for 67 species across 14 different regional landing points. Importantly, the revenues generated from aquaculture were much lower (USD 5.8 billion), highlighting the relative importance of inland fisheries in the Mekong subregion (despite the massive contribution of Pangasius culture production in Viet Nam).

In Europe, Mawle and Peirson's (2009) research on the economic evaluation of inland fisheries in England and Wales is somewhat distinctive as the focus is upon recreational fisheries, as opposed to commercial capture fisheries. A two phased approach saw: (i) 7 000 licensed anglers contacted and their views solicited regarding their activity (days fished) and angling-related expenditures; and (ii) 911 members of the public questioned about their willingness to pay (WTP) to protect salmon rivers from serious decline and to improve the quality of said rivers. The findings were then scaled up to produce national estimates. This allowed the authors to estimate that about GBP 1 billion is spent annually by licensed freshwater anglers in pursuing their hobby, whereas the overall societal loss attributed to a precipitate decline in salmon stocks would be of the annual order of GBP 350 million.

The most comprehensive study in Oceania was that of Baker and Pierce (1998), who assessed the MUV of South Australia's commercial inland fisheries for nine key species using monthly catch data from 1992/3 to 1996/7 and Adelaide market prices. However, they acknowledge the historical MUV of the fishery was "greatly underestimated" as it failed to take into account where certain species were sold. Little of the European carp (*Cyprinus carpio*) catch, for example, was sold on the Adelaide market (less than 20 percent according to the authors), being destined instead for the more lucrative markets in Sydney and Melbourne. Thus, although traditional evaluation techniques suggested a 1996/7 MUV for the fishery of AUD 3 527 805, the MUV rose to AUD 4 938 247 when allowance was made for the possibility of sale in other markets. The MUV increases to AUD 6 119 301 (73.5 percent above official MUV estimates) when account was taken of fish sold locally outside of the Adelaide market.[16] More recent research, however (Burgin, 2017), suggests that, with the exception of the commercial eel harvest, most Australian states have no or limited inland commercial fishing.

There are a limited number of subnational or subregional valuation studies that offer some insight into the valuation processes and problems associated with specific inland fisheries. This is because most valuation studies are based on habitats (i.e. wetlands, rivers, lakes) rather than specific resources (i.e. fisheries). Hence, fisheries account for only part, albeit a significant part in some instances, of the habitat's TEV (McCartney *et al*., 2010). The WWF (2004) study on the *Economic value of the world's*

[15] Aquaculture and reservoir culture in the lower Mekong basin produced a further 500 000 tonnes worth USD 436 million.

[16] The authors also acknowledge that the fishery is a "major bait" supplier, though the value of this bait is unpriced and so excluded from GEV calculations.

wetlands, for example reviewed 89 EV studies[17] covering 63 million hectares (less than 5 percent of the world's wetlands) across the globe and concluded that the surveyed wetlands were worth a "very conservative" USD 3.4 billion per year. The study also disclosed fisheries contributed values of USD 18.7 million in the case of the Lake Chilwa wetland in Malawi (88.7 percent of total wetland value (TWV)), USD 64 904 in the Muthurajawela wetland in Sri Lanka (0.9 percent TWV), USD 10 518 for commercial fishing in the Whangamarino wetland in New Zealand (under 0.1 percent TWV), USD 6.9 million for recreational fishing in the Charles River basin wetlands in the United States of America (7.2 percent TWV), and USD 8.3 million for aquaculture in the Dutch Wadden Sea (0.3 percent TWV).

One of the earliest examples of a subnational, fisheries-specific study was a 1969 Columbia River study by Norton, Brown and Richards (1969) which sought to compare the economic value of the anadromous fishery with the cost of the river restoration programme. Using data drawn from a comprehensive 1962 survey of Oregon anglers, they estimated, conservatively, the net economic value of the river's salmon-steelhead sport fishery to range from USD 4.69 million to USD 5 million, whereas ex-vessel market values of the anadromous catch indicated the commercial fishery was worth slightly over USD 3 million per annum. These values were refined following later studies by Brown (1976) and Meyer and Koski (1982).

A more unusual study evaluated the net economic value of a programme to remove an indigenous species (the northern pikeminnow, *Ptychocheilus oregonensis*) from the Columbia and Snake Rivers, where it preyed on outmigrating juvenile salmonids, by rewarding anglers for catching and removing the species (Radtke *et al.*, 2004). This study estimated the economic value of an eradication programme to lie between USD 3.6 million and USD 8.6 million, comprising the value for the new pike minnow fishery (USD 1.8 million) and USD 1.8 million to USD 6.8 million because of increased adult salmonid abundance.

A more recent example is the study of the Chinese Sturgeon Natural Reserve in Yichang, China (Gan *et al.*, 2011), which used catch data and average annual prices to calculate that the direct use values derived from fishery products represented only 2.2 percent of the value of the whole ecosystem reserve (equivalent to USD 1.62 million).

Finally, Campos-Silva and Peres (2016) estimated that revenues averaging USD 10 601 per annum could be generated from Arapaima (*pirarucú*) catches from each floodplain lake along the middle section of the Juruá River in Amazonia, providing total allowable catches (TACs) were established and there was full compliance with the ensuing management measures.

As is apparent from the above, in seeking to estimate the value of the world's inland fisheries the same difficulties are faced as were faced by WWF (2004) in the attempt to place a value on the world's wetlands fully a decade earlier, namely "the extremely limited availability of past studies on this particular theme to guide … deliberations".

[17] Of these 89 studies, 37 were from the United States of America or Canada (4), 18 from Asia, 11 from Europe, 10 from Africa, 7 from the Oceania, 3 from Latin America, 2 from the Caribbean and 1 was from the Pacific island economies. WWF (2004) note that rivers and floodplains were not included in the study, going on to emphasize that "specific studies on the economic value of rivers still need to be undertaken" (p.14).

5.4 THE TOTAL USE VALUE OF THE WORLD'S INLAND FISHERIES

Estimating the total use value (TUV) of the world's inland fisheries, as noted in Section 5.2, needs to confront three major problems: establishing what has been caught; valuing what has been caught; and estimating the cost of catching the fish.

5.4.1 ESTABLISHING WHAT HAS BEEN CAUGHT

It is widely accepted than inland fisheries catches are often "unrecorded or drastically underreported, particularly with reference to the prevalence of small-scale or artisanal fishing in inland waters" (Lynch *et al*., 2016). FAO (2016) attribute this to the unreliability or non-existence of inland fisheries data collection systems. As a consequence, Baran, Jantunen and Chong (2007: 24) acknowledged underreporting of catch by as much as 250 to 360 percent in the Mekong basin. Bartley *et al.* (2015), however, suggest improvements in national collection systems may explain why some countries (Bangladesh and Myanmar are cited) have seen substantial increases (100 percent and 450 percent respectively) in reported catches over the last decade. The reason for such data deficiencies lie in the nature of inland fisheries: fish are caught and landed at multiple points along the lake, river or reservoir-side by multiple actors, many of them harvesting fish for direct household consumption – such fish never enter the formal marketplace. The consequence is that the contribution of inland fisheries to meeting domestic nutritional requirements and food security is grossly underestimated (Welcomme *et al.*, 2010, Cooke *et al.*, 2016).

The approach that has been used is as follows:

- Data on inland capture fisheries was extracted from FAO FishStatJ for 2011 to 2015, and an average annual catch figure for the period by country (dividing countries into landlocked and coastal) and region[18] was computed (Table 5-2). It is recognized that this data <u>does not typically include subsistence fisheries</u>, except in instances where national data agencies have incorporated estimates of these in their reported figures.[19]
- Landings from diadromous catches (Section 5.5) and brackishwaters (Section 5.6) are dealt with separately, although the same data extraction technique and period is used.
- The issue of NMUV, or alternatively "lost" or "hidden inland" fisheries, in terms of its likely effects upon TUV is dealt with in Section 5.7.
- The NMUV of recreational fisheries is addressed in Section 5.8
- Table 5-2 also reports inland aquaculture production and USD value, compiled from the same source, enabling a comparison of the total MUV (capture and culture) of inland fisheries.

Inland capture fisheries production over the period 2011 to 2015 averaged 9 861 399 tonnes (20 percent) annually, with inland aquaculture contributing a further 38 852 300 tonnes (80 percent).

[18] This is performed to smooth out year-on-year fluctuations that can potentially distort country values.

[19] Although FISHStatJ does not record whether this has been done, in a number of instances it reports that the given figure is an estimate, as opposed to a figure reported by a member country. On the basis of the data, the reported catches are estimated by either FAO and/or national authorities in 73 (49 percent) of the 148 countries for which inland fishery catch reports exist.

Table 5-2: Regional and global summary of inland catch of freshwater fish and aquaculture production presented as 5-year averages (2011 to 2015)

Region	Total inland catch landlocked countries (tonnes)	Total inland catch coastal countries (tonnes)	Total regional inland catch (tonnes)	Percentage of global inland freshwater fish catch	Total FW aquaculture (tonnes)	Total value of FW aquaculture (USD)	Percentage of global FW aquaculture	Total inland catch (Tonnes)	Percentage of global total inland fish production
Africa	1 027 843	1 724 286	2 752 129	28	683 778	1 728 167	1.8	3 435 908	7.1
Americas	23 868	492 948	516 816	5	839 156	2 236 545	2.2	1 355 972	2.8
Asia	53 912	6 279 675	6 333 587	64	37 073 733	56 792 424	95.4	43 407 321	89.1
Europe	18 806	227 728	246 534	2	253 135	638 666	0.7	499 668	1.0
Oceania	0	12 333	12 333	0.13	2 998	19 936	0.01	15 331	0.03
LIFDC	950 315	3 530 353	4 480 668	45.4	6 363 444				
Global total	1 124 429	8 736 969	9 861 399	-	38 852 800	-	-	48 714 200	-
% of global inland fish	2.3	17.9	20.2	-	79.8	-	-	100	-

Notes: As the data are presented for freshwater finfish species only, Table 5-2 excludes brackishwater production, which is shown separately in Table 5-6. Diadromous fish are shown in Table 5-5. Production data is the average production over the years 2011 to 2015, as reported by/to FAO

Source: FAO. 2017b.

The 52 low income food deficit countries (LIFDCs) delivered and average of 47 percent (4 591 764 tonnes) of inland capture and 16 percent (6 363 444 tonnes) of inland aquaculture output over the 2011 to 2015 period. However, whereas LIFDC capture production was almost equally split between the 37 African LIFDCs (51.6 percent) and the 11 Asian states (48.1 percent), LIFDC culture production was almost exclusively concentrated in Asia (92.6 percent).[20] Landlocked countries globally accounted for 1 124 429 million tonnes (11 percent of inland catch) with Uganda dominating (424 341 tonnes). Malawi, Mali and Chad also recorded annual catches of about 100 000 tonnes or more.

The world's major inland capture fisheries are located in Asia (64 percent of inland capture production), where two nations (China and India) land over 1 million tonnes each year, with China alone accounting for 1 647 227 tonnes (17 percent) of global inland catches. Twenty-one nations, ten from Asia, eight from Africa, two from the American continent (Brazil and Mexico) and one from Europe (the Russian Federation) all land more than 100 000 tonnes each year, and account for 85 percent of inland captures. Europe and Oceania only contribute marginally to the global inland capture total. In the case of Europe, although there are between 14 000 and 15 000 boats and an estimated 1 000 fishers without boats operating in the region's commercial inland fisheries, catches are dominated by the Russian Federation (140 237 tonnes, 57 percent of European catch). Finland, Germany, Poland, Spain, and the Ukraine record catches of above 5 000 tonnes each year. A similar scenario is evident in the American continent, where Brazil dominates regional capture production (227 865 tonnes or 44 percent of regional catches), and four other nations (Mexico, Venezuela (Bolivarian Republic of), Peru and Colombia) land more than 20 000 tonnes annually. It should be noted that retained recreational catches in North America are considered substantial, but are not reported to FAO (see Section 2.5.3). African capture production is rather more evenly distributed, with five nations (Uganda, Nigeria, the United Republic of Tanzania, Egypt, and Congo Democratic Republic) reporting captures of about 200 000 tonnes or more per annum in the 2011 to 2015 period. A further 21 countries report annual catches that exceed 20 000 tonnes (eight exceed 50 000 tonnes each year), highlighting the importance of inland fisheries in contributing to food security (Chapter 4), employment (Chapters 6 and 7), and resilient livelihoods (Chapter 9) across the African region. In Asia, 17 countries harvest more than 20 000 tonnes annually from their inland waters (10 harvest more than 100 000 tonnes annually), the importance of inland capture production to exports, food security and local livelihoods being reinforced by regional aquaculture production as Table 5-2 indicates. The region produces 95 percent of the global aquaculture production emanating from inland waters (92.5 percent in terms of USD value), with the top ten Asian producers posting higher levels of inland culture than capture production.

In terms of species (Table 5-3, details in Annex 5-1 and Annex 5-2), the major reported species captured are carp and other cyprinids (1 449 682 tonnes, 19 percent of landings over the 2011 to 2015 period) and tilapia and other cichlids (720 414 tonnes, 9 percent landings).[21] In Africa, silver cyprinid and Lake Malawi sardines (56 percent and 15 percent respectively of African cyprinid catches) dominate cyprinid catches (492 904 tonnes), whereas tilapia catches (464 943 tonnes) are principally of Nile tilapia (40 percent of catch). In Asia, common carp (8.5 percent landings) and silver barb (5 percent) are the most important identified species in the 790 158 tonnes landed of cyprinids over the 2011 to 2015 period, with Nile tilapia accounting for 34 percent of the 154 643 tonnes of tilapia and other cichlids harvested.

[20] Culture production (in volume terms) was of greater significance than capture production in just six LIFDC states (India, Pakistan, Nepal, Uzbekistan, the Syrian Arab Republic, and Kyrgyzstan).

[21] A significant part of the catch is, unfortunately, not attributable to specific species within the relevant taxonomic group in FishStatJ. In the case of cyprinids, 727 409 tonnes (49 percent of total) are reported as "cyprinids nei" and "tilapias nei" comprises 55 percent of the 713 619 tonnes of tilapias and cichlids recorded. Moreover, 5 980 825 tonnes (78 percent of total) are reported as "other freshwater fishes nei" for the period 2011 to 2015.

Table 5-3: Major fish species caught by region (2011 to 2015)

Region	Inland species	Catch (Tonnes)	Percent of regional catch
Africa	**Carps, barbels and other cyprinids**	**492 904**	**17.9**
	Lake Malawi sardine	74 289	2.7
	Silver cyprinid	278 911	10.1
	Others	139 704	5.1
	Tilapias and other cichlids	**464 943**	**16.9**
	Nile tilapia	187 165	6.8
	Others	277 778	10.1
	Miscellaneous freshwater fishes	**1 794 282**	**65.2**
	Nile perch	258 763	9.4
	Catfish	195 551	7.1
	dagaas /kapenta	59 195	2.2
	Mudfish	34 279	1.3
	Others	1 246 494	45.3
	Total Africa	**2 752 129**	**100.0**
Americas	**Carps, barbels and other cyprinids**	**34 972**	**6.8**
	Common carp	29 656	5.7
	Others	5 316	1.0
	Tilapias and other cichlids	**98 508**	**19.1**
	Miscellaneous freshwater fishes	**383 336**	**74.2**
	Catfish	87 150	16.9
	Others	296 186	57.3
	Total Americas	**516 816**	**100.0**
Asia	**Carps, barbels and other cyprinids**	**790 158**	**12.5**
	Common carp	67 235	1.1
	Silver barb	42 951	0.7
	Others	679 971	10.7
	Tilapias and other cichlids	**154 643**	**2.4**
	Nile tilapia	53 053	0.8
	Others	101 590	1.6
	Miscellaneous freshwater fishes	**5 388 787**	**85.1**
	Catfish	181 855	2.9
	Others	5 206 931	82.2
	Total Asia	**6 333 587**	**100.0**
Europe	**Carps, barbels and other cyprinids**	**131 637**	**53.4**
	Freshwater bream	29 233	11.9
	Others	102 404	41.5
	Miscellaneous freshwater fishes	**114 896**	**46.6**
	European perch	23 847	9.7
	Northern pike	20 371	8.3
	Others	70 678	28.7
	Total Europe	**246 534**	**100.0**
Oceania	**Tilapias and other cichlids**	**2 319**	**18.8**
	Miscellaneous freshwater fishes	**10 013**	**81.2**
	Total Oceania	**12 333**	**100.0**
Global	**Total**	**9 861 399**	
	Carps, barbels and other cyprinids	**1 449 671**	**15**
	Tilapias and other cichlids	**720 413**	**7**
	Miscellaneous freshwater fishes	**7 691 315**	**78**

Source: FAO. 2017b.

In the Americas, common carp (85 percent of carp catches) monopolize cyprinid catches. In the case of miscellaneous freshwater fishes, the most important (>20 000 tonnes per annum) identified by name are Nile perch (301 714 tonnes), snakeheads (275 197 tonnes), the nurse tetra (111 946 tonnes), *dagaas*/*kapenta* (102 146 tonnes), mudfish (77 230 tonnes) and a variety of catfish (370 538 tonnes). In Europe, freshwater bream (22 percent of catch) dominate cyprinid catches, whereas the most important of the 114 896 tonnes of miscellaneous fish caught annually over the period 2011 to 2015 were the European perch (21 percent of catches) and the northern pike (18 percent of catches).

In addition, a further 431 471 tonnes and 355 827 tonnes of freshwater crustaceans and molluscs were harvested respectively, primarily in Asia (93.8 percent and 98.8 percent of totals) over the period 2011 to 2015 (FishStatJ, Appendix Table 1). The major crustacean producer was China (329 436 tonnes, 76.4 percent of total) and, to a lesser extent, Bangladesh (50 161 tonnes) and Indonesia (16 434 tonnes), with the main crustacean species caught reported to be freshwater prawns (oriental and Siberian, 275 351 tonnes, 63.8 percent of total). China was also the principal origin of freshwater mollusc capture (271 401 tonnes, 76.3 percent of total) followed by the Philippines (61 701 tonnes, 17.3 percent). However, with the exception of Japanese corbicula (9 030 tonnes landed in Japan or 88.7 percent of global total) and South Korea (1 147 tonnes, 11.3 percent]) and 670 tonnes of clams, the residual 345 650 tonnes (97 percent of molluscs) were simply reported as "freshwater molluscs nei."

5.4.2 HOW TO VALUE WHAT HAS BEEN CAUGHT

Monetizing the inland catch is equally, if not more, problematic as prices vary by time, place and species, reflecting local supply and demand factors. Mille, Hap and Loeng (2016), for example, noted that the price of a tonne of fish in the Lower Mekong in 2012/3 varied from USD 632 in the Tonle Sap to USD 2 032 in the receding water season (USD 878 to USD 1 720 respectively in the main fishing season).[22] Price volatility is most acute in markets where the product (such as fish) is perishable, although this can be ameliorated when preservation opportunities such as drying, smoking, pickling or other forms of processing exist. Ideally, valuation methods should employ FSV (price at point of first sale, referred to variously as beach price (marine), farm-gate price (inland capture or culture), or ex-vessel price) as opposed to market prices – although the latter are often the easier to obtain. FAO (Globefish) does provide monthly market price reports, but these are restricted to the European markets, whereas the quarterly highlights update concentrates on the major seafood commodities. A one-off Freshwater Fish commodity update was released in August 2015, but its focus was restricted to tilapia, Pangasianodon, and Nile perch, moreover this only reported market prices for such commodities for Spain and the United States of America. In 2012, FAO introduced a Fish Price Index (FAO-FPI), derived from trade data for the European Union, United States of America and Japan relating to fresh and frozen whitefish, salmon, crustaceans, tuna, pelagics and "other fish", into their aggregate Food Price Index. Critically, in the context of the current study, the authors (Tveterås *et al*., 2012) state that the competitiveness of international fish markets will ensure that "prices from international trade can [be a] proxy for non-trade domestic seafood prices" (p. 2).

The approach was as follows:

- Data by species type were extracted from Fishstatj to compute an average annual catch figure (by major species type, where possible) for the period 2011 to 2015 by country (Annex 5-3). The same table also provides price data and notes the accompanying sources consulted).
- Average inland 2015 fish prices (USD/tonne) were computed for each country using either a weighted average (where some details on the relative proportion of different species in the final catch were available) or a simple average (where no details on species split was available).[23]

[22] The same price fluctuations are evident in aquaculture: FAO (2006) report that the retail price of 1 kg of Russian raised carp varied from 35 to 45 RUB during the autumn-winter period, to 80 to 100 RUB during the spring-summer period.

[23] As not all prices are 2015 values, we convert to 2015 prices using the FAO-FPI (although this is clearly not ideal).

- One problem encountered was that a number of the prices were market prices, rather than FSV. One possible solution would have been to reduce market prices by a scaling factor so as to remove the price mark-up, but this simply introduced a further estimation into the analysis. It was therefore decided not to do this, although it is recognized that this will inflate the estimated value of such fisheries.
- Prices, for the reasons noted above, should therefore be treated as indicative, rather than definitive.
- Table 5-4 documents the major inland capture countries in each region and the estimated MUV of these fisheries valued in terms of (end of) 2015 prices. The exception is the African region, where the results are extrapolated from price data for 2011 presented in De Graaf and Garibaldi (2014).

Table 5-4: Towards an estimation of the value of the world's inland capture fisheries (2015)

Region	Country	Quantity* (tonnes)	Average price (USD/kg)	MUV (USD million)	VAR (USD Million)	GVA (USD million)
Africa	**Total Africa**	**2 752 129**	**2.1**	**5 779.5**	**0.77**	**4 450.2**
Americas	**USA**	**9 250**	**5.37**	**49.72**		**29.83**
	(Canada)	17 807	5.37	95.71		57.43
	Mexico	**118 648**	**2.13**	**252.72**		**151.63**
	(Central America & the Caribbean)	10 390	2.13	22.13		13.28
	Brazil	**227 865**	**3.63**	**827.52**		**496.51**
	(Argentina, Chile, Paraguay, Uruguay)	34 842	**3.63**	**126.53**		**75.92**
	Peru	**31 599**	**2.21**	**69.83**		**41.90**
	Bolivia (Plurinational State of), Colombia, Ecuador, Guyana, Suriname, Venezuela (Bolivarian Repblic of))	66 414	**2.21**	146.77		88.06
	Total Americas	**516 816**	**3.08**	**1 590.9**	**0.60**	**954.6**
Asia	China	1 647 299	1.63	2 687.55		1 827.53
	Myanmar	836 586	3.16	2 645.93		1 799.23
	Bangladesh	830 316	2.56	2 121.90		1 442.89
	Cambodia	482 450	1.59	768.64		522.68
	Viet Nam	161 937	1.93	311.83		212.05
	Pakistan	124 462	2.51	312.82		212.72
	India	1 209 010	3.65	4 415.87		3 002.79
	Thailand	205 343	2.37	486.91		331.10
	Indonesia	380 789	3.35	1 275.64		867.44
	Philippines	118 487	2.65	314.44		213.82
	Sri Lanka	67 694	1.30	88.00		59.84
	Lao PDR	47 218	3.71	175.27		119.18
	(Rest of Asia [1])	221 997	**2.55**	**566.83**		**385.44**
	Total Asia	**6 333 587**	**2.55**	**16 171.6**	**0.68**	**10 996.7**
Europe	Germany	16 264	0.88	14.39		8.63
	Finland	20 544	2.8	57.47		34.48

Table 5-4: Towards an estimation of the value of the world's inland capture fisheries (2015)

Region	Country	Quantity* (tonnes)	Average price (USD/kg)	MUV (USD million)	VAR (USD Million)	GVA (USD million)
	Poland	18 368	2.69	49.38		29.63
	Russian Federation	140 237	1.21	169.07		101.44
	(Rest of Europe [2]):	51 120	2.2	112.32		67.39
	Total Europe	**246 534**	**1.63**	**402.6**	**0.60**	**241.6**
Oceania	Papua NG	10 814	2.27	24.54		13.60
	(Other developing states)	94	2.27	0.20		0.12
	Australia	1 099	10.73	11.80		7.10
	(New Zealand)	325	10.73	3.50		2.10
	Total Oceania	**12 332**	**3.25**	**40.0**	**0.60**	**22.9**
Global	**Total World**	**9 861 399**	**-**	**23 985**	**-**	**16 666**

Notes: Research was undertaken to obtain a sample of fish prices from the major producing countries (shown in bold in the Table) in each region. Appendix (Table 2) provides full details of these prices, their source, and how the average price (USD/kg) shown in the above table was computed. Cost and time prevented us from undertaking this exercise for all countries and so, in the case of other nations (namely countries in parenthesis e.g. Argentina, Japan, Austria etc.) proxy prices were used. These were taken from either a neighbouring major producer (in the case of the Americas and Oceania) or applied the regional weighted average price (in the case of Asia and Europe, except for the Russian Federation).

[1] Rest of Asia: Afghanistan, Armenia, Azerbaijan, Bahrain, Bhutan, Brunei Darussalam, Cyprus, Georgia, Indonesia, Iraq, Iran IR, Israel, Japan, Jordan, Korea DPR, Kazakhstan, Korea RO, Kuwait, Kyrgyzstan, Lebanon, Malaysia, Maldives, Mongolia, Nepal, Oman, Palestine, Qatar, Palestine, Saudi Arabia, Singapore, Syrian Arab Republic, Tajikistan, Timor-Leste, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, Yemen

[2] Rest of Europe: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czechia, Denmark , Estonia, France, Greece, Iceland, Ireland, Italy, Hungary, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Fmr Yug Rp of Moldova, Republic of Montenegro, Netherlands, Norway, Portugal, Romania, San Marino, Serbia, Serbia and Montenegro [now separate states], Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom

The African work of De Graaf and Garibaldi does not provide an explicit breakdown of catch by species when computing a 2011 market use value (MUV)[24] in their 2014 paper. Instead their surveys required correspondents in the 23 countries sampled (accounting for 53 percent of the 2011 African inland catch total of 2 707 315 tonnes) to provide data on the "average price (USD/kg) fishers obtain for selling their [inland] fish" (ex-vessel or landing site price). These prices were used to produce a weighted average price across the sampled countries, a price which was then applied across the sampled (23) and non-sampled (31) countries so as to produce national and regional MUVs, which are shown in Tables 7 and 30 in De Graaf and Garibaldi (2014).

A reasonable assumption here is that that the species composition of African national inland catches, particularly when aggregated across 54 countries, are unlikely to have deviated sharply over the five-year period (2011 to 2015) and therefore it is presumed that the species composition of African catches in 2015 is identical to that of 2011. De Graaf and Garibaldi (2014, Table 30) report a 2011 average ex-vessel/farm-gate price of USD 2.28 per kg and a GPV of USD 4 676 million. For 2015, an average estimated ex-vessel/farm-gate price of USD 2.1 per kg is used, based on the movement in the FAO Fish Price Index (FAO-FPI) over the period. This indicates that the inland catch of 2 752 129 tonnes had a MUV of about USD 5.78 billion.

[24] In their paper, De Graaf and Garibaldi use gross production value (GPV), although this is equivalent to MUV in our terminology.

Ten Asian countries annually capture over 100 000 tonnes from their inland waterbodies, with a further six recording average captures of over 30 000 tonnes in the period. Unfortunately, a major proportion of the catch is unidentified, being simply referred to in the literature (90.2 percent) as "freshwater fishes nei". The 6 333 587 tonnes of fish caught in Asia's inland waters are estimated to have a 2015 MUV of USD 16.2 billion. Although Chinese inland catches are almost double those of any other regional producer, relatively lower domestic prices reduce its share of regional GPV (16.6 percent). India (27.2 percent), Myanmar (16.2 percent) and Bangladesh (13.1 percent), along with China, account for almost three-quarters of the GPV derived from the region's inland capture fisheries.

No region-wide prior study of inland fisheries values exists in the Americas. In order to generate a regional GPV, four key inland capture countries were identified (Brazil, Mexico, Canada/United States of America, Peru) from which prices were sourced (see Annex 5-3). In Mexico, for example, the country's largest fish market (La Nueva Viga in Mexico City) priced carp and tilapia at MXN 20, MXN 33 and MXN 32 to 40 per kilogram respectively in December 2015.[25] The 516 816 tonnes landed in the Americas were estimated to have an MUV of USD 1.59 billion with Brazil (52 percent), as might be expected, providing the major part of this.

In the case of European inland fisheries catch, Ernst & Young (2011) reported a total value of EUR 100 million to EUR 110 million at point of first sale in 2007/2008. Data were sourced from the European Market Observatory for Fisheries and Aquaculture Products, which provided prices at point of first sale, rather than the ex-farm prices (which were somewhat higher[26]) and were reported in the December 2015 Globefish European Price Report. The 246 534 tonnes landed in Europe were estimated to have a 2015 MUV of USD 402.8 million in 2015, with the Russian Federation responsible for the major part (42 percent) of the total. A similar process was undertaken in Oceania, producing an estimated MUV in 2015 of USD 40 million.

In total, it is estimated that the global MUV of inland catch fisheries in 2015 was about USD 24 billion.

A similar exercise was undertaken with regard to the harvesting of inland crustaceans and molluscs but, as the majority of each are harvested in Asia, Chinese prices were used and the same principles adopted as indicated above, to estimate a MUV of USD 5 billion in 2015 from this source (details of the calculations are provided in Annex 5-2).

5.4.3 ESTIMATING THE COST OF CATCHING THE FISH

The GVA of inland capture fisheries requires the costs of production (inputs, including labour) to be deducted from the income generated. This in turn requires detailed local studies. Tuan *et al.* (2009, Table 7), for example, estimated that the cost of fuel, fishing equipment fees and hired labour in the capture fisheries of Giang-Cau Hai lagoon in Viet Nam amounted to VND 4.7 billion, producing a VAR of 0.68 for the fishery.

The difficulty is moving from local VARs to national, or even regional, VARs. A further problem encountered in such analyses, is the valuation of own labour, as opposed to labour that is hired. Imputing values for labour effort based on local hired labour rates may be relevant when ascertaining the "level of fishing effort" in bio-economic terms and the sectoral contribution to GDP (UN/FAO, 2004), but is not so appropriate in the current context when the fisher has few alternative income-earning opportunities (i.e. fishing is an "occupation of last resort").[27] The approach was as follows:

- A review of the current literature on VARs (by region) was performed, highlighting (by underlining) what was considered to be the most appropriate VAR to apply in the context of the analysis.

[25] Applying the end of 2015 USD/MXN exchange rate (1 USD= MXN 14.7) produces USD prices of USD1.36 and USD 2.18 to 2.72 (average USD 2.45).

[26] Globefish, for example, valued live carp at USD 2.91 per kilo, although Crucian carp retailed at much less (USD 1.36 per kilo). European catfish sold at USD 5.83 per kilo.

[27] In other words, the opportunity cost of labour is near to zero.

- These are also reported in Table 5-4, and allow the estimation of the GVA of the world's inland capture fisheries.

A NEPAD study (cited by Chimatiro 2012) acknowledge that well-managed fisheries generally post a VAR of between 0.3 and 0.7 of first sale value, going on to suggest that the VAR of 0.4 (employed in a paper on fisheries wealth generation delivered to the African Ministers of Fisheries and Aquaculture Conference in 2010) was "a conservative rule of thumb" measure, and undervalued Africa's fish resources. Instead, they suggested a VAR of 0.6 was more realistic in the African context. De Graaf and Garibaldi (2014, Table 8) found inland fishing VARs ranged from 0.34 (Burundi) to 0.97 (Democratic Republic of Congo) across 19 reporting countries, with ten countries reporting rates of 0.8 or more. However, they cautioned that "some countries reported unreliable VARs… as values close to 1 did not include the production costs, while values verging on 0 would make the fishing activity unprofitable*''* (p. 20), and settled on applying a weighted average VAR of (0.77) in their inland analysis.

There is little published work on VARs in the Americas. One exception is Viana *et al.* (2007), whose work in Amazonas/Brazil over the period 1999 to 2002 produced VARs between 0.75 and 0.89. Almeida, McGrath and Ruffino (2001) did similar work on the 575 strong commercial fishing fleet in the lower Amazon basin where they classified boats by ice capacity – from 200 kg to 38 000 kg. They suggested VARs of between 0.36 and 0.43 (depending on boat size and whether fixed costs were included in the calculations). Although these latter VARs are also likely to be reflective of the scenario in North America, given the nature of the commercial inland fisheries encountered there, the former VARs (0.75 to 0.89) are more representative of much of Central America and the Southern cone, where small-scale fishers and fisheries predominate (and where the majority of the Americas inland catch is harvested). In the light of this, a VAR of 0.6 was applied, towards the higher end of the range identified by NEPAD (cited by Chimatiro 2012).

In Asia, Ringler and Cai's (2003) work on riverine capture fisheries in the Mekong basin resulted in an identical VAR (0.68) to that found by Tuan *et al.* (2009). Israel *et al.* (2007) estimated the MUV of fishing in the wet and dry seasons of Siem Reap province in Cambodia for both motorized and non-motorized fishers. This produced VARs of between 0.62 and 0.75. However, excluding labour costs (which were generally "household labour and not hired labour") raised VARs to between 0.83 and 0.94. In comparison, the VAR for culture production in Siem Reap varied from 0.18 (if labour costs were included) to 0.36 (if such costs were excluded). Sinh, Navy and Pomeroy (2014) who worked on the snakehead value chain in the lower Mekong basin of Cambodia and Viet Nam not only disclosed sharply lower VARs (0.23 to 0.4, depending on season), but also found (depending on assumptions) that between 35.8 percent and 52.3 percent of farmers of cultured snakeheads were making operational losses. Elsewhere in the region, Ahmed (cited in Norman-Lopez *et al.*, 2008) produced a VAR of 0.75 for the riverine fisheries of Bangladesh; Koeshendrajana and Cacho (2001) encountered a much lower VAR (0.23) in South Sumatra, a value they attributed to overfishing (own effort expended – and costed – being well beyond maximum economic yield (MEY) and maximum sustainable yield (MSY) levels); and Renwick (2001) found a VAR of 0.67 across three reservoirs in southeast Sri Lanka.

From a review of the literature, there is no evidence of VARs being derived for either the smaller inland capture fisheries of both Europe and Oceania or freshwater crustacean and mollusc production. Therefore the same VAR used for the Americas[28] was applied.

As Table 5-4 indicates, the total global GVA accruing from reported inland capture fisheries production in 2015 was estimated to be about USD 16.7 billion, with just over two-thirds of this being generated in Asia (Africa generates 26.6 percent). This compares to an estimated aquaculture 2015 MUV of USD 61.4 billion (Table 5-2). The GVA of inland fisheries in LIFDCs is estimated to have a value of USD

[28] If we had instead applied the "African" VAR of 0.77 then the aggregate GVA of the American continent, Europe and Oceania would have increased by USD 326 million, raising the total global GVA to USD 17 billion.

7.7 billion, 20 percent greater than the value of aquaculture production (USD 6.4 billion) in these countries.[29]

5.5 THE TOTAL USE VALUE OF DIADROMOUS SPECIES

Although the majority of the 32 000-plus known fish species subsist solely in either marine (58 percent) or fresh (41 percent) waters, a small subset (the diadromous species) move between fresh and salt water over their respective life cycles. Anadromous species such as salmon, sturgeons, shad and smelt are born in freshwater, migrate to the ocean as juveniles, and then return as adults to spawn in freshwater rivers and lakes. In contrast, catadromous species, of which the eel family is the most well-known (but also includes the thin lipped mullet and some flounder species), spawn at sea before migrating to inland freshwaters (estuaries and rivers) to continue their growth (Daverat *et al*., 2011).[30]

It is undeniable that the life cycle of all anadromous species requires spending some time in freshwater (even when they are the products of aquaculture, they are released into freshwaters before migrating to the sea). What is debatable is the contribution of freshwater ecosystems to the value generated through the capture of diadromous species.

In this study, the answer is based on the locale in which the species is captured: if the diadromous fish is caught in inland waters then the full value realized is attributed to inland capture production. Conversely, if the fish is caught at sea, the value is treated as marine capture production – and thus outside the purview of this chapter.

On average, 358 714 tonnes of diadromous fish were captured annually in inland waters over the period 2011 to 2015, principally by Bangladesh (32.93 percent) and the Russian Federation (32.9 percent).

The hilsa shad (*Tenualosa ilisha*) is most abundant in the Ganga-Brahmaputra-Magna river systems and accounts exclusively for the Bangladeshi diadromous catch. Mohammed and Wahab (2013) estimate that it accounts for about one-tenth of the national catch, 1 percent of the country's GDP and provides direct employment to about 500 000 fishers. Concerns over the inland overfishing of hilsa juveniles saw the government introduce a hilsa management plan in 2003, declare four hilsa sanctuaries in 2005 (and a fifth in 2011) and a national closed season for two weeks in the October breeding period (Islam *et al*., 2016). However, catches continued to rise, surpassing 100 000 tonnes in 2010 and peaking at 135 396 tonnes in 2015.[31] In India, the hilsa fishery (which accounts for more than 70 percent of the country's current diadromous landings) has already collapsed, a collapse which Roy, Manna and Sharma (2016, p. 86) attribute to poor implementation of net size regulations, ineffectual extension services, poor enforcement of the closed season, and recurring climatic hazards. Annual landings, which were usually about 40 000 tonnes in the 1990s, peaked in 2001 at 64 599 tonnes, and dropped below 10 000 tonnes after 2010.

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[29] The principal exceptions are India (where the value of aquaculture production was 35 percent above that of inland capture production) and Bangladesh (412 higher). Data available from the authors.

[30] A third type, the *Amphidromoids* (whose number include sirajo and river gobies and mountain mullet) are born in freshwater/estuaries, drift into the ocean as larvae, then migrate back into freshwater to grow into adults and spawn.

[31] Islam *et al.* (2016, p. 315) report extensive illegal fishing, noting that between November 2014 and May 2015 the government seized 131 836 tonnes of illegally caught juvenile hilsa and confiscated 64 443 700 metres of fishing nets.

Table 5-5: MUV for global capture fisheries of diadromous fishes (average metric tonnes 2011 to 2015)

Country/Regions **Species (weight in tonnes)**	**Average tonnes catch 2011 to 2015**	**Percentage of global total**	**Local prices USD/kg**	**Date**	**2015 price (USD)**	**MUV (USD '000)**	**VAR**	**GVA**
Bangladesh *Shads (118,111)*	118 111	**32.9**	6.74	Sep-2013	6.21	733,572	0.68	498 829
Russian Federation *Miscellaneous diadromous fishes (1 140); salmon,trout, smelt (114 875); shad (1 938)*	118 027	**32.9**	7.91	Sep-2017	8.21	969 461	1.21	1 173 047
Iran (Islamic Rep. of) *Salmon, trout, smelt (8); shad (22 865);sturgeon,paddlefish (56)*	22 929	**6.4**	1.20	Sep-2017	1.13	25 988	0.68	17 672
Japan *Salmon, trout, smelt (16,839)*	16 981	**4.7**	1.00	2015	1.00	16 981	0.68	11 547
Turkmenistan *Shad (14,680)*	14 685	**4.1**	1.20	Sep-2017	1.13	16 644	0.68	11 318
Canada *River eels (62); salmon, trout, smelt (8 999); shad (791)*	9 947	**2.8**	0.96	Dec-2015	0.96	9 566	0.60	5 739
Philippines *Miscellaneous diadromous fishes (7 019);river eels (1 752)*	8 771	**2.4**	3.93	Sep-2017	3.72	32 655	0.68	22 206
United States of America *Salmon, trout, smelt (5 175); shad (1 597)*	7 988	**2.2**	0.96	Dec-2015	0.96	7 681	0.60	4 609
Ukraine *Shad (7,081)*	7 081	**2.0**	0.29	Sep-2017	0.28	1 977	0.60	1 186
India	6 990	**1.9**	23.53	Aug-2017	22.27	155 666	0.60	93 400
Top ten countries	**331 509**	**92.4**						
Rest of the World	**27 205**	**7.6**				**0**		**0**
Africa	**1 948**	**0.5**	2.10	2015	2.10	**4 090**	0.77	**3 150**
Rest of Americas	**1 010**	**0.3**	0.96	2015	0.96	**970**	0.60	**582**
Rest of Asia	**3 644**	**1.0**	10.73	2015	10.73	**39 096**	0.68	**26 585**
Oceania	**1 539**	**0.4**	0.96	2015	0.96	**1 477**	0.60	**886**
Europe	**19 064**	**5.3**	0.96	2015	0.96	**18 302**	0.60	**10 981**
Grand total	**358 714**	**100**				**2 034 127**		**1 881 738**

In the Russian Federation the diadromous catch is dominated by salmon,[32] principally the chum/dog/keta (43 percent landings in 2011 to 2015 period), the pink or humpback (17 percent), and the sockeye (13 percent), and is regulated by the Committee of Anadromous Fish Catch Regulation (CAFCR) in each administrative subdivision. State scientific organizations recommend total allowable catches on an annual basis, and the CAFRCs link these catches to approved fishing grounds and then assign quotas to commercial and recreational fishers in proportion to the applications received (Nakhshina, 2016). Because restrictions on who can fish (and where) and because enforcement is weak, there is a strong likelihood that official reported figures underestimate the true catch level. In Japan the chum/dog/keta salmon accounts for the major part of diadromous landings (68 percent) and commercial and recreational fishers benefit from an extensive salmon hatchery stock enhancement programme (Kitada, 2014). The Caspian Sea and the Caspian kilka/sprat form the basis of both the Turkmen and Iranian diadromous fisheries. Catches in both countries have fallen in the twenty-first century as overfishing and the invasive effects of the comb jelly *Mnemiopsis leidyi* (discussed in more detail in the Central Asia Section 2.2.6) have taken their toll on local kilka stocks (Fazli and Jelodar, 2013).

In North America, freshwater whitefish represents half of the diadromous catch, with lower volumes of shads (13 percent) and char/trout (7 percent) reported. The major inland commercial diadromous fisheries take place on the Great Lakes, which are bisected by the United States of America–Canadian border, with lake whitefish (*Coregonus clupeaformis*) a principal target. In the space of a century, catches in the Great Lakes collapsed from an 1879 peak of 11 000 tonnes to about 3 000 tonnes by the 1950s because of overfishing, pollution runoff from lakeside agriculture and the introduction of the parasitic sea lamprey (*Petromyzon marinus*) into the waterbodies. Since then, more aggressive management strategies have seen a recovery in stocks and catches, though Ebener *et al.* (2008, p. 113) recognize that the fishery still experiences problems because of the invasion of dreissenid mussels (which reduced the biomass of *Diporeia* spp., the principal prey of whitefish) and substantial increases in the filamentous algae *Cladophora glomerta* (which has clogged gear). It is only in the Philippines that river eels form a substantive part (20 percent of national catch and 8 percent of global eel catch) of diadromous catches. Capture production is mainly concentrated in the Cagayan Valley in Luzon Island, and has grown from 200 tonnes in 2002 to an average of 1 752 tonnes over the 2011 to 2015 period (Crook, 2014).

The MUV of the inland diadromous fishery is computed in an identical way to that of the main inland capture fisheries. Table 5 shows the average catches by country/region over the 2011 to 2015 period. Prices (in USD/kg) were obtained for key species from various sources and rebased to 2015. This enabled us to compute the national, regional and global MUV and GVAs[33] of the fishery. The MUV of the diadromous fishery is estimated to be worth USD 2 034 million annually over the period 20011 to 2015 with just under half this total landed in the Russian Federation (47.6 percent), and the hilsa fishery of Bangladesh contributing a further 36 percent. Relatively few diadromous species are caught in the inland waters of the LIFDC group of countries. In contrast, the inland farming of diadromous fish produced just over one million tonnes, and generated revenues averaging USD 4.57 billion annually over the 2011 to 2015 period. Just over 1 million tonnes of diadromous fish (worth USD 4.57 billion) were cultured annually over the period 2015, largely in Asia (69 percent of production), with lesser amounts harvested in Europe (19.6 percent).

[32] Irvine and Ruggerone (2016) note that Russian statistics fail to distinguish between hatchery and wild adult salmon, whereas Hasegawa, Ohta and Takahashi (2017) note than nearly two billion hatchery-reared chum salmon are released annually into more than 200 Japanese streams. In this chapter we do not seek to distinguish between hatchery-born and wild salmon (or other anadromous species), but simply assess the TUV of the reported diadromous catch in inland waters.

[33] In the absence of any literature suggesting the cost of catching diadromous fish is more/less than other inland fish, we have elected to use the same regional VAR as were employed in Table 5-4.

5.6 THE TOTAL USE VALUE OF BRACKISHWATER FISHERIES

The term "brackishwater" has multiple connotations, and can be employed to describe tidal estuaries, large seas (such as the Baltic and the Caspian), mangrove habitats, closed lagoons fed by brackish fossil aquifers, flooded coastal marshlands, and the wastewater produced as a by-product of osmotic (salinity gradient) power generation (Segerstrale, 1958; Elliot and McLusky, 2002; McLuskey and Elliot, 2004). De la Cruz (1994, p. 24) suggests there are more than 781 892 hectares (ha) of brackishwater ponds in Southeast Asia alone, principally in Indonesia (276 442 ha), the Philippines (222 907 ha), Viet Nam (189 000 ha) and Thailand (72 296 ha). FAO identifies brackishwaters as estuaries, coves, lagoons, bays and fjords, waters in which salinity levels range from 0.5 parts per thousand to full strength seawater.[34] FishStatJ proceeds on this basis to provide data on brackishwater culture production by country and by species type (freshwater, marine or diadromous fishes).[35] Table 5-6 provides data on the level and value of freshwater fish production in brackishwaters (inland waters and coastal areas) over the period 2011 to 2015.[36]

Table 5-6: Brackishwater capture fishery production (2011 to 2015)

Country	Tonnes	Percentage of total	Cumulative percentage	Value in USD ('000s)	Percentage total in USD
Egypt	750 614	73.2	73.2	1 117 571	74.5
Indonesia	119 350	11.6	84.8	155 277	10.3
Viet Nam	113 056	11.0	95.8	152 862	10.2
Taiwan POC	21 756	2.1	98.0	36 249	2.4
Philippines	16 280	1.6	99.6	25 503	1.7
Others	4 586	0.4	100.0	13 222	0.9
World total	**1 025 641**	**100**		**1 500 684**	**100**

Source: FAO. 2017b

Brackishwater fish production averages an estimated 1 025 641 tonnes worth USD 1 500 million over the five-year period.

Egypt accounts for almost three-quarters of reported brackishwater production (more than 99 percent from inland waters), followed by Indonesia and Viet Nam. Centred upon the Northern Lakes area in the Nile delta region, the traditional *hosha* system has given way to the semi-intensive (earthen ponds) and intensive (ponds, concrete tanks or cages) culture of Nile tilapia (*Oreochromis niloticus*). Egypt has become the second largest producer of farmed tilapia in the world after China (Rothuis *et al.*, 2013). As well as tilapia (55 percent brackishwater production), mullet (30 percent) and carp (11 percent) are also important in an industry employing as many as 68 000 Egyptian workers (Rothuis *et al.*,2013). In Indonesia, 680 000 hectares of *tambak* (brackishwater ponds) are an important livelihood source for more than half a million rural households (Putra *et al.*, 2013, p. 293). Milkfish (*Chanos chanos*) production is supplemented by grouper (estuarine), mullet and carp (lagoon/pond) culture, delivering almost 120 000 tonnes worth USD 155.3 million annually. Catfish (*Pangasianodon hypophthalmus*) dominates low salinity brackishwater (and freshwater) fisheries production in Viet Nam, with

[34] FAO Coordinating Working Party on Fishery Statistics (CWP) http://www.fao.org/cwp-on-fishery-statistics/handbook/aquaculture-statistics/en/

[35] As brackishwater capture production is not recorded, the reported data almost certainly underestimates the harvest from such waters (capture production from such waters being reported under either marine or inland capture data).

[36] Diadromous production is covered in Section 4.3 of this chapter. We exclude marine fishes on the basis that their life cycle transitions from marine water to brackishwater (where they are captured), and so never generally enter inland waters. Conversely, as freshwater fishes are inland in origin, only terminating their lives in brackish lagoons or similar habitats, we consider them to be an integral component of the total economic value of inland/freshwater fisheries.

production centred principally on the Mekong delta (85 percent of production) and, to a lesser extent, the Red River delta (Van Trong, 1999; Phuong and Minh, 2005; Wilder and Phuong, 2002). However, salinity intrusion, as a consequence of climate change, most particularly in the Can Mau, Bac Lieu, and Kien Giang regions, could cost the country an estimated USD 132 477 per hectare in reduced catfish production alone by 2020 (Kam *et al.*, 2012). In Taiwan, brackishwater culture has expanded rapidly to provide just over half of the country's total inland culture production, with tilapia and milkfish being the preferred species (Chen and Qiu, 2014, p. 154ff). In sharp contrast, in the Philippines, only 6 to 7 percent of total inland culture production is sourced from brackishwaters, with milkfish the predominant cultured species (Guerrero and Guerrero, 2004).

Elsewhere, brackishwater fish production either goes unrecorded, or is subsumed in inland capture/culture production data, making the separate estimate of the true economic value of brackish capture fisheries an impossible exercise.

5.7 ESTIMATING THE VALUE OF "HIDDEN" INLAND CAPTURE FISHERIES

FAO (2016) report that "it is well known that data collection systems for inland water catches in several countries are unreliable or non-existent" (p. 16). This is evident in the analysis of inland capture fisheries data, where estimates are more typical than hard data (this is discussed in Section 10.1.1). This is hardly surprising given that fish are caught and landed at multiple landing points by multiple actors (much more so than in marine fisheries), often as one component of a wider, and more complex, livelihood strategy. Large-scale monitoring of inland fish harvesting although desirable is, however, impractical given the likely costs of such a dispersed activity (Youn *et al*., 2014). Estimation of these "hidden harvests" is therefore imperative: not only to allow a more accurate value to be placed on the value of fish extracted from inland waters, but also to aid effective policymaking in delivering on the provision of domestic nutritional requirements and national/regional food security.

Early work by Coates (1995) proposed that actual inland capture fishery catches could be as much as double those officially reported to FAO. A report by FAO, WorldFish Center and the World Bank (2008), on the basis of interrogating national household consumption studies across six countries, concluded that inland catches could be underreported by some 40 percent (ranging from 20 percent in Bangladesh to 670 percent in Viet Nam). World Bank (2010) expanded the sample size (from six to eight countries) and suggested the degree of under-reporting could be even higher (70 percent). UNEP (2010) re-interpreted FAO estimates of under-reporting reported in the inland fisheries reviews of 1999 and 2003 to suggest a more accurate inland catch figure would be 20 million to 30 million tonnes (rather than the 10 million tonnes actually reported). More recently, however, FAO (2016) pointed out that many major inland producers (six out of eight) reported sharp increases in inland catches in 2013 (ranging from 18 to 78 percent) when compared to the preceding decade, and so the magnitude of these "hidden" catches may thus have reduced.

If landings are underestimated or unreported, then consumption is likely to be substantially greater than estimates produced through recourse to catch statistics. This prompted Fluet-Chouinard, Funge-Smith and McIntyre (2018) to estimate inland fish catch for 42 countries in 2008 (54 percent of reported global inland catch) using national Household Consumption Survey data. Their analysis indicated that catches, in aggregate, were in fact 64.8 percent higher (13.93 million tonnes) than the reported figure (10.3 million). Extrapolating these findings to the rest of the world indicated a global inland catch in 2008 of about 17.3 million tonnes (see Section 10-5).

"Hidden" inland fisheries catch clearly cannot be excluded when estimating the TUV of the world's inland fisheries. The approach here is a cautious one and starts from the assumption that the majority of the world's inland fisheries are already fully exploited (Allan *et al*., 2005; FAO, 2012; IFAD, 2014), and so any reported increases in capture production are likely to be a result of a more precise reporting of existing catches rather than any real increase in landings. The 2008 under-reporting estimate [64.8 percent] drawn from Fluet-Chouinard, Funge-Smith and McIntyre (2018) is refined by recourse to the FAO (2016) position suggesting that the scale of hidden harvests has reduced (based on their finding a 17.6 percent increase in reported landings for their sample set (2014) when compared to average reported landings over the preceding decade). The assumption is therefore that the reported landings over the 2011 to 2015 period (Table 5-2) were under-reported by a factor of 47.2 percent (64.8 to 17.6) and, moreover, that this estimate was: (i) constant across regions; and (ii) applied equally to inland diadromous landings. To calculate the MUV of the "hidden harvest", regional prices and VARs were used (Table 5-4). The hidden inland fisheries harvest (Table 5-7) is calculated as being annually worth an estimated USD 12.4 billion (GVA worth USD 8.6 billion), with the main contributor being Asia overall (69.2 percent of total MUV), with Africa being important in terms of non-diadromous captures (24 percent of total).

Table 5-7: The economic value of unreported "hidden harvest" (2015)

FRESHWATER	Africa	Americas	Asia	Europe	Oceania	Total
Average tonnes (2011 to 2015)	2 752 129	516 816	6 333 587	246 534	12 333	9 861 399
Hidden (47.2%)	1 299 005	243 937	2 989 453	116 364	5 821	4 654 580
Prices (USD/kg) from Table 5-4	2.10	3.08	2.55	2.20	3.25	n/a
MUV: USD million	**2 728**	**751**	**7 623**	**256**	**19**	**11 381**
VAR from Table 5-4	0.77	0.6	0.68	0.6	0.6	n/a
GVA: Inland freshwater (USD million)	*2 100.6*	*450.6*	*5 184*	*153.6*	*11.4*	*7 902*
DIADRAMOUS	**Africa**	**Americas**	**Asia**	**Europe**	**Oceania**	**Total**
Diadromous tonnes (2011 to 2015)	1 948	18 945	192 111	144 171	1 539	358 714
Hidden (47.2%)	919	8 942	90 676	68 049	726	169 312
Prices (USD/kg)	2.1	0.96	10.73	0.96	0.96	n/a
MUV: USD million	**1.93**	**8.58**	**972.95**	**65.33**	**0.7**	**1 049.5**
VAR	0.77	0.6	0.68	0.6	0.6	n/a
GVA: Inland diadromous (USD million)	*1.49*	*5.1*	*661.6*	*39.2*	*0.4*	*707.79*
Total MUV: USD million	**2 729.93**	**759.58**	**8 595.95**	**321.33**	**19.7**	**12 426.5**
Total GVA	**2 102.09**	**455.7**	**5 844.6**	**192.8**	**11.8**	**8 606.99**

5.8 THE NMUV OF FRESHWATER RECREATIONAL FISHERIES

An overview of participation in the world's recreational fisheries is provided in Chapter 8)[37]. Arlinghaus, Cooke and Potts (2013, p.91) recognize that recreational fishing (catch and release/catch and retained) and recreational fishers may overshadow inland capture production in a number of countries, most notably in North America, Europe and Oceania. Although recreational fishing takes place across much of Africa and Asia, most visibly involving internationally mobile sportsfishers who target specific (large/giant or highly prized) species, inland freshwater fishing in these regions (particularly in the LIFDC) can play an integral role in livelihood strategies.

Estimates of the numbers engaged in recreational fishing globally vary sharply (van der Hammen, de Graaf and Lyle, 2016). Cooke and Cowx (2004) estimated 727 million engaged globally with recreational fishing, whereas Funge-Smith *et al.* (Chapter 8 in this volume) put the number of freshwater recreational fishers at 174 million. Kapetsky (2001), moreover, suggested that freshwater recreational fishing effort might represent as much as half of global food fishing (recreational + commercial) effort.

In terms of estimating economic value, "true" recreational fisheries are distinct from capture fisheries for, although part of the catch may be destined for either sale or self-consumption, value is also generated by the very act of fishing itself (Parkkilla *et al.*, 2010). Hence, estimating value through recourse to catch values will underestimate the true value of recreational fisheries. Instead, alternative valuation techniques are needed. One option is to use expenditure-based approaches: extracting information on the value of licences purchased and/or spent on fishing trips or, alternatively, estimating the turnover of the fishing tackle/bait industry and the recreational boating industry. In Australia, for example, Campbell and Murphy (2005) and Dominion Consulting (2005) estimated the annual value of retail sales in the bait and tackle industry (marine and inland) was AUD 223 million (June 1999 to May 2000) and AUD 565 million (2003/4) respectively. ABS (2003) calculated the annual turnover of the recreational boating industry (60 percent of which was attributable to recreational fishing) to be about AUD 500 million, with the annual influx of international recreational fishing trippers contributing more than AUD 200 million to the economy.

One unavoidable problem with this approach is that expenditures are not disaggregated by type (freshwater or marine) of recreational fishing. A second option is to use contingent valuation (CV) techniques, such as the travel cost method (TCM),[38] to establish the willingness to pay (WTP) of recreational fishers. These have the advantage of capturing consumer surplus,[39] but are complicated, lengthy and expensive to implement as acknowledged earlier. A meta-study covering 48 marine and freshwater studies over the period 1977 to 2001 by Johnson *et al.* (2006) disclosed 391 WTP estimates, with values ranging from USD 0.048 to USD 612.79 per fish. Further analysis found that WTP per fish depended on the species targeted, with higher WTP encountered for anadromous and big game fish, and lower WTP for mid-size common freshwater sports fishes such as pike and bass, and freshwater "pan" fish (catfish, carp, and other freshwater fish).

Although Welcomme *et al.* (2010) report an "explosive development" of recreational fishing in many transitional economies in Asia and a "few countries in Southern Africa (Angola, South Africa, and Zambia)", here the focus is on the main recreational fishing regions/nations (see Funge-Smith *et al*., Table 8-1 in this volume). Table 5-8 provides an overview of published work on the economic value of

[37] We interpret recreational fisheries as fishing that does "not constitute the individual's primary resource to meet basic nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets" (FAO, 2012a).

[38] The TCM assumes that the WTP for recreational fishing can be estimated through recourse to the expense, including both time and travel cost, individuals are prepared to incur to indulge in the activity within a given period.

[39] For some consumers, the price they are willing to pay is equal to the market price (that is, the cost of licence/permit). In such instances, there is no consumer surplus. For other consumers, the cost of the licence/permit is seen as a "bargain" and, if they were to be asked, they would be willing to pay a price in excess of the permit costs. This excess represents the consumer surplus and forms part of the true economic value of recreational fishing.

recreational fisheries in these regions as a precursor to establishing what the global NMUV of recreational fisheries might be.

In North America, Brownscombe *et al.* (2014) estimate, on the basis of regular five-year surveys covering 32 000 to 38 557 Canadian recreational fishers, that recreational angling generated annual revenues of about CAD 8.8 billion (CAD 5.6 billion in the form of "related major purchases" and CAD 3.2 billion in the form of direct expenditures) over the period 1975 to 2010. In terms of 2015 prices this would equate to Canadian recreational spending of about USD 9.67 billion.[40]

In the United States of America, estimates of the contribution of freshwater recreational fishing vary sharply. The United States Fish and Wildlife Service (2012) suggested the sector contributed USD 26 billion annually, whereas (UNEP, 2010) cites 1996 data suggesting 35 million people in the United States of America spent USD 38 billion on freshwater angling.[41] The American Sportfishing Association (ASA, 2013) estimated that the 28.7 million freshwater and Great Lakes anglers of the United States of America spent USD 33.6 billion annually in pursuit of this activity, about USD 1 170 per head in 2011 (USD 35.4 billion in 2015 prices).[42]

In South America, few studies are available (see Chapter 8, Box 8-1). Baigún and Delfino (2003) examine pejerrey (*Odontesthes bonariensis*) recreational fisheries in the Pampean lakes of Argentina, and report preferred management operations to deliver better fishing yields an average surplus of USD 208 000 per lake. In the Pantanal, Shrestha, Seidl and Moraes, (2002) use a WTP-TCM methodology to calculate 64 860 trips were made by an estimated 46 000 recreational anglers, generating "social welfare" values of USD 35 million to USD 56.4 million (average USD 45.7 million), whereas 2009 expenditure data provided by Freire *et al.* (2012) suggests inland recreational fishing could generate more than USD 154 million in revenues annually. In the absence of other valuation data, extrapolation was performed based on the findings of both Shrestha *et al.* (based on 46 000 anglers) and Freire (220 000 anglers) to the estimated number of recreational anglers in the region provided by in Chapter 8 of this review (1 700 000 anglers). This would suggest the NMUV of recreational fisheries in South America could be about USD 1 186 million to USD 1 689 million (Freire's figure would be USD 1.31 billion in 2015 prices, whereas Shrestha's figure would be USD 2.7 billion in 2015 prices).

Data on the NMUV of Chinese recreational fishing is both sparse and does not differentiate between inland and coastal recreational fishing. Yang *et al.* (2017), in an article on reforming the country's fishery subsidies, notes that income from recreational fisheries (ranging from the manufacture and sales of tackle, design and building of recreational fishing boats, and the provision of boat charters) amounted to just 3.2 percent of all fishery income in 2015, well behind the equivalent for the United States of America (33 percent). Both Ping (2014) and Yang *et al.* (2017) simply report data from the Ministry of Agriculture (MoA) on the total economic contribution of China's recreational fisheries. Li (2015), in contrast, reproduces recreational fisheries data (both gross output and value added) by province. Separating the 31 provinces into inland and coastal provinces suggests the NMUV of Chinese inland recreational fisheries lies somewhere between CNY 7.8 million (inland provinces only) and CNY 21.1 billion (all provinces) (USD 1.21 billion to USD 3.26 billion, or USD 1.34 billion to USD 3.62 billion in 2015 prices).

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[40] We convert reported values drawn from the various studies cited into 2015 USD values by using the Consumer Price Index (CPI-U) data provided by the United States Department of Labor, Bureau of Labor Statistics (see http://www.usinflationcalculator.com/).

[41] The same document suggests the direct and indirect expenditure of an estimated 25 million European recreational fishers (fresh and marine) could be approximately USD 8 billion in 2010.

[42] The ASA (2013) also report that, through the multiplier effect (monies spent by companies/employees supporting the industry), the inland recreational fishery had a USD 80.6 billion impact upon the national economy.

Table 5-8: The economic value of inland recreational fisheries: selected research to date

Continent/ Region	Country	Locale	Year (data)	Survey site	Method	Paper value[1]	USD equiv. (million)	Authors
Americas	Canada	Canada	2010	Country	Expenditure	CAD 8.8 billion	8 900.9	Brownscombe *et al.* (2014)
	USA	USA	2011	Country	Expenditure	USD 33.6 billion		ASA (2017)
	Argentina	Argentina	1998/99	Pampean lakes	CV – TCM	USD 208 000 (per lake)		Baigún and Delfino (2003)
	Brazil	Brazil	1994 (Aug/Nov)	Pantanal	WTP-TCM	USD 35 to USD 56.4 million		Shrestha, Seidl and Moraes (2002)
			2009	Country	Expenditure	USD 153.5 million[2] + USD 0.5 million		Freire (2012)
Asia	China	China	2011	Country	Not disclosed	CNY 25.6 billion	3 960	Ping (2014)
			2011		Gross output	CNY 21.1 billion	3 260.0	Li (2015)
			2014		Not disclosed	CNY 43 billion		Yang *et al.* (2017)
Europe	Germany	Germany	1998	Country (and Bavaria)	Angling Assoc. survey	(DM 2.4 billion)	1 440.6	Wedekind, Hilga and Steffens (2001)
	Denmark	Nordic	1999	5 countries	Expenditure and WTP	Denmark USD 89 million		Toivonen *et al.* (2004)
	Finland					Finland USD 283 million		
	Iceland					Iceland USD 30 million		
	Norway					Norway USD 299 million		
	Sweden					Sweden USD 387 million		
	UK	UK	2003 (Scotland) 2005	Scotland, England/Wales, Northern Ireland	Expenditure	Scotland GBP 112.6 million	184.2	Winfield (2016)
						England/Wales GBP 1 000 million	1 820.3	

Table 5-8: The economic value of inland recreational fisheries: selected research to date

Continent/ Region	Country	Locale	Year (data)	Survey site	Method	Paper value[1]	USD equiv. (million)	Authors
			(England/ Wales) 2006/7 (Northern Ireland)			NI = GBP 31.9 million	57.9	
Russian Federation	-	-	1996	Country	Not disclosed	RUB 7 791 million	1 521.0	Division of Biological Sciences of the Russian Academy of Sciences
			2008	Moscow region	Not disclosed	RUB 75 billion	3 020	Technology Growth (2009)
				Rest of Federation outside Moscow region		RUB 195 billion	7 850	
Oceania	New Zealand	New Zealand	2014 (Feb)	Otago region	WTP-TCM	NZD 63.7 million to NZD 189 million	96.3	Jiang (2015)
	Australia	Queensland	2002/3	3 major freshwater dams	WTP-TCM	AUD 738 791	0.4	Rolfe and Prayaga (2007)
		Victoria	2013/4	Lake Purrumbete		AUD 411 249 to AUD 1 417 526	0.9	Hunt *et al.* (2017)
		National	2000/1	All Australia	Expenditure	AUD 342 million	188.0	Henry and Lyle (2003)

[1] "Paper value" refers to the value cited in the paper. USD equivalent rates are cited in the following column and are computed using exchange-rates prevailing at the time when the underlying research was undertaken and were taken from http://www.macrotrends.net/ except for Russian Federation data where conversion of USD into RUB was accomplished using data on average official exchange rates from the World Bank (see https://data.worldbank.org/indicator/PA.NUS.FCRF).

[2] Our calculations are based on Freire *et al.* (2012) data on the number of licenced fishers (220 000), trips (3 to 12, average 7), spending per trip (62 percent spent up to BRL 300 per trip) and a USD 1 = BRL 2.04 exchange rate. This understates the true value as the other fishers (38 percent) spent upwards of BRL 300 per trip. Foreign recreational fishers contributed a further USD 0.5 million [estimated].

The data for the inland recreational fishing population in 34 European countries are collated and presented in Chapter 8 (this review), yet data on the NMUV of such activities are only available in the case of seven countries. Wedekind, Hilge and Steffens (2001) report that the annual turnover of German recreational fisheries was about DM 2.4 billion (USD 1.4 billion or USD 2.04 billion in 2015 prices), but fails to provide details on the full provenance of that figure. Winfield (2016) summarizes data drawn from comparable surveys across the constituent parts of the United Kingdom, which highlight the importance of game versus coarse fishing in aggregate expenditures on freshwater angling in Scotland (GBP 107.7 million for game, GBP 4.9 million coarse) and Northern Ireland (GBP 25.7 million and GBP 6.2 million respectively). In the case of England and Wales one million licensed anglers spent an estimated GBP 1 billion on such activities.

Toivonen *et al.* (2004) is the most comprehensive regional study, analysing the economic value of recreational fisheries in the five Nordic countries in 1999. In the study, 25 000 Nordic fisherman (response rate 45.8 percent) were asked to detail their annual fishing expenditures and their actual WTP for their past 12 month's fishing experience. This implied an NMUV of USD 1 277 million for the region[43] with national NMUVs ranging from USD 30 million (Iceland) to USD 387 million (Sweden), with the authors warning that their approach "may result in underestimates" (p. 3). In the absence of other data on the value of European recreational fisheries, the findings of Toivonen *et al.* (2004) were used to produce a continent estimate.[44] First, an NMUV per freshwater angler in each of the five Nordic countries was computed using the data provided in Chapter 8 (Table 8-2), discarding the two extreme figures.[45] The ensuing range was combined (USD 356 to USD 486) and multiplied by the number of European anglers (25 753 500) reported in Chapter 8 of this document to suggest a NMUV of European recreational fishing of approximately USD 9.168 billion to USD 12.516 billion. Finally, as the original NMUV per angler values were based on 1999 Nordic prices, the value was recomputed in terms of 2015 prices (using the methodology outlined in footnote 37). This suggests the 2015 NMUV of European recreational fisheries (excluding the Russian Federation) could range from USD 13.04 billion to USD 17.81 billion.

Perhaps the greatest lacuna relates to the value generated by recreational fishing in the Russian Federation. Although Chapter 8 (Table 8-2) reports that 17.5 percent (25 million) of the Federation's population engage in inland recreational fishing, an extensive search failed to uncover a single peer reviewed article that sought to place a value on this activity. The Basic Research Program of the Division of Biological Sciences of the Russian Academy of Sciences did report that 187 681 licences were sold in 1996 for RUB 7 791 million (USD 1 521 million in 1996, USD 2 298 million in 2015 prices) by the basin departments of fish protection, but this grossly understates the real value of "amateur fishing" (as it is referred to locally) in the Federation. A more recent value provided by (Technology Growth, 2009) estimated the potential market value of recreational fishing in the Moscow region in 2008 was about RUB 75 billion (USD 3.02 billion in 2008[46], USD 3.32 billion in 2015 prices),

[43] Their paper also estimated a non-use value (NUV) of USD 622 million in terms of the value non-fishermen were willing to pay to maintain the current status of fishing stocks and the quality of recreational fisheries in the five countries.

[44] The "true" European NMUV is dependent upon both the species mix (countries with higher levels of "game" or diadromous fish will have higher NMUV than countries where lower-value species such as cyprinids dominate freshwater catches, all other things being equal) and income levels (anglers in higher-income countries will generally evince a higher monetary WTP than those in lower income countries). However, applying a NMUV derived from high-income Nordic countries to lower-income countries in South and East Europe, which are less reliant upon game fish will compensate for the likely Nordic underestimate that Toivonen *et al.* (2004) refers to.

[45] 2.1 million Finnish anglers generate an NMUV of USD 283 million, or USD 134 per angler. Figures for the other countries are USD 332 (Norway), USD 486 (Sweden), USD 356 (Denmark) and USD 8 571 (Iceland). Discarding the two extremes (Finland and Iceland), leaves a range of USD 356 to USD 486.

[46] Conversion of USD into RUB accomplished using data on average official exchange rates from the World Bank (see: https://data.worldbank.org/indicator/PA.NUS.FCRF).

and RUB 195 billion (USD 7.85 billion in 2008, USD 8.64 billion in 2015 prices) in the rest of the Federation.

In the case of Oceania, the two major recreational fishing nations are Australia and New Zealand. In New Zealand, Jiang's (2015) research suggests freshwater recreational angling in Otago generated between USD 51.4 and USD 152.6 million. As Otago contains just 23 percent of the nation's lakes and only two of the country's ten largest rivers (Clutha-Matau and Taieri) (ORC, 2016) it is conjectured that, nationally, freshwater recreational angling in New Zealand could perhaps generate revenues amounting to USD 205.6 to USD 610.4 million (USD 205.8 million to USD 611.1 million in 2015 prices). In Australia, Rolfe and Prayaga (2007) report the WTP for a 20 percent improvement in fishing experience in the three dams surveyed (USD 1 319 270), whereas Hunt *et al.* (2017) found the revenues generated from recreational fishing in Lake Purrumbete (USD 369 496 to USD 1 273 608) were up to sixteen times greater than the cost of stocking the fishery. More useful in terms of estimating the nationwide value of recreational fishing was the study by Henry and Lyle (2003), although it is now somewhat dated. Their research suggested that freshwater fishing, principally for European carp (*Cyprinus carpio*), redfin (*Perca Fluviatilis*), golden perch (*Macquaria ambigua*) and trout/salmon, accounted for 19 percent of fishing effort (about 3.9 million fisher days) in 2000/1, and led to annual Australian spending of about USD 189 million (USD 256.4 million in 2015 prices) on freshwater fishing related items.

Although these simple calculations are fraught with assumptions as indicated previously in this chapter, it is estimated that the NMUV of inland recreational fishing in 2015 is in the range of USD 64.55 billion to USD 78.74 billion (Table 5-9).[47] This value is comparable to the MUV of inland aquaculture, but a value that comfortably exceeds the MUV (inclusive of diadromous and hidden catches) of the world's inland capture fisheries. Moreover, our recreational fishing estimates exclude consideration of Africa and most of Asia (China excepted), because of the lack of studies on recreational fisheries in these regions (Cooke and Cowx, 2014). Unlike in inland capture fisheries, North America is the leading region, accounting for about half the estimated value of global recreational fisheries.

Table 5-9: Estimated NMUV of the world's inland recreational fisheries (2015)

Region	Subregions	NMUV (USD billion)
North America	*Canada*	9.67
	United States of America	35.4
South America	*South America*	1.31 to 2.7
Asia	*China*	1.34 to 3.62
Europe	*Russian Federation*	3.32 to 8.64
Europe	*Rest of*	13.04 to 17.81
Oceania	*Australia*	0.26
	New Zealand	0.21 to 0.61
Total world		**64.55** to **78.74**

[47] This is similar (USD 70 billion) to the annual estimated contribution of recreational fisheries to GDP (assuming value-added to be about 40 percent) published by the World Bank (2010). Although the source of the VA and multipliers used to derive the estimates in that publication are not referenced.

5.9 CONCLUSION AND RECOMMENDATIONS

Inland fisheries are clearly important and possess considerable value, whether as a source of employment and food to millions of people across Africa, Asia and Latin America, or as a source of recreation and relaxation to anglers in Europe, North America and Australia (UNEP, 2010). Nevertheless, seeking to place an economic value on the fisheries wealth captured and extracted from inland waterbodies (whether for commercial, subsistence or recreational purposes) is extremely challenging.[48]

World Bank (2010) highlights the deficiencies in official records relating to the number of small-scale fishers, and the existence of multiple landing points along lake, river or reservoir sides militates against obtaining accurate details of the totality of their catches (Section 10.1). Moreover, placing a precise value on such catches is impossible as prices can fluctuate sharply in both spatial and temporal terms as acknowledged earlier within this chapter. Apart from this, is the value of nutrition and food security that these fisheries provide in countries where there are limited alternatives.

The "value" of inland fisheries extends beyond pure capture fisheries too, as an estimated 174 million people engage in recreational fishing across the globe. Here too, in seeking to valorize such fisheries there arises the problem of identifying the number of recreational anglers, as well as how to capture the NMUV (the pleasure derived from undertaking the activity, above and beyond the monies spent on the pursuit – the "consumer surplus") of such fishing.

There is also a danger that by focusing solely on the valorization of inland capture fisheries, the importance of such waters and fisheries to the generation of value in associated ecosystems or production systems is downplayed. First, as Section 5.5 has noted, whereas diadromous fish spend part of their life cycle in both marine and inland freshwater environs, our analysis only attaches values to those caught in inland waters. Diadromous fish captured in marine waters (such as the global salmon and hilsa catches from marine waters) are accorded zero value in this analysis, even though inland waters have played a critical part in their development. Second, as Youn *et al.* (2014) highlight, the distinction between capture and culture production is not absolute: in some instances open-access waterbodies are stocked with hatchery-reared stock (this is so in many Asian culture-based fisheries, and in the case of chum salmon in Japan), whereas in other instances species are captured early in their life-history in open-access waters and then raised in captivity (Miah, Bari and Rahman (2010), for example, estimate there are more than 450 000 shrimp larvae collectors in the brackishwater Sundarbans estuary in Bangladesh who then sell their produce to shrimp farms in the region). Although the analysis and discussion concentrates on inland capture production, inland aquaculture production data are also reported as this allows comparison with capture production, and aggregation – so as to enable an estimate of the TUV (capture and culture) of all fisheries extraction activities undertaken in inland waters. Third, as noted in Section 2, although inland freshwater resources and, specifically in the context of this research, the fisheries therein may also possess non-use values (in the form of existence, option and bequest values), our analysis is limited to the valorization of use values. Given these (large) caveats, and taking on board other qualifications as highlighted in the preceding subsections, it is possible offer tentative estimates as to what might be the TUV of inland capture and freshwater culture fisheries (Table 5-10).

Prior to commenting upon these results and given the various caveats and assumptions made (as noted in each the corresponding subsections of the chapter, it must be restated that the figures presented can offer no more than an approximation as to what might be the total use value (2015) of the world's inland fisheries. Some caution should therefore be taken in interpreting and utilizing these findings, and this analysis would certainly benefit from updated figures.

[48] Value is estimated by reference to economic (based on the quantities of fish extracted) rather than biological (the size and composition of the underlying fisheries biota/biomass) yardsticks.

Table 5-10: The total use value (TUV) of the world's inland fisheries (2015), USD billion

Inland capture fisheries	Africa	Americas	Asia	Europe	Oceania	Total
Inland	5.78	1.59	16.19	0.4	0.04	24.00
Diadromous	Negligible	0.02	1.02	0.99	Negligible	2.03
Molluscs and crustaceans	-	-	5.0	-	-	5.0
Recreational	-	46.38 to 47.77	1.34 to 3.62	16.36 to 26.46	0.47 to 0.89	64.55 to 78.74
"Hidden" harvest	*2.73*	*0.76*	*8.60*	*0.32*	*0.02*	*12.43*
Total inland capture	*8.51*	*48.75 to 50.14*	*32.15 to 33.8*	*18.07 to 28.17*	*0.53 to 0.95*	*108.01 to 122.20*

FW aquaculture	Africa	Americas	Asia	Europe	Oceania	Total
Freshwater spp.	1.7	2.2	56.8	0.6	0.02	61.32
Diadromous spp.	0.02	0.66	2.87	1.0	Negligible	4.57
Molluscs/crustaceans	0.02	-	3.4	-	-	3.4
Brackishwater spp.	1.1	-	0.4	-	-	1.5
Total aquaculture	*2.84*	*2.86*	*63.47*	*1.6*	*0.02*	*70.79*
GRAND TOTAL	**11.35**	**51.61** to **53.0**	**95.62** to **97.90**	**19.67** to **29.77**	**0.55** to **0.97**	**178.8** to **192.99**

The MUV of inland freshwater fisheries catches (as reported to FAO) is estimated as being about USD 26 billion, with the major contributions coming from Asia (66.1 percent) and Africa (22.2 percent). Acknowledging, as past research has done (most notably World Bank, 2010), that a significant proportion of the inland catch goes unreported and that this proportion is likely to have reduced over the past few years, gives an upwards revision of the estimate of the total use value of inland freshwater fisheries to USD 38.53 billion. This is further increased to USD 43.53 billion, if the value of freshwater molluscs and crustaceans is added in.

The value of capture fisheries is somewhat dwarfed by the use values generated by recreational fishing. The 2015 NMUV of recreational fishing is estimated to lie somewhere in the range of USD 64.55 billion to USD 78.55 billion, with the United States of America/Canada accounting for almost 72 percent of this value. Moreover, this is almost certainly an understatement of the NMUV of this market given there is either no (in the case of Africa) or little (in the case of Asia and Latin America) data available on the burgeoning recreational fishing activity outside Europe and North America.

Aggregating these values (NMUV of inland recreational fisheries and the MUV of inland capture fisheries) suggests the sector is worth an annual estimated USD 108 billion to USD 122 billion. Even if the costs of capture (VAR) were deducted, the GVA is approximately USD 90 to USD 100 billion. To put this in context: the total value of the global seafood trade, which includes both capture fishery and aquaculture products in 2016 was USD 141.6 billion (FAO, 2017c).

This study has sought to place a value on the economic wealth of the world's inland fisheries. Although it might be useful to complete an annual (inland) fisheries wealth assessment, it is more imperative to view the current analysis as a stepping stone to offer greater insights into the **economic impact** of these fisheries on the global plane. Pertinent avenues of research are described below.

Inland capture fisheries

The *Hidden harvest* report (World Bank, 2010) played an important role in raising awareness of the importance of small-scale fisheries from a social and economic perspective, most notably indicating that small-scale inland fisheries provided employment for over half (60 million) of those employed in fisheries in the developing world. Yet this importance was not reflected in either the analysis or the ensuing policy recommendations. There is thus a strong case to extend the *Hidden harvest* study, but this time ensuring a greater focus is given to the particular specifics of small-scale inland capture fisheries (more so given that one-quarter of the world's LIFDCs are landlocked.

This study has only focused on the extraction of fish resources from inland waterbodies. It has not addressed the myriad of value-chain activities (processing and distribution) that deliver a final fish product to the consumer. If De Graaf and Garibaldi (2014) are correct, and the post-harvest sector accounts for about 25.3 percent of total value,[49] then at the global scale the post-harvest subsector could be contributing more than USD 8 billion in value-added terms. Deeper investigation of such inland value-chains is therefore essential if more effective policy interventions designed to enhance food security, raise nutritional intakes and provide more stable employment are to be introduced.

In other work (see Thorpe *et al.*, 2014) the gendered nature of fisheries production within the developing world has been highlighted. Specific research into the gendered nature of inland fisheries is relatively sparse, and merits redress if policy interventions are to be gender-sensitive.

Inland capture/culture fisheries

This review has applied VAR (however imperfect) to estimate the GVA of inland capture fisheries. There is a need to examine further the reliability of such capture VARS (through case studies) and to establish a series of VARs which approximate to the costs of inland culture production across the different regions.

As Youn *et al.* (2014) note, the distinction between capture and culture production can be blurred, more so when the captured/cultured fish has left the water and entered the onshore value chain. More research is also required into the value and volume of the international trade in inland (capture + culture) fish and inland fish products, as such trade can have profound impacts upon national food security aspirations and household consumption (Fluet-Chouinard, Funge-Smith and McIntyre, 2018).

Inland recreational fisheries

The socio-economic importance of recreational fisheries and the values generated through such activities (North America apart) is poorly understood and infrequently articulated in the literature. As Cooke and Cowx (2004) noted over a decade ago, there is a pressing need for FAO to regularly report on recreational angling participation and harvest rates, particularly for developing countries. As this chapter shows, there is almost a complete absence of material on Africa or Asia (China excepted), and to commission regular reports on key aspects of this more than USD 60 billion global activity is highly desirable.

The biggest lacuna in the valuation of recreational fishing relates to such activities in the Russian Federation, where over 25 million engage in recreational angling (much of which, almost certainly, is to supplement household diets and income). Insights into Russian recreational fishing and fishers would be a welcome addition to the literature.

Finally, the emergence of the Sustainable Development Goals (SDG) on the international development agenda offer both an opportunity and a threat to inland fisheries (capture, culture, and recreational) and fishers. An opportunity in the sense that the SDGs provide an extensive framework through which the contribution of inland fisheries to reducing poverty, ameliorating hunger, creating/ensuring decent work, reducing inequality, promoting responsible consumption and production, and preserving terrestrial ecosystems can be both highlighted and advanced. They are also a potential threat, in the sense that other stakeholders (industry, service sectors such as tourism etc.) can equally invoke the SDGs to advance their own agendas. Swift action is therefore required, in the rapidly changing context

[49] Kebe (2008) suggests the percentage could be even higher, possibly 30 to 40 percent.

of the twenty-first century, to map – and articulate – the multiple benefits that protecting and sustainably developing inland fisheries offers to the global community.

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6 CONTRIBUTION OF INLAND FISHERIES TO EMPLOYMENT

Simon Funge-Smith, Jennifer Gee, Fiona Simmance and Felix Marttin

SUMMARY

Inland capture fisheries employ millions of rural people. There are between16.8 million and 20.7 million people employed in inland capture fisheries. Another 8 million to 38 million are employed in the post-harvest sector. This represents about 2.5 percent to 6 percent of the global agricultural workforce. Women represent more than 50 percent of the workforce in inland fisheries.

Inland fisheries are predominantly small-scale fisheries with limited commercial large-scale fisheries. Inland fisheries are generally less dangerous than marine capture fisheries but, because of the poverty of small-scale inland fishers, there are still problems with child labour and unsafe working conditions in some inland fisheries.

6.1 WORK IN INLAND FISHERIES

Inland capture fisheries provide a wide range of jobs for people. Jobs in the sector and associated value chains range from the production and sale of inputs (including fishing gear, boat construction and maintenance, and bait), the actual catching of fish, fish processing, to marketing and distribution. Catching of fish takes place on lakes, rivers, floodplains and reservoirs, using different fishing techniques, ranging from simple hand-held gear or collecting by hand aquatic fishery products to larger, organized operations such as the *dai* barrage fisheries in Cambodia or *sábalo* fisheries in the Amazon River in Brazil. Post-harvest activities, such as fish marketing and distribution can take fishworkers far from the original fish harvesting point.

Inland capture fisheries can be carried out for subsistence, as part of diversified livelihood strategies, in more specialized commercial enterprises operated by small households, or in larger integrated multinational companies serving mainly export markets. Although operational scale is contextual and a small-scale operation in one country may be considered a medium-scale operation in another, some common features are possible to establish. Small-scale fisheries are generally characterized by low capital input activities, low capital investments and equipment, and labour-intensive operations.

Most inland fisheries operations are considered small scale and important for employment in developing countries, especially as they usually take place in rural areas. Inland fishery operations are rarely mechanized or industrialized. Commercial inland fisheries do exist (see Section 1.5) and these operations employ labour in both harvesting and processing.

6.2 INLAND FISHERY EMPLOYMENT

Inland capture fisheries are important as a source of direct employment and income to an estimated range of 16.8 million to 20.7 million people globally, particularly in developing countries (HLPE, 2014; FAO, 2014; World Bank, 2012).

The majority of inland fisheries are small scale in nature and this is an important determinant of the number of people employed and income generated. Small-scale fisheries create employment several times greater than large-scale fishing as the lower levels of mechanization of the fishing operations typically require greater levels of human input. Thus, inland capture fisheries make important contributions globally to livelihood security (IFAD, 2011; Welcomme 2011; HLPE, 2014). It has also been estimated that potentially more than twice as many (39 million) are involved along the supply chain, including women who are predominately engaged in secondary activities (Table 6-1, World Bank, 2012).

Table 6-1: Estimates of employment in inland capture fisheries and associated post-harvest activities

Inland fishery employment in developing countries	**Small-scale**	**Large-scale**	**Total**
Number of fishers (millions)	18	1	19
Post-harvest (millions)	38	0.5	39
Total workforce (millions)	56	2	58
Women in workforce (%)	54	28	53
Inland fishery employment in developed countries	**Small-scale**	**Large-scale**	**Total**
Number of fishers	98 000	2 000	100 000
Post-harvest employment	206 000	1 000	207 000
Total	304 000	3 000	307 000
Women in workforce (%)	44	29	44

Source: World Bank, 2012

Developing countries provide 95 percent of the world's inland fishery catch (FishStatJ) and this catch provides critical livelihood contributions to the fishers. There are about 150 countries globally that report some level of inland fishing to FAO, but fewer countries that report inland fishery employment data to FAO. Based on national reporting to FAO and some case study estimates (DeGraaf and Garibaldi, 2014; World Bank, 2012), the global number of inland fishers is estimated at 16.8 million people with a further 8.3 million employed in the post-harvest sector (Table 6-2). The details by country are provided in Annex 6. The reported number of inland fisheries is in line with the figure estimated in the World Bank (2012) study.

Table 6-2: Regional reported data* for inland fishers and sector-disaggregated data

Region	**Inland fishers**	**Post-harvest**	**Percentage of global total inland fishers**
Southeast Asia	9 871 379	1 303 853	58.5
South Asia	2 820 694	4 424 796	16.7
Africa	2 739 975	2 122 840	16.2
China	755 622	475 000	4.5
South America	**411 877	n.a.	2.4
Central America	***107 447	n.a.	0.6
East Asia	84 723	n.a.	0.5
Europe	35 962	n.a.	0.2
Central Asia	24 858	n.a.	0.1
West Asia	9 403	n.a.	0.1
North America	5 000	n.a.	0.0
Oceania	342	n.a.	0.0
Russian Federation	n.a.	n.a.	n.a.
Total	**16 867 282**	**8 326 489**	**100**

* Based on country employment table in Annex 6

**Estimate by COPESCAALC (2018): 1 087 643 inland fishers

***Estimate by COPESCAALC (2018) (including Mexico): 52 969 inland fishers

n.a. Not available

However, as FAO does not collect national statistics on post-harvest employment the reported figure for post-harvest employment is considerably lower than the 39 million estimate of the World Bank, (2012) (Table 6-1, Figure 6-1).

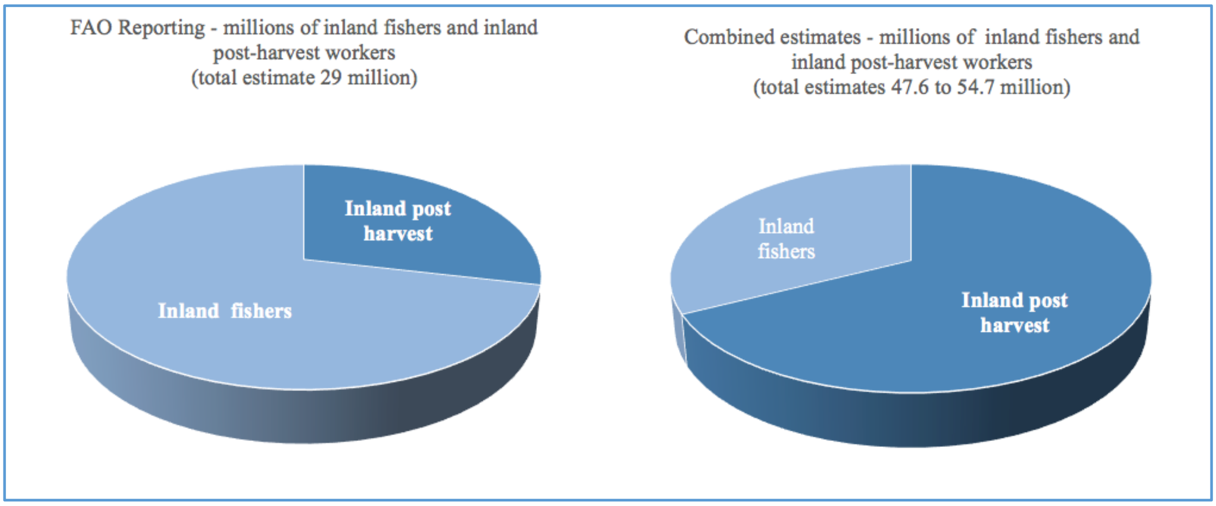

Figure 6-1: Summary of estimated global employment in inland fisheries (millions) comparing official national reporting to FAO with combined national estimates and project data.

From 1996 to 2014 there has been a general increase in the number of countries reporting on inland fisheries engagement and an increase in the number of people reported. Comparing the five-year averages, from the start of the period, with the average from 2009 to 2014, there was nearly a ten-fold increase in the people engaged in the sector. This increase is both a reflection of increased reporting, both within countries and by countries, but would also seem to reflect an increasing trend of engagement in the sector.

Estimates of global employment in the sector vary because of differences in the scope of the enumeration of engagement. This ranges from engagement in only the primary sector to also include processors, traders and other activities along the fish supply chain. This is further complicated by the fishers' variable time engagement in the sector, from occasional, seasonal to full-time fishing (FAO, 2014), and from an hour or so pulling traps in a rice-field canal, to whole days spent on the water. These varying degrees of engagement may challenge national statistical systems to account for participation in inland fisheries accurately, especially if only full-time fishers are recorded.

The national reports of fishery employment provided to FAO are generally assumed to account for employment, where fisheries are a significant household economic activity. About 60 percent of all reporting countries provide a breakdown between the degrees of time engagement but the others do not. Of these reporting countries, just under half only report on full-time engagement whereas the remainder report only as unspecified. Clearly, this indicates that in some cases, national reports exclude inland fishing where it is conducted as an occasional activity or an activity with limited economic impact on the household.

A total of 60 million has been estimated as employed in fisheries value chains (for both marine and inland fisheries). Of this total, over half are engaged in small-scale inland fisheries (World Bank, 2012).

Where data exists on the post-harvest sector the average employment ratio is 1 fisher to 1.8 post-harvest processors (+/- 4.3) (Table 6-3), which would indicate that employment in the post-harvest sector could range between 30.8 million and 37.9 million people, which is more in line with the World Bank (2012) estimate (Table 6-1) than the reported figures (Table 6-2 and Annex 6).

Table 6-3: Ratio of post-harvest jobs to inland fishers

Ratio of Post-harvest jobs to fisher job	Countries
1:20	Nigeria, India, South Sudan, Cote D'Ivoire, Tanzania (United Republic of), Democratic Republic of Congo, Cambodia
0.1:1	Malawi, Mozambique, Burundi, Togo, Congo, Senegal, Ghana, Benin, China, Indonesia, Guinea, Kenya,
0.05:0.1	Madagascar, Gambia, Egypt, Burkina Faso

Source: DeGraaf and Garibaldi, 2014; World Bank, 2012

Based on the known weaknesses in recording employment accurately in small-scale and artisanal fisheries, it can be concluded that the global figure of 32.3 million inland fishers is a low estimate of the total number of people engaged in inland fishing, but it may be a fair reflection of those who are engaged in inland fishing full time.

The underestimates particularly lie in the categories of occasional engagement and of work in the post-harvest sector. Drawing on data from case studies (for example, World Bank, 2012; DeGraaf and Garibaldi, 2014), the indication is that associated post-harvest and marketing activities of inland fisheries are typically at least equal to the number of primary engagement jobs. The underestimates particularly lie in two categories: occasional engagement in the primary sector and work in the post-harvest sector. Drawing on data from case studies (for example, World Bank, 2012; DeGraaf and Garibaldi, 2014), it appears that the number of people engaged in associated post-harvest and marketing activities of inland fisheries are at least equal to the number of people engaged full time in the primary sector.

6.3 DECENT WORK IN INLAND FISHERIES

Decent work is "productive work for women and men in conditions of freedom, equity, security and human dignity". It is productive work that delivers a fair income, security in the workplace, social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, and to organize and participate in the decisions that affect their lives, and equality of opportunity and treatment for all women and men. Decent work is a universal and indivisible objective, based on fundamental values and principles. Decent work applies to all workers, whether or not they are working with a formal contract with an employer, or self-employed.

The International Labour Organization has developed a balanced and integrated programmatic approach to achieve decent work – the "Decent Work Agenda" – consisting of four pillars: (1) employment creation and enterprise development; (2) social protection; (3) standards and rights at work; and (4) governance and social dialogue.

There are six priority characteristics that must be demonstrated for work to be considered decent:

1. The core labour standards, as defined in ILO conventions, are respected (i.e. there is no child labour, no forced labour, freedom of association, no discrimination).
2. An adequate income is provided.
3. The work entails an adequate degree of employment security and stability.
4. Minimum occupational safety and health measures are adopted.
5. Excessive working hours avoided and sufficient time for rest is allowed.
6. Access to technical and vocational training is promoted.

This concept of decent work is challenging to achieve in inland fisheries, because the inland fisheries sector is typically characterized as mainly small scale, informal, rural, consisting of many family-based operations. These families are often poor, lack alternative employment opportunities and conduct their activities in rural or remote areas. Working conditions in the sector are not specifically regulated and most inland fishers would be considered as self-employed. In some cases, children are also involved in fishing operations, including processing and marketing, as part of family-based operations. There are also instances where children are used as labour outside of family-based operations.

Fishers and fish workers might not be aware of their rights to decent work, or are more pre-occupied with catching something to eat instead of ensuring that decent work standards are applied. Since inland fishing is rarely organized and not typically subject to any formal oversight, regulations or standards, there are situations where inland fishing activities may result in conditions of health and safety that are deleterious to fishers, both adults and children.

The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the context of food security and poverty eradication (FAO SSF-Guidelines) indicate the need for states to:

> *Promote decent work for all small-scale fisheries workers, including both the formal and informal sectors. States should create the appropriate conditions to ensure that fisheries activities in both the formal and informal sectors are taken into account in order to ensure the sustainability of small-scale fisheries in accordance with national law. (Article 6.6, FAO SSF-Guidelines)*

Since inland fisheries are largely small-scale, family-based operations, there is relatively little formal organization of the sector. This also means that global statistics on decent work (and decent work deficiencies) in the inland fisheries sector are scarce or non-existent.

6.3.1 OCCUPATIONAL HEALTH AND SAFETY

The inland capture fisheries subsector is often considered less dangerous than the marine subsector, as it is undertaken in shallower waters and closer to shore. Also, usually the gears used are smaller and mechanization is less in the inland subsector than in the marine subsector. However, there are instances where inland capture fisheries take place in large waterbodies, at great distances from shore, with mechanized, complicated gears. It would therefore be incorrect to classify the inland capture fishery subsector as inherently less hazardous or safer than the marine capture fishery subsector.

A few examples of hazards related to tasks in inland capture fisheries:

- Use of fishing vessels (typically small boats/canoes) which are not safe (unseaworthy)
  - on large reservoirs, large lakes/great lakes, lagoons and in fast flowing rivers
  - rapid changes in the weather (storms) on large waterbodies can exacerbate the unsafe state of the boat/canoe.
- During the rainy season fishers might experience unexpected/unpredictable water flows, in some cases linked to sudden unexpected dam discharges.
- Platforms/structures in rivers/lakes that are being used for fishing might collapse during operations.
- When working in man-made reservoirs (e.g. Lake Volta or Lake Kariba), sometimes nets might get entangled in trees that were not removed before the reservoir filled up. To untangle these nets, people (sometimes children) must dive and untangle the nets. Sometimes these people get entangled into the net and drown.
- Sometimes people (including children) need to dive into the water to scare fish into nets. This might result in hypoxia, entanglement into the net (resulting in drowning).
- There are documented cases of fatalities because of hypothermia in ice-fishing activities in arctic regions.

6.3.2 CHILD LABOUR

Child labour is defined as work of children who are too young for the type of work they do, work that interferes with their schooling and, as applies to all children under 18 years of age, work that risks harming their health, safety or morals. Not all activities children engage in are child labour. Some activities may stimulate their development as they allow them to acquire precious skills and contribute to their own and their family's survival and food security. These activities can be beneficial as long as they are not hazardous, not undertaken for long hours and do not interfere with school and learning (FAO-ILO, 2013).

Child labour is widespread in many parts of the sector given that fishers and fishing/aquaculture communities are often poor and vulnerable, and they have limited access to resources, credit and loans, productive services and markets, and often lack access to social protection, institutional support, and education. Therefore, families, fishers and communities are dependent on the labour of children in order to sustain themselves. Child labour often inhibits children from attending or completing compulsory education and can involve hazardous work that is detrimental to their social and physical development. Such child labour harms children's well-being and the potential of the subsector to generate long-term benefits. Gender roles and division of labour in fisheries and aquaculture activities tend to reflect those of adults, with boys generally being more involved in fishing and girls in aquaculture and post-harvest activities.

One reason for the use of child labour is that this cheap labour reduces operational costs. As such this is effectively a hidden subsidization of fishing through use of child labour (which may also be forced labour in some circumstances). Working with stakeholders from the fisheries and aquaculture sector (including retailers, producer organizations, governments, producer organizations, and businesses) is vital to reduce and prevent child labour in fisheries and aquaculture.

The international legal framework to address child labour, based on the Minimum Age Convention 1973 (No. 138) and the Worst Forms of Child Labour Convention 1999 (No. 182), is still not adequately applied and enforced in many contexts and child labour remains prevalent, especially among informal, small-scale informal fisheries and aquaculture enterprises. The relevant international instruments regarding child labour are summarized in Box 6-1.

Box 6-1: Legislation and international guidance concerning child labour

UNGA Convention on the Rights of the Child (CRC) protects children's rights. It abolishes child labour stating "the right of the child to be protected from economic exploitation and from performing any work that is likely to be hazardous or to interfere with the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral or social development" (Article 32).

ILO Convention 138 Minimum Age permits light work to be undertaken during the ages of 12 to 15, and sets the minimum age of employment at 14 or 15 years.

ILO Convention 182 Worst Forms of Child Labour prohibits slavery, illicit activities, and hazardous work to be undertaken by any child under the age of 18. Hazardous work is work mentally, physically, spiritually, socially, or morally harmful for a child.

ILO Work in Fishing Convention 188 stipulates age limits for work on board fishing vessels (art.9) and ILO recommendation 199 Work in Fishing provides non-binding guidance on its implementation. The convention is also implemented through flag state and port state inspection.

FAO Code of Conduct for Responsible Fisheries covers safety and health standards and adherence to international law on child labour.

FAO Technical Guidelines on Aquaculture Certification guides the development, organization and implementation of credible aquaculture certification schemes.

FAO Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Reduction (SSF Guidelines) urges states to eradicate forced child labour and small-scale fisheries actors to recognize children's well-being and education and to respect the CRC.

Despite the almost universal ratification of child labour conventions (Minimum Age Convention, 1973 [No. 138], and Worst Forms of Child Labour Convention, 1999 [No. 182]), their incorporation into national legislation often does not explicitly take into account fisheries and aquaculture in terms of regulation, implementation and enforcement. For example, hazardous work lists (the main regulatory instrument to identify and protect children from hazardous work, in accordance with the Worst Forms of Child Labour Convention) often do not include a sufficient level of detail for hazardous activities in fishing, aquaculture or fish processing; when they do, it is often in the context of export-oriented value chains. Limited capacity on fisheries and aquaculture issues of the ministry of labour, and on child labour issues in fisheries and aquaculture departments, further hinders addressing child labour effectively.

Below are four examples of child labour in inland capture fisheries (FAO-ILO, 2013):

On Lake Volta in Ghana, there are reported cases of children being traded as commodities for monetary benefits (Afenyadu, 2010; ILO-IPEC, 2013). They are trafficked through middlemen to distant destinations, unknown to both parents, to work in fisheries, for example, taken from their home villages to catch kapenta (*Limnothrissa* spp.) in Lake Volta. The depletion of fishery resources in the lake is ostensibly the reason attributed to this "hiring" of children as workers, as they are a source of cheap labour. Their smaller fingers are believed to enable them to remove kapenta more efficiently from small-meshed gillnets, and they often have to dive to release entangled gillnets from tree stumps on the shallow lake bottom. In the process, they are exposed to a high rate of parasitism (for example, bilharzias and guinea worm) and are also at risk of drowning. Night fishing with children leads to high rates of school dropouts (ILO-IPEC, 2013).

On Lake Chilwa, young boys work as *bila* boys to guide and disentangle the seine nets when they are pulled in. This is a dangerous task, because they must be in the water for a prolonged period of time and dive to unsafe depths (Nyasa Times, 2013).

On Lake Malawi, young boys are sometimes used for bailing water out of the small fishing boats operating on the lake. These *chimgubidi* ("water pumps") have to work throughout the fishing trip, often all night, and are not allowed to fall asleep or get seasick. If they fail on any of these counts, they receive only half pay, and if they get seasick, they have to drink lake water (to "treat the sickness") (FAO-ILO, 2011).

In the Ugandan fishing sector (Lake Victoria), children working on the fish landing sites were considered to be child labour, owing to the nature of work they do according to their age or, the circumstances under which work was done. Of all children taking part in the study, 94 percent were in child labour. The proportion of those affected increased with age, and was highest among 15 to 17 year olds (95 percent). More boys (95 percent) were affected than girls (88 percent). The proportion of children in hazardous work was 71 percent. (Walakira and Byamugisha, 2008; Walakira, 2010).

Sixty-three percent of children residing in Myanmar villages where inland fisheries are a main source of income participate in economic activities related to fisheries. In a study area (Labutta township, Ayeyarwady region), children start working in fisheries as early as age five and up through teenage years and into adulthood. Child workers carry out a variety of activities, many causing direct risk of harm including drowning, wounding from fishing equipment and exposure to disease-carrying mosquitoes. Sixteen percent of the child respondents at the village-level had not attended school in the year prior to the survey. Most children work for parents or relatives and do so regularly for more than three hours per day (ILO, 2016).

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7 GENDER DIMENSIONS OF INLAND FISHERIES

Fiona Simmance, Simon Funge-Smith and Jennifer Gee

SUMMARY

Women's engagement in inland fisheries is often invisible although they play a significant role in many fisheries. Women are often narrowly associated with post-harvest processing and marketing activity, but they also engage in fishing.

In 61 countries that report disaggregated data and where women a recognized as fishers, the ratio is 1 fisherwoman to every 7.3 fisherman. Here are 44 countries which report that women do not engage in fishing.

Women's access to income from fish processing and marketing may have a stronger and more beneficial impact on household incomes than income from fishing by men. Despite their dependence upon the fishery, this may be poorly reflected in fishery management decision-making processes. Vulnerable women engaged in post-harvest marketing of fish may be dependent upon male fishers for access to fish, relying on transactional sex for preferential supply of fish.

7.1 WOMEN'S ENGAGEMENT IN INLAND FISHERIES

Women represent over half of the people engaged in global inland fisheries, however their role in the fishery has largely been invisible and unrecognized (HLPE, 2014; Bartley *et al.*, 2015). Fishing activities have been narrowly defined as those that men particularly engage in – in other words, boat-based fishing activities. The types of fishing activities in which women more typically engage in such as fishing, collecting and foraging in waterbodies and along shorelines have been overlooked in the definitions applied for surveys. Biases in sampling methods and research, such as a focus on fishing when it is the primary economic activity, have often led to studies focusing on fishermen. These biases have led to significant gaps in understanding the involvement of women, as well as the involvement of both men and women along the supply chain in small-scale fisheries (Kleiber *et al.*, 2015). Recent studies are making the role of women in inland fisheries more visible via adopting a gender approach to fisheries (Williams, 2008; FAO, 2015). Thus, a gender-neutral term of "fisher" is more appropriate for the sector (Branch and Kleiber, 2015).

Assessments provided to FAO report that women accounted for more than 19 percent of all people directly engaged in the fisheries primary sector in 2014, and that the proportion of women engaged in fishing activity exceeds 20 percent in inland fisheries (FAO, 2016).

The division of labour within the sector is often gendered, with men predominately involved in fishing and women largely participating in pre-harvest and post-harvest activities. These gendered roles are shaped by gender norms, traditions and cultures, for example fishing frequently is deemed to be too dangerous and physically demanding for women, or trading in distant markets too risky for young women (Deb *et al.*, 2015; Béné *et al.*, 2016) or the other roles and responsibilities of women constrain their ability to spend extended periods away from the home to engage in fishing trips. Even in cases where women are directly engaged in fishing they may not self-identify as fishers (FAO, 2016).

The participation of women in inland fishing covers the spectrum of fishing activities from foraging and gleaning, to fishing from shore or on boats and beyond into the management, preparation and repair of fishing gear and provisioning of financing. Globally, women are also highly involved in the post-harvest elements of the fish trade including trading and marketing of inland fish products (FAO, 2015; Montfort 2015). Women also engage in wider activities and their practices can be distinct from those of men (Weeratunge *et al.*, 2010). Women have been found to assist in mending fishing gears, collect fish bait, financially support fishing family members, act as gear owners who employ fishermen, and actively participate in fishing near shore (Williams, 2001; FAO, 2015; Deb *et al.*, 2015; Ngwenya *et al.*, 2012).

Women engage in distinct fishing practices that are often in shallow water, close to home and use inexpensive gears that catch small fish species for subsistence consumption and income. For example, women occasionally fish in shallow water with baskets in the Okavango Delta in Botswana (Box 7-1), and have been widely reported to fish close to home in floodplain and upland fisheries in Zambia, Bangladesh, Cambodia's Tonle Sap, and the Peruvian Amazon (Ngwenya *et al.*, 2012; Rajaratnam *et al.*, 2016; FAO, 2015; Murray, 2006).

Box 7-1: Women basket fishers in the Okavango Delta, Botswana

In the Okavango Delta in Botswana, East Africa, women comprise approximately 44 percent of fishers engaged in the small-scale inland fishery sector. The ecosystem is a highly dynamic pulsed system, where communities adapt their livelihood strategies to optimize utilization of the resources. In some villages, women actively engage in fishing using baskets to fish two to three days per week. These women basket fishers harvest small fish species for subsistence consumption and income. Fishing activities supplement their primary livelihood activity of agriculture, and women have excellent knowledge of the local ecology and resource dynamics. However, despite the role of women in the primary sector of the fishery and their excellent knowledge of the local ecology, women are often excluded from fisheries management and decision-making processes and are marginalized. A gendered approach to fisheries governance is required along with the inclusion of women's untapped source of local ecological knowledge for a more complete understanding of ecosystem dynamics.

Source: Ngwenya *et al.*, 2012.

There is a tendency to assume that all women's fishing activities are rather unspecialized and confined to the use of simple collection equipment such as knives, small traps, nets or traps, baskets or bags and simple lighting gear if activities are conducted at night. However, there are also examples where women are also actively engaged in fishing from small boats in lakes and rivers. This is conducted either in support of family fishing activity or independently, this diversity is illustrated in Table 7-1.

Table 7-1: Examples of women as fishers around the world

Region	Country	Women's fishing activity	Reference
Southeast Asia	Cambodia	Some women participate directly in fishing activities with their family members in lakes, rivers and streams. Fish selling is almost exclusively the domain of women. However, despite their pervasive involvement, women's invaluable contribution is often overlooked and undocumented	Siason *et al*. (2010)
		Tonle Sap	
	Thailand	Women fish or collect fish on lakes using their own boats	World Bank (2012)
	Lao PDR	Women repair nets and catch fish. Lao women process the fish for preservation, eating and for selling at the markets.	Siason *et al*. (2010)
		Women highly involved in the collection of aquatic animals (ricefields and wetlands)	Meusch *et al.* (2003)
China	Yunnan	Women fish individually or assist men in fishing in Yunnan, China	Yu Xiaogang (2001)

Table 7-1: Examples of women as fishers around the world

Region	Country	Women's fishing activity	Reference
South Asia	India	Hand collection, trapping and scoop gears are used by tribal and scheduled caste women in the wetlands (*beels*) and small waterbodies of Assam.	Baruah (2015)
	Nepal	Women of certain communities, e.g. Tharu, Majhi, Mukhiya and others, follow the traditional practice of catching fish with traditional gears in ditches, swamps, canals and paddy fields in small or large groups	Siason *et al*. (2010)
	Bangladesh	Tribal women around the Kapati reservoir were involved in fish harvesting, marketing, drying and post-harvest activities such as carrying fish from the pontoon to land, sorting, icing, packing and loading the transport vehicle	Ahmed, Rahman and Chowdhury, (cited in Suntornratana and Visser, 2003)
		Women are engaged in boat fisheries for hilsa in the Meghna River delta	Naznin (2016)
South America	Peru	Indigenous Tsimane' women actively participate in fishing with hooks and lines, but not with bows and arrows in the Peruvian Amazon	Diaz-Reviriego *et al*. (2017)
Central America	Mexico	Women are engaged as part of the Mayan and non-indigenous communities practicing subsistence fishing on common property lands (ejidos) in Quintana Roo	Arce-Ibarra and Charles (2008)
Africa	Botswana	Women occasionally fish in shallow water with baskets in the Okavango Delta in Botswana	Ngwenya *et al.*, (2012)
	Zambia	1 percent of fishers are women in Lake Kariba, Zambi	
	the Congo	In Salonga area of the central basin of the Congo River, women use basket traps to fish the flood plain and river margins	Béné *et al*. (2009)
Oceania	Viti Levu, Fiji	Women dominate fishing activities in Tonai, Viti Levu, using fishing nets to catch fish to feed their families	Dakuidreketi and Vuki (2014).

In the Mekong River floodplain, women also fish with their husbands via assisting with operating the boat and sorting fish catches in order to maximize the fishing season (FAO, 2015). These practices also often catch smaller fish species, which are sun dried, and provide a more environmentally conserving and nutritious food source when eaten whole (HLPE, 2014; FAO, 2015).

In addition, women provide emotional support to fishermen, such as in floodplains in Bangladesh, where women practice worship and prayer for good fishing catches and safe return of fishermen (Deb *et al.,* 2015).

Norms, beliefs and gender relations between fishers, households and in communities often confine women to occupy the low value end of the supply chain (HLPE, 2014; Deb *et al.*, 2015; Rajaratnam *et al.,* 2016). Men often have greater access to high profit fishery activities, such as in Lake Victoria where men dominate the valuable export fishery (Lwenya and Abila, 2001). Women have responsibility for household chores and care of children, which limits their mobility to better markets and time available for fish related activities. In addition, men often have greater power in decision-making and better access to credit and loans, resulting in women having less bargaining power over resources and less ability to expand a business (HLPE, 2014; Rajaratnam *et al.,* 2016). As a result, women can be more vulnerable to changing resources and competition as evident through observations of women undertaking "fish for sex" transactions (Box 7-2) (Béné and Merten, 2008; Porter, 2012).

Box 7-2: Women's vulnerability and "fish for sex"

Gendered norms and cultures have been found to lead to women having less access, bargaining power and profits in inland fisheries compared to men. As a result, women have been found to be more vulnerable to fluctuating fishery resources and competition in some fisheries (Abbott *et al*., 2007).

Within some inland fisheries, women fish traders engage in transactional "fish for sex"to secure better access to fish and lower prices from fishermen (Béné and Merten, 2008). An example is in the Kafue River floodplain fisheries where female traders engage in "fish for sex"transactions (Béné and Merten 2008) to secure preferential access to fish. These groups of women were particularly vulnerable to poverty because of being single, widowed or divorced, and elderly or young, where strategies to secure access to fish helped improve profit margins (Béné and Merten, 2008).

It has been argued that "fish for sex" arises within inland fisheries as a result of the challenges female fish traders experience in accessing fishermen and fish within dispersed, competitive and highly fluctuating fisheries (Abbott *et al*., 2007).

Source: *Béné and Merten, 2008.*

Gender dynamics have also been highlighted as an important factor affecting the pathways of fish to food security (Figure 4-1, Chapter 4) (HLPE, 2014). In Lake Victoria, men have been shown to spend most of their fishing livelihood income on alcohol and non-household food security items, compared with women (Box 7-3) (Fiorella *et al.,* 2014; Geheb *et al.,* 2008).

Box 7-3: Gender and food security in Lake Victoria's fishery

Lake Victoria is the largest of East Africa's Rift Valley lakes, and supports a large inland fishery, including a highly valuable export fishery. The lake is located within Uganda, Tanzania and Kenya. Men largely control the highly valuable fisheries and dominate fishing activities. Women on the other hand are involved in fish processing and trading activities that are often less valuable. Communities around Lake Victoria experience poor sanitation, high prevalence of HIV/AIDS and malaria. Despite the high-income generation from the export fishery, fishing communities also experience high malnutrition rates above national averages.

A study by Geheb *et al. (*2008) investigating the link between food security and fishing communities around Lake Victoria found that differences in priorities of income expenditure influenced malnutrition. Income from fish sales were important for purchasing food staples and meeting households' food, health care and educational needs.

Men had higher incomes because of their dominance over highly valuable fish related activities, and also had control over income expenditure decisions within the household. Men often contributed sporadically to household maintenance through one-off payments for education for example, and used income on personal expenditure such as on alcohol. Women on the other hand earn small but frequent income that is spent on daily household needs such as food.

This highlights the complexity in understanding pathways between livelihood activities and food security. Gender norms and relations influence accessibility to resources, roles and responsibilities, the benefits obtained, and expenditure patterns.

Source: *Geheb et al., 2008.*

Men and women spend income in different ways and wider studies show women's income often has a greater contribution to household food and nutritional security, despite their limited resources (Quisumbing *et al*., 1995; Porter, 2012). Studies have shown that increasing women's independent income, reduces inequality and poverty in a household (Porter, 2012).

Climate change is also a gender issue, where gender norms and cultures influence livelihood activities, the experiences of climate change and responses to coping with it (Skinner, 2011). Women often experience higher poverty, lower food and nutritional security and increased vulnerability compared to men because of differences in access to resources and constraints. In some contexts, women and girls experience less food intake compared with male members of the household (Quisumbing *et al.*, 1995; Porter, 2012). Skinner (2011) claimed that women are 14 times more likely to be impacted by disasters than men as a result of their higher vulnerability.

Women often adapt to climate change via diversifying into small local activities whereas men migrate and seek formal employment (Skinner, 2011). However, men also experience climate change in different ways and can take more risks and find it emotionally difficult to cope. Thus, intra-household relationships between men and women are important to understand when investigating vulnerability to climate change. The impact of climate change on fisheries resource dynamics will likely amplify the vulnerability of women in the fishery sector (Weeratunge *et al.*, 2010).

More local level assessments of the impacts of climate change on fisheries and the effects on men and women fishers' livelihoods are required (Welcomme, 2011; Béné *et al.*, 2016). Clearly, disaster responses have to be formulated to address the different impacts and needs of men and women in the same households and communities. Fishers, including women fishers, have also been identified as providing an untapped potential source of valuable local ecological knowledge (LEK) for understanding the impacts of climate change on fisheries (Kleiber *et al.,* 2015).

7.2 REGIONAL VARIATIONS IN INLAND FISHERIES EMPLOYMENT

In rural economies, compared to other natural resource-based livelihood strategies, fishery-related livelihood activities have been found to have a higher income earning potential and can generate income all year round; contributing to annual livelihood security (Heck *et al.*, 2007; Béné *et al.*, 2016). These studies test the past assumptions that all fishers are the "poorest of the poor" (Pollnac *et al.*, 2001; Béné *et al*., 2003). In addition, fish-related activities can act as a safety net during climate induced agricultural lean months or for the increasing numbers of landless poor (HLPE, 2014; Kawarazuka and Béné, 2011).

Where case studies have been conducted, higher figures for employment and participation in inland fisheries emerge (World Bank, 2012; DeGraaf and Garibaldi, 2014). This can be explained by a number of factors: the survey is often more targeted or uses disproportionate sampling; a broader range of fishing activities is included; and all degrees of engagement are included. Surveys like that proposed in the Big Numbers Project (WorldFish Center, 2008) also ensure that seasonal engagement – a frequent occurrence in inland fisheries – is investigated.

Here, inland fisheries in two regions – Asia and Africa – are briefly explored. Part-time engagement in inland fishing may be highly seasonal, opportunistic and even a coping strategy in times of stress or hardship and so engagement figures may vary inter-annually according to the state of other sectors and environmental considerations. Some explanations for the variation are: fishing rates increase in flood years for most rural floodplains; migration increases for fishing-related activities during lean seasons (e.g. in Cambodia's Tonle Sap or Great Lake); and fishing increases as a result of conflicts that make farming crops or livestock impossible (Lake Chad). Aside from material benefits of income and employment, fisheries often form a rich component of personal identity and job satisfaction (Pollnac *et al*., 2001; Weeratunge *et al.*, 2014) within fishing communities.

Asia

Throughout Asia inland fisheries play important roles in employment and food provision. For example, in Bangladesh some 10 million people fish and support a total of 50 million household members (WorldFish Center, 2008). In Cambodia 80 percent of the 1.2 million people living around Tonle Sap use the lake and its rivers for fishing (Ahmed *et al*., 1998). Of these people, there are an estimated 496 000 full-time and part-time inland fishers, some of whom are subsistence fishers. In addition, more than 920 000 people are involved in small-scale processing of inland catches. This activity takes place during the peak fishing period after the rainy season, and employment is mainly part time and often organized on a household basis (Thouk *et al*. cited in World Bank, 2012).

Women in Asia are key players in seafood trading and selling. Most of the estimated 5 000 to 6 000 fish markets throughout the lower Mekong basin are conducted by women (UNEP, 2010). Women are also highly engaged in foraging and gleaning of molluscs, crustaceans, small fish, aquatic plants in shallow waters, in floodplains and rice fields and wetlands as well as in shallow waters of waterbodies and streams. For example, surveys in the lower Mekong basin show that women are often heavily engaged in subsistence fishing and collection of aquatic animals and plants in inland waters. However, as with other data on inland fisheries, this is not always adequately reported.

Africa

Total employment in all sectors of inland fisheries in Africa is estimated at 4 958 000 in an extrapolation from surveys. From this total value, 3 370 000 would be fishers and 1 588 000 from the post-harvest sector. Inland fisheries employ 55 percent of the total fishing labour in Africa (de Graaf and Garibaldi, 2014). In the countries included in the study, inland fisheries were very relevant and the sample included almost 2 million people who were employed in the inland fisheries subsector: 66 percent as fishers and 34 percent as processors. Almost 26 percent of the total were women and the great majority of the women (87 percent) worked as processors (DeGraaf and Garibaldi, 2014).

Several studies on inland capture fisheries in Africa (Lake Chilwa in Malawi, Lake Victoria in Kenya, Lake Kyoga in Uganda) found that fishers had higher incomes compared to non-fishers (Allison and Mvula 2002; Ellis and Bahiigwa 2003). Béné *et al. (*2009) described the link between fisheries and livelihoods as a “bank in the water” function where fisheries can act as a cash crop and an important primary and secondary source of income. A recent estimate of employment and income for seven major river basins found that in West and Central Africa fisheries provide a livelihood to more than 227 000 full-time fishers and yielded an annual catch of about 570 000 tonnes with a first-sale value of USD 295 million (Neiland and Béné, 2008).

In Africa the great majority of women in inland fisheries are employed in post-harvest (91.5 percent), however 7.2 percent of small-scale fishers are women (almost entirely employed in inland fisheries).

7.3 FAO STATISTICS ON WOMEN’S ENGAGEMENT IN INLAND FISHERIES

Based on member countries reports to FAO, the gender breakdown for inland fisheries participation varies across countries (Table 7-2). The reports provide in principle, the ratio of male fishers to female fishers, however, it is possible that reports may include post-harvest and allied activities as well. (This is a persistent issue for inland fishing reporting, regardless of gender status).

Women’s involvement in fishing in the countries that report disaggregated data to FAO was one female fisher per 7.3 male fishers. In 38 reporting countries, female participation in inland fishing had a relatively high ratio (1 female fisher to between 1 and 20 male fishers). This ratio may be misleading as it obscures the fact that in some countries fishing activities are more or less exclusively a male occupation. Further, the global ratio is also strongly driven by the figures from Myanmar, which reported 15 million inland fishers as being exclusively male. This is atypical for the region and almost certainly is not an accurate reflection of women’s engagement in the sector. Women are substantially employed in the post-harvest processing of inland fish in Myanmar (for example, in the preparation of fermented fish known locally as *ngapi*) as well as in marketing.

In total, 44 countries reported no female fishers although this may exclude female fishers who are engaged in fishing as an occasional activity. This reporting also excludes recreational fisheries and thus ignores the participation of women in recreational fishing (e.g. in Finland, where the reported employment only covers commercial fishing, yet women represent up to 50 percent of the 2.1 million recreational fishers).

Table 7-2: Ratio of male to female fishers based on country reporting to FAO

Number of male fishers per female fisher	No.	Countries
Unspecified	4	Cambodia, Central African Republic, Taiwan POC, Paraguay
<1:1	1	Nepal
1 to 5	15	Botswana, Chad, Brazil, Bhutan, Republic of Korea, Kazakhstan, Japan, Venezuela (Bolivarian Republic of), India, Guinea, Austria, Mauritius, China, Nigeria, Burkina Faso
5 to 20	26	Colombia, Nicaragua, Mali, Peru, Hungary, Lesotho, Madagascar, Latvia, Eswatini, Guinea-Bissau, Somalia, Equatorial Guinea, Namibia, Angola, Gabon, South Africa, Cameroon, the Sudan, Ghana, Sierra Leone, Zimbabwe, Liberia, Belize, El Salvador, Democratic Republic of the Congo, Switzerland,
20 to 50	12	Malawi, Ecuador, Sweden, Sri Lanka, Zambia, the Congo, Rwanda, Uganda, Estonia, Ethiopia, Serbia, Bolivia (Plurinational State of),
>50	7	Romania, United Republic of Tanzania, Mozambique, Djibouti, Togo, Uzbekistan, Benin,
All male	44	Albania, Argentina, Armenia, Azerbaijan, Bangladesh, Belarus, Brunei Darussalam, Bulgaria, Burundi, Canada, Croatia, Korea DPR, Dominican Rep., Finland, French Polynesia, Gambia, Guatemala, Guyana, Honduras, Indonesia, Iran IR, Iraq, Italy, Jordan, Kenya, Kyrgyzstan, Lebanon, Lithuania, Mexico, Montenegro, Morocco, Myanmar, New Zealand, Niger, Pakistan, Panama, Philippines, Poland, Senegal, Suriname, Syrian Arab Republic, Tunisia, Turkey

A more significant figure is the participation of women in fishing reported from those countries where women take an active role in fishing. Overall, in the 61 countries where women were recognized as employed in inland fishing in gender disaggregated figures provided to FAO, the gender ratio is one female fisher to 3 male fishers. This figure is strongly driven by a number of countries (Nigeria, Nepal, Mali, India, China, Chad, Brazil) with very large inland fishery employment including both men and women.

The World Bank (2012) report provided an overall gender breakdown of women in the work force of 54 percent for the inland fisheries subsector, but did not distinguish between fishing and post-harvest related activities. This higher figure (giving a ratio of greater than 1:1 women to men employed) is because of the combination of fishing and post-harvest activity and reflects the relatively high participation of women in post-harvest activities. This balances their lower participation in primary fishing activities. Women’s involvement in the inland fisheries subsector equals that of men, and is considerably greater than that of the small–scale marine fisheries sector where women are overall 36 percent of the workforce (World Bank, 2012).

Although no data are presented here, there are similar considerations regarding age disaggregation in fisheries (i.e. numbers of rural youth employed or participation by children). There is a need also to explore more clearly children’s role in fishing and post-harvest activities as often children participate in inland fishing as a family activity, and in some reported cases are actively employed in the fishery.

The significant participation of women in inland fisheries both as active fishers as well as in the post-harvest sector emphasizes the importance of policies that are gender balanced and take into account different roles and also the different forms of fishing which are engaged in by men and women. The first step to build a foundation for gender mainstreaming has to be ongoing efforts to improve data collection and reporting on the engagement of women in fisheries.

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8 RECREATIONAL FISHERIES IN INLAND WATERS

Simon Funge-Smith, Douglas Beard, Stephen Cooke and Ian Cowx

SUMMARY

Recreational fishing involves considerable numbers of people around the world in both developed and developing countries. There is an average of 6.7 percent of the population engaged in recreational fisheries in those countries where recreational fishing is a common activity (>174.5 million). Some estimates place this figure higher. A sense of the value of recreational fisheries can be derived from direct costs, which are estimated in excess of USD 44 billion per year, and the indirect costs are estimated at over USD 100 billion per year.

Indications from a number of countries suggest that the retained catch from inland recreational fisheries is likely to be substantial, about 5.4 percent of total global reported catch. This catch is reported rarely to FAO, therefore at least some of this catch explains under-reporting in countries such as those in Eastern Europe, the Russian Federation, Ukraine, Central Asia and North America.

The introduction and establishment of non-indigenous fish for recreational fishing would benefit from more systematic reporting as their potential to become invasive often only becomes apparent a considerable time after the initial introduction.

8.1 ESTIMATION OF THE NUMBER OF INLAND RECREATIONAL FISHERS

Distinguishing artisanal and/or subsistence fisheries from recreational fishing is often difficult, especially in developing countries. Often the gears used may be similar and the recreational fish catch may be consumed in the home or in some cases sold/bartered, which is contrary to the definition of recreational fisheries. The FAO (2012) Technical Guidelines on Recreational Fisheries suggest that all recreational inland fisheries should demonstrate the following characteristics:

- the fishing is conducted for leisure or sport;
- the fish caught are released, or if retained, do not constitute the primary source of nutrition; and
- the fish captured are not used for the purpose of legal or illegal trade.

In some countries, recreational fishing may be considerably more important in terms of fish caught and retained than any commercial fishery. Countries may not report inland recreational fishing catches because of the challenge of gathering statistics on this dispersed activity. Catches of individual fishers may not be that significant; however, on aggregate the sheer amount of fishing effort may account for a statistically significant amount of fish in relation to the catches of inland fishers who engage in fishing as part of an economic livelihood.

Recreational fishing is an activity that is rarely reported in inland fishery related production statistics. The main reasons for this are the difficulty in collecting such dispersed statistics and possibly a presumption that the catches are minimal and are neither part of an economically productive livelihood, nor linked to household food security. There are exceptions and the economic value of recreational fishing as a subsector is becoming increasingly appreciated. This in turn is yielding some improved data on this hitherto hidden subsector.

The rates of participation in recreational fishing around the world are considerable. Of the countries where some data are available, some 6.7 percent of the population engages in recreational fishing in inland waters at some time in a year (Table 8-1).

Table 8-1: Regional summary of number of recreational fishers

Subregion	Total population	Number of recreational fishers	Recreational fisheries as percentage of the population
North America	349 038 000	31 291 507	9.0
South America	228 482 000	1 700 000	0.7
China	1 342 733 000	90 000 000	6.7
Eastern Europe	169 920 670	9 336 000	5.5
Northern Europe	31 582 000	5 719 500	18.1
Southern Europe	78 324 000	2 330 000	3.0
Western Europe	250 691 000	8 368 000	3.3
Oceania	26 087 000	778 440	3.0
Russian Federation	143 170 000	25 000 000	17.5
TOTAL	**2 620 027 670**	**174 523 447**	**6.7**

Estimates of the total number of recreational fishers vary between 220 million (World Bank, 2012) and 700 million (Cooke and Cowx, 2004). Cooke and Cowx (2004) estimate 11.5 percent of the global population engages in either marine or inland recreational fishing. Arlinghaus and Cooke (2009) estimate the average participation rate in all recreational fishing by the total population in a given country based on countries with reliable statistics is 10.6 ± 6.1 percent (mean ± SD) (Cooke *et al*., 2016).

As a baseline indication of the extent of inland recreational fishing, the Fédération Internationale De La Pêche Sportive En Eau Douce[50] indicates that is has 57 affiliated country federations whose membership of clubs and associations regularly hold freshwater angling competitions. Several of these countries are not included in Table 8-2, which lists the number of recreational fishers.

Using available estimated inland water recreation fishing data (various estimates derived over a relatively long period 1980 to 2014), the average for an expanded set of countries for inland waters only is 6.7 percent. This is within the range for total recreational fishing and is perhaps representative of the inland water recreational sector (being somewhat larger than the marine recreational sector).

The figures that emerge from actual country estimates are in the region of 174 million inland water recreational fishers in 43 countries (Table 8-2). This represents approximately 6.7 percent of the national population engaging in recreational fisheries in those countries where recreational fishing is a common activity. In some countries, the number of national recreational fishers is less important both in terms of economic impact and catches than the number of fishing tourists (notable examples are Iceland and Brazil).There are known to be more recreational fishers in countries with substantial inland water resources for which estimates are not available. The growth in recreational fishing parks in Asia is an indication of this.

[50] De La Pêche Sportive En Eau Douce : http://www.FIPS-ed.com

Table 8-2: Estimated number of recreational fishers by country

Country	Population	Inland recreational fishers	Recrea-tional fishers as % of populat ion	Year	Reference
CHINA					
China	1 342 733 000	90 000 000	6.7	2008	Jianzhong Shen (cited in Aas, 2008)
RUSSIAN FEDERATION					
Russian Federation	143 170 000	25 000 000	17.5	2012	Russian Fisheries Authority estimate (unreferenced)
NORTH AMERICA					
United States of America	314 912 000	28 724 569	9.1	2011	U.S. Fish and Wildlife Service (2011)
Canada	34 126 000	2 566 938	7.5	2010	Fisheries and Oceans Canada (2012)
WESTERN EUROPE					
France	58 850 000	3 000 000	5.10	1992	Le Goffe and Salanie (2005)
United Kingdom	61 943 000	1 500 000	2.4	2009	UK Fishing License sales 2009
Germany	83 389 000	1 500 000	1.8	1996	FAO (1996)
Netherlands	16 759 000	1 271 000	7.6	2013	Van der Hammen and DeGraaf (2013)
Austria	8 092 000	410 000	5.1	2002	Kohl and Hutschinski (2000)
Belgium	10 601 000	300 000	2.8	1996	FAO (1996)
Switzerland	7 060 000	240 000	3.40	1999	Schwarzel-Klingenstein *et al.* (1999)
Ireland	3 997 000	147 000	3.68	2003	Williams and Ryan (2004)
EASTERN EUROPE					
Ukraine	47 807 000	5 200 000	10.9	2003	Aps 2003
Poland	38 429 000	2 000 000	5.2	1998	Cowx (cited in Aps, 2003)
Belarus	9 720 000	1 000 000	10.3	2004	Aps, Sharp and Kutonova (2004)
Hungary	10 283 000	325 000	3.17	1999	Kovacs and Furesz (cited in Arlinghaus *et al. (*2015)
Czechia	10 291 000	330 000	3.21	2003	Spurney *et al.* (cited in Arlinghaus *et al.*, 2015)
Bulgaria	8 131 000	180 000	2.2	1998	Cowx (cited in Aps, 2003)
Romania	22 842 000	106 000	0.5	1996	FAO 1996
Slovakia	5 384 000	89 000	1.7	1998	Cowx (cited in Aps, 2003)
Serbia	10 639 000	88 000	0.8	2004	Aps (2004)
Slovenia	1 995 000	14 000	0.7	2004	Aps (2004)
Montenegro	614 670	3 000	0.5	2004	Aps (2004)
Rep. of Moldova	3 828 000	1 000	0.0	2003	Aps (2003)
NORTHERN EUROPE					
Finland	5 292 000	2 100 000	39.7	2008	Toivonen (cited in Aas, 2008)
Lithuania	3 143 000	1 500 000	47.7	2008	Estimate in Aas (2008)

Table 8-2: Estimated number of recreational fishers by country

Country	Population	Inland recreational fishers	Recrea-tional fishers as % of population	Year	Reference
Norway	4 386 000	900 000	20.5	1996	FAO (1996)
Sweden	9 571 000	796 000	8.3	2013	Swedish Agency for Marine and Water Management (+/- 207 000)
Denmark	5 254 000	250 000	4.8	1996	FAO (1996)
Latvia	2 288 000	120 000	5.2	2003	Aps (2003)
Estonia	1 339 000	50 000	3.7	2003	Aps (2003)
Iceland	309 000	3 500	1.1	2008	NASCO (2008) Estimated from 350 rods/100 days (limit on salmon)
SOUTHERN EUROPE					
Italy	56 937 000	2 000 000	3.5	1996	FAO (1996)
Portugal	10 141 000	230 000	2.3	1996	FAO (1996)
Croatia	4 400 000	57 000	1.3	2004	Aps, Sharp and Kutonova (2004)
Bosnia and Herzegovina	3 887 000	35 000	0.9	2004	Aps, Sharp and Kutonova (2004)
Fmr. Yugoslav. Rep. Macedonia	2 086 000	5 000	0.2	2004	Aps, Sharp and Kutonova (2004)
Cyprus	873 000	3 000	0.3	1996	FAO (1996)
SOUTH AMERICA					
Brazil	200 362 000	1 200 000	0.6	2012	Freire, Machado and Crapaldi (2012), (a note also states it could be as much as 10 million)
Argentina	28 120 000	500 000	1.8	1980	Country paper in FAO (1980). Baigún and Delfino (2001) report an estimate of 1 million recreational fishers in riparian cities of the La Plata catchment and 1.5 million in the Pampas region
CENTRAL AMERICA					
Mexico	91 650 000	3 300 000	3.6	1993	Mexico Secretariat of Tourism
Oceania					
Australia	21 645 000	700 000	3.2	2008	In Aas (2008,). Estimated from 20 percent of fishing effort in freshwater
New Zealand	4 442 000	78 440	1.77	2013	Ministry for the Environment and Statistics New Zealand
CENTRAL ASIA					
Azerbaijan	9 417 000	20 000	0.22	2013	Salmonov *et al*. (2013)

8.2 RETAINED INLAND RECREATIONAL FISHERY CATCH

In many countries that have substantial numbers of the population participating in recreational fisheries, a significant portion of the catch is retained and consumed. The catches from this recreational fishing can be a considerable increase above the inland fish catch reported to FAO, which may typically only reflect commercial inland fish landings and do not include the retained recreational fish catch. This is particularly evident in the reports from Central Asian countries, many Eastern European countries, Asia, the United States of America and Canada.

There are relatively wide ranging rates of participation in recreational fishing in inland waters, and also in the amount of effort (e.g. number of fishing days) per fisher. In surveys that have been conducted, one of the greatest constraints on fishers is finding the time to go fishing (Arlinghaus, Tillner and Bork, 2015; Aprahamian *et al*., 2010; Cowx, 2015). The amount of fish retained is also quite variable, with high levels of catch and return in countries such as the United Kingdom, to almost complete retention in countries such as Finland, Eastern European countries, Central Asian countries and China, where part of the attraction of the fishing activity is that the catch will form part of a meal.

Table 8-3: Estimates of retained catch of recreational fisheries in inland waters

Country	Total inland fishery catch reported to FAO	Estimate of retained recreational catch (tonnes)	Recreational catch as percentage of total inland fishery catch reported to FAO	National recreational catch as percentage of total inland recreational fishery catch	Year
United States of America	29 275	396 242	1 354	64.19	2004
Rep. of Korea	10 221	98 942	968	16.03	2012
Canada	28 142	22 758	81	3.69	2010
Russian Federation	262 983	17 711	7	2.87	2010
Finland	29 476	16 132	55	2.61	2015
Argentina	15 445	15 077	98	2.44	2010
Japan	41 635	12 268	29	1.99	2009
Norway	450	10 000	2 222	1.62	2003
Sweden	1 368	9 000	658	1.46	2010
Hungary	6 472	4 742	73	0.77	2013
Australia	185	4 060	2 195	0.66	2001
Czechia	3 812	3 812	100	0.62	2014
Slovakia	1 608	1 936	120	0.31	2010
Netherlands	2 000	1 626	81	0.26	2008
Poland	414	1 021	247	0.17	2007
New Zealand	752	988	131	0.16	2008
South Africa	900	900	100	0.15	2011
United Kingdom	2 268	69	3	0.01	2013
Total	**437 406**	**617 284**			

Note: Very large percentages indicate that the recreational catches are not included in the national inland fishery report to FAO.

Source: Adapted from Cooke *et al*., 2018

It is considered that this catch could amount to a significant additional catch for inland waters (Cowx 1995; Cooke and Cowx, 2004) that is not captured in the FAO global statistic. There have been various efforts to estimate this hidden catch, using typical catch per fisher or fishing effort estimations. None of the estimates come with a high degree of certainty, because of the wide range of assumptions that are applied in their derivation and a lack of differentiation between fish caught in marine or inland waters. Cooke *et al*. (2018) have provided the most recent effort to estimate global retained recreational fish catches (Table 8-3).

The indications from the different types of recreational fishery in a number countries are that the retained catch from inland recreational fisheries is at least 5.4 percent of the total global catch of inland fisheries and possibly much more, as many countries have recreational fisheries that are not part of this estimate.

As this catch is rarely if ever included in the fish catch reported to FAO, at least some of this catch explains apparent under-reporting in countries such as those in Eastern Europe, the Russian Federation, Ukraine, Central Asia and North America. There are exceptions to this, an example being Finland, which has a limited commercial inland fishery but reports a significant inland fish catch, representing the estimated catches of the recreational fishery.

8.3 TRENDS IN RECREATIONAL FISHING

Trends in participation in recreational fishing are hard to establish. Some reports indicate that there are declining rates of participation as a result of increasing urbanization, more sedentary lifestyles and rising costs of licenses and equipment (Hickley and Tompkins, 1998; Aps, 2003) and even overcrowding (Le Goffe and Salanie, 2005). This is reflected in declining license sales in a number of countries (United States of America, France). However, increased license sales have been found when actively promoted or discounted. Increases are found elsewhere following active promotion. An example is the United Kingdom, which saw considerable increased in license sales following a promotional campaign, although these subsequently declined (Aprahamium *et al.*, 2010).

There is evidence that recreational fisheries are growing strongly in emerging economies and an indicator of this is the increasing global value of equipment sales for recreational fishing (both inland waters and marine). Sales of recreational fishing equipment were projected to reach USD 20.3 billion by 2015 and the fastest growth in the equipment markets was in the Asia-Pacific and Latin American regions (noting that in these regions they are starting from a low base) (Global Industry Analysts, Inc., 2009).

One matter that emerges from the literature, is that the number of licensed recreational fishers is considerably less than the estimates of the number of people who respond to surveys that they have participated in recreational fishing (up to a factor of two in the case of the United Kingdom). This is because:

- a fishing license (seasonal/annual) may be officially recorded, but day permits may not;
- certain forms of recreational fishing do not require a license (e.g. marine recreational fishing in many countries, inland water recreational fishing in some countries; exclusion of certain waterbodies, fishing in private waters;
- senior citizens or children may be exempted; and
- a proportion of recreational fishers do not comply with licensing or permitting requirements.

In most developing countries there is simply no need to have a recreational fishing license and this greatly limits our ability to estimate participation, e.g. in China (Jianzhong Shen, cited in Aas, 2008).

8.4 THE VALUE OF RECREATIONAL FISHING IN INLAND WATERS

Estimating the global economic value of recreational fisheries in inland waters is challenging because of the variety of ways in which this can be measured. This is discussed in more detail in the valuation chapter (Chapter 5).

A primary issue is one of distinguishing between inland water and marine recreational fishing. Recreational fisheries are not typically measured in terms of the value of the catch (an exception might be Finland where the retained catch is consumed in the home and may constitute significant financial value, but even here the associated values of the fishery are likely to be considerably more). This is because it may or may not be retained and the actual cost of the fish is often a minor component in the overall economic value of recreational fishing activities. The associated costs of licenses, equipment, transport, accommodation, food, salaries of fishing guides and a host of other services can all be included in the valuation. The major distinction often used is that of direct costs to the recreational fisher (e.g. direct expenditures) and the values that are the result of economic multipliers of the recreational fishing sector (e.g. associated values of employment, boat hire, retail and equipment industry jobs).

Finding this information in a consistent form for the many countries where some form of recreational fishing takes place has not been particularly fruitful. There are estimates for a number of developed countries that have relatively good records, but the wide range of types of recreational fishing activities in newly industrialized and developing countries is less well recognized and rarely accounted for.

For those countries where some estimates have been made, the valuation figures available are for a mixture of direct and indirect costs. Depending upon the study, both values were not always available, but where both were available (three examples), the multiplier between direct and indirect costs ranged between 2.32 and 2.43. In the valuation chapter (Chapter 5), the estimate of the non-market use value (NMUV) of inland recreational fishing in 2015 was in the range of USD 64.55 billion to USD 78.74 billion

8.5 ENVIRONMENTAL AND SOCIAL IMPACT OF RECREATIONAL FISHING

There is increasing awareness of how recreational fisheries affect fish stocks in countries where recreational fishing has been long established and has become a commercial leisure activity (e.g. Europe, North America, Japan). Studies have covered impacts of stocking and introductions, nutrient enrichment, ecosystem disruption, evolutionary trends and social impact (Arlinghaus *et al*., 2016). Far less is known about the situation in countries where it is a relatively new pastime (e.g. parts of Asia, Latin American and African countries). However, potentially the impact may be very significant (Box 8-1). Cooke and Cowx (2004) for example speculate that 12 percent of global fish landings may come from recreational fisheries. There is no comparable figure available for inland waters, however in waters with low productivity such as cold mountain streams or lakes and black water streams and rivers and in some reservoirs recreational fishing can often be responsible for a much higher share of the catch than the artisanal fisheries (Regidor, 2004).

The importance of inland water recreational fishing on policies concerning the use of inland waters and environmental regulation can be considerable in those countries where the value (and often the retained catch) of recreational inland water fishing exceeds the value of commercial inland fisheries (Hickley and Tompkins, 1998; Aps, 2003; Ernst & Young, 2011). Advocacy and lobbying by the recreational fishery can also extend into broader environmental issues relating conservation and protection, water and environmental quality, environmental flows as well as the introduction or movement of alien species (Granek *et al.*, 2008; Tufts, Holden and Demille, 2015; Copeland *et al.*, 2017). The recreational fishery may lobby for introduction of species as sport fish may oppose the development of aquaculture facilities as they compete for water usage or may present unquantifiable risks for health and genetic impacts from escapees (Lewin, Arlinghaus and Mehner, 2006).

Box 8-1: Recreational fisheries in inland waters in Latin America

In the North and South temperate zones, recreational fishery is the dominant use of inland waters' fish resources, and the sector is experiencing explosive development in many transitional economies, including many countries in Latin America (Bennett and Thorpe, 2008). The increasing importance of recreational fishing throughout the Latin American region manifests itself in the abundance of advertisements for fishing tours and competitions available on the Internet. There are angling associations or fishing clubs in all the countries and a simple Internet search for "pesca recreativa" provides tens of thousands of hits.

There is only limited quantitative information available on participation in recreational fishing. Carvalho Filho (cited by Lopes and Landell Filho, 2001) estimates that there are 30 million recreational fishers in Brazil although the proportion of these fishing in inland waters is not clarified. The economic potential of recreational fisheries is also considerable and the value of a fish caught by recreational fishers is many times higher than that of the same fish when caught by a commercial food fisher. Direct income is generated from the sale of fishing licenses that may have to be paid to the owner of the fishing rights, whether this is a public or private entity. The sector also has a considerable secondary income generating effect through producers and sellers of fishing equipment, bait providers, boat renters, guides, lodge owners, travel agencies, restaurants, boat constructors, producers of books, magazines, documentaries and digital information on sports fishing, producers of stocking material.

There are three general types of recreational fishers in Latin America:

i) Foreign tourists (predominantly North Americans) travelling to Latin America to fish. This is widespread throughout the region, but tends to concentrate in areas known for their natural beauty such as Lake Titicaca, the Andean and Patagonian Lakes, parts of the Amazon and Central American lakes.
ii) Affluent domestic tourists who reside in the urban centres and who go camping and fishing in the countryside during vacation periods. This sector flourishes in places like Santa Cruz in Bolivia (Plurinational State of), Río Negro in Brazil, reservoirs in Venezuela (Bolivarian Republic of), throughout the lower Paraná Basin and in the Pantanal.
iii) The third grouping is closely linked to subsistence fishing as these are local fishers, who also aim to provide food for their family. This type of fishing takes place in almost any stream or waterbody and normally does not target any particular species. Fishing by children belongs in this group and may also be encouraged by the parents (Garcez and Sánchez-Botero, 2006).

The preferred species in the fisheries varies according to the geographic area. In the heights of the Andes the most favoured target species are the two introduced trouts: rainbow trout (*Onchorhynchus mykiss*) and brown trout (*Salmo trutta*). Recreational fishers focus on dorado (*Salminus brasiliensis*) and large catfish species in the Paraná. In the tropical lowlands, a large variety of species grow big enough to be attractive as trophies, but the most favoured are *Cichla* spp., *Colossoma macropomum*, arowanas (*Osteoglossum bicirrhosum*) and big catfishes.

Several of the most popular sport fish mentioned above are also important target species for the artisanal fishery. In order to avoid conflicts there is a tendency for recreational fisheries to centre on regions with limited artisanal fishing, for example black water rivers and cold water streams. Conflicts nevertheless frequently. The participation of middle and upper classes in recreational fisheries makes this group politically influential and well organized. This is in stark contrast to artisanal and subsistence fishers, usually belong to the lowest income strata and are typically poorly organized. The result is that current management practices (e.g. gear bans, minimum sizes, closed seasons or areas) often favour the recreational sector to the detriment of small-scale fishing for consumption or for sale. An example of this is the southern part of the Pantanal (Resende, 2003; Violin and Alves 2017), which has, effectively, been reserved for recreational fishing with very significant losses of potential food production (tens or even hundreds of thousands of tonnes). When recreational fishing is organized as a package tour, there may be little involvement of the local community and few local benefits. Conversely, recreational fishers in the first two categories mentioned above frequently use local fishermen as guides, and in some places (for example in the Pantanal) the fish caught is sold to compensate the fishers for their losses.

In addition to the direct impact on the fish resources by the extraction of fish, the fishers are also responsible for disturbing the, sometimes sensitive, fauna and flora in areas that would otherwise not be frequented by many people. In areas visited by many tourists there are problems with the accumulation of waste including discarded gear. It is common practice in some types of fishing to attract the fish groundbaiting and this can be an important source of eutrophication in smaller, nutrient poor waterbodies.

There are also benefits that can be gained from greater institutional engagement with recreational fishers. For example, they can support monitoring of compliance with fishing regulations and help to improve environmental monitoring. Moreover, they can help with data collection in support of science for fishery management.

Catch-and–release recreational fishing in now a common strategy in many recreational fisheries (Cooke and Schramm, 2007; Arlinghaus *et al*., 2007; Danylchuk and Cooke, 2011) with examples from all over the world:

- United Kingdom and the Netherlands – most of the open water coarse fisheries
- Common carp in much of Western Europe
- Cichla spp. in the Brazilian Amazon (Reiss, 2003)
- Trout fishing in New Zealand, and the United States of America
- Salmon in the United Kingdom
- Muskellunge in midwestern North America
- Golden dorado in the Juramento River, in Salta, Argentina.

There has been considerable research on the sub-lethal consequences of catch and release on various species (Arlinghaus *et al*., 2007). The practice is linked both to stress or damage during capture with release mortality ranges ranging from negligible to over 90 percent (Bartholomew *et al*., 2008) with mortality rates mediated by factors such as gear type, species, angler experience, and water temperature (Arlinghaus *et al*., 2007). These need to be accounted for in management plans and practices in catch and release fisheries and should be species specific (Cooke and Suski, 2015). As a result of the variable survivability of post release fish, the impacts or benefits of this practice remain contentious for some fisheries (Aas *et al*., 2002).

As the value and interest in recreational inland water fisheries grows in developing countries, the regulatory framework is often inadequate for effective management of this activity. This is because regulations largely apply to the commercial or subsistence inland fisheries and may not cover the management of recreational fisheries (including the introduction and movement of alien species). In other instances, where regulations exist, there are still pressures to provide non-native sport species in game parks. Although these may be considered isolated introductions and movements, they do represent a plausible risk of escape, although the numbers may be low and the likelihood of establishment may be minimal (when compared to the risk and impact of mass escapes from ornamental breeding farms). The risks are considerably higher in the case of stocking of open waters for establishing recreational fisheries. The escape of live fish that have been bred as bait is an additional impact of recreational fishing, and has resulted in a number of species becoming established beyond their natural range (CABI, 2017a, 2017b, 2017c, 2017d).

Some examples of deliberate introductions for recreational fishing are:

- the widespread introduction and movements of brown trout (brown) as a recreational sport fish species occurred relatively widely during the late nineteenth and early twentieth centuries and resulted in the establishment of recreational fisheries for trout in almost every continent (Bhutan, Afghanistan, India, Pakistan, Kenya, South Africa, Australia, New Zealand);
- the widespread introduction of the common carp (United States of America, India, Western Europe, Murray–Darling Basin, Australia);
- the generally unregulated introduction and movement of Latin American species (Arapiama, red tailed catfish, Pacu) and North American species (Alligator gar) as sport fish into Asian recreational fishing parks;
- introduction of the Asian snakehead into the United States of America;
- introduction of wels catfish and zander into the United Kingdom, China, Italy, Netherlands, Portugal, Spain, Syria, Tunisia, and France (CABI, 2017a);
- introduction of *Cichla ocellaris* in Lake Gatun in Panama (Zaret and Paine 1973);
- introduction of smallmouth bass (*M. dolomieu*) to continents outside of its native range into Asia (Japan, Viet Nam), Africa (Mauritius, South Africa, The Kingdom of Eswatini , Tanzania, Zambia, Zimbabwe), Europe (Austria, Belgium, Czechia, Denmark, Finland, France, Germany,

The Netherlands, Norway, Slovakia, Sweden and the United Kingdom) and Oceania (Fiji and Guam) (CABI, 2017b)

- lake trout (*S. namaycush*) has been introduced into other countries such as Argentina, Austria, Bolivia, Czechia, Denmark, Finland, France, Germany, Italy, Japan, Morocco, New Zealand, Norway, Peru, Slovakia, Spain, Sweden, Switzerland and the United Kingdom (CABI, 2017c);
- walleye, white crappie and black crappie have been moved beyond their natural range in North America (CABI, 2017a); and
- introduction of Pejerrey (*Odontesthes bonariensis*) into Chile, Bolivia (Plurinational State of), Paraguay, Peru, Italy (CABI, 2017d)

These introductions and establishments of fish for recreational fishing would benefit from more systematic reporting as their potential to become invasive often occurs a considerable time after initial introduction.

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9 AQUATIC BIODIVERSITY AND INLAND FISHERIES

Devin Bartley and Simon Funge-Smith

SUMMARY

Aquatic ecosystems (inland and marine) represent the most biodiverse sources of food consumed by humans. This includes vascular plants and algae, and animals such as crustaceans, molluscs, reptiles, amphibians and finfish. Freshwater ecosystems cover only about 1 percent of the earth's surface, but provide habitat for over 40 percent (13 000) of the world's freshwater fish species. Another 2 000 species of fish can also live in brackishwater.

In general, the level of knowledge on freshwater biodiversity (i.e. species richness, endemism, production, level of endangerment and value), is poor or out of date for many areas.

Freshwaters are one of the ecosystems most heavily impacted by humans. Major impacts on biodiversity include pollution, habitat loss and degradation, draining wetlands, river fragmentation and poor land-management. Biodiversity of fish can and does serve as indicators of ecosystem health. Freshwater biodiversity is threatened and has declined in many areas as a result of these impacts, According to the IUCN Red List, the highest number of threatened, endangered or extinct species is in Asia.

The greatest freshwater diversity in inland fisheries is found in Asia, but South America has the greatest overall fish biodiversity (i.e. not limited to freshwater). The Neotropics contain the highest amounts of fish biodiversity and the tropical and subtropical floodplain rivers and wetlands are the ecoregions with the highest levels of biodiversity. South America also has the highest levels of endemism. Rice fields are an important source of biodiversity and include over 200 species of fish, insects, crustaceans, molluscs, reptiles, amphibians and plants (in addition to rice) that are used by local communities.

Many freshwater species are important to the aquaculture industry as sources of broodstock for spawning and early life history stages (e.g. eggs, larvae) for ongrowing, i.e. raising the fish to marketable size.

Non-native aquatic species can contribute significantly to the production and value in fisheries and aquaculture. The use of international guidelines on species introductions and a precautionary approach are advised when considering moving species into new areas.

9.1 THE IMPORTANCE OF AQUATIC BIODIVERSITYWHAT IS AQUATIC BIODIVERSITY?

The Convention on Biological Diversity has provided an internationally agreed definition of "biological diversity" or its equivalent, "biodiversity":

> Biological diversity means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems. *(www.cbd.org)*

This definition therefore includes an increasing inclusivity of what is considered to be biodiversity from individual genes, of species, right up to the inclusion of ecological processes among the various components of the ecosystem. Thus biodiversity can be assessed from genes through to ecosystems. This flexibility challenges comparison of biodiversity estimates among different studies: one study may report on diversity at the species level whereas another may report on numbers of families or orders (see below). It also demonstrates that ecosystems and their processes are key factors influencing biodiversity.

There are generally three dimensions of biological diversity that can be measured:

- richness, i.e. the number of different taxa in an area;
- evenness i.e. whether the species in an area are equal numerically, or one or two species dominate; and
- endemism, the unique biological diversity that exists in a particular area and nowhere else.

Diversity at the genetic level has also been established to indicate the number of different genes, how different groups are from each other genetically, and how genes are organized in the genome. These measures are primarily used in specialized scientific publications on genetic resources. The more common measures or indicators are the number of species in a given area (species richness) and endemism. These two measures are used in this chapter.

9.1.1 BIODIVERSITY IS AN INDICATOR OF THE HEALTH OF A FISHERY OR ECOSYSTEM

Given the wide range of ecosystem services provided by biodiversity (see Section 3.3), can biodiversity be an indicator of the health of a fishery or an ecosystem? Fish have been shown to be sensitive indicators of ecosystem degradation from eutrophication, habitat degradation and fragmentation, acidification and climate change (see references in Poikane *et al*., 2017). WWF (2016) reported a decreasing Living Planet Index (LPI) for freshwater ecosystems based on biodiversity assessments that indicate the health of freshwater ecosystems is declining. The number of threatened and endangered species in freshwater ecosystems is also increasing (Jelks *et al*., 2008), further indicating poor health of inland waters. To comply with the European Union Water Framework Directive, which mandates that European countries achieve "good" ecological quality of their aquatic ecosystems, countries have established fish-based assessments of inland water quality. These assessments are often based on the index of biological integrity or similar measure (Karr, 1981).

Welcomme (1985) observed that the species composition of the catch from river fisheries changes in response to fishing pressure. The abundance and presence of larger species at various life stages decreases from the river in response to fishing, whereas the abundance of smaller species increases. Often production in these systems remains constant or even increases as the smaller species with faster growth and recruitment become more abundant in the river and in the catch.

Thus, it is apparent that biodiversity of fish can and do serve as indicators of ecosystem health and as an indication of overfishing. However, lack of adequate surveys (Revenga and Kura, 2003) and of standardization among studies prevents comparisons or global assessment of the different waterbodies and fisheries (Poikane *et al*., 2017).

9.1.2 ROLE OF AQUATIC BIODIVERSITY AS FOOD

The biodiversity of inland waters provides goods to people around the world in the form of fishery resources (see Chapter 3.3) and the capture fisheries of Asia have the highest levels of biodiversity (Figure 9-1) as measured by "species units" in FAO Fisheries Statistics.[51] The low number of species units reported from the former Union of Soviet Socialist Republics (USSR) may reflect problems in reporting inland fishery statistics following its dissolution.

[51] Numbers derived from FAO FishStatJ, which contains entries at a several taxonomic levels, e.g. species, family, order or phyla, depending on how member governments report their fishery statistics to FAO.

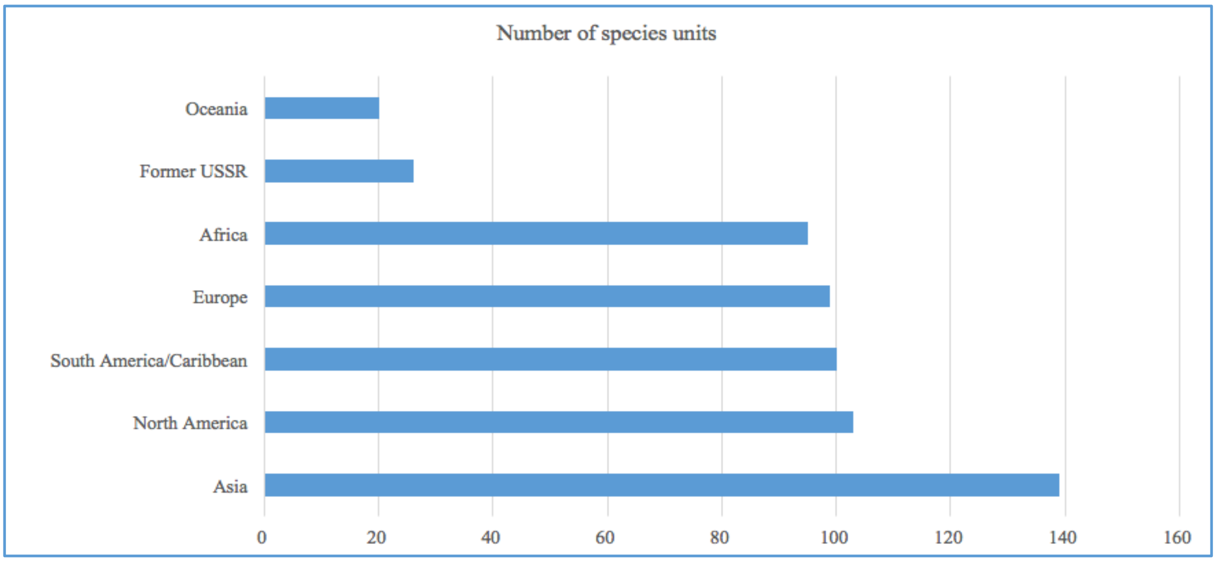


Figure 9-1: Number of "species units" taken from inland waters by continent

Source: FishStatJ – Capture Fisheries data set

Fish are the most diverse taxa with nearly 300 species units arising from inland waters as reported to FAO (Table 9-1). This is about 1 percent of the total diversity of all fish species. The extremely low diversity of invertebrates and aquatic plants reported is probably an underestimate and probably reflects difficulties in obtaining data from small-scale and artisanal fisheries (see Bartley *et al*., 2015).

Table 9-1: Biodiversity of wild and farmed species units (production in 2014)

	Wild species all aquatic environments	Freshwater capture		Freshwater farmed	
	Species (units)	Species (units)	Production (tonnes)	Species (units)	Production (tonnes)
Finfish[1]	31 000	294	10 915 729	221	43 378 850
Molluscs[2]	85 000	3	345 833	5	277 743
Crustaceans[3]	52 000	19	506 911	20	2 744 537
Plants (macro and micro)[4]	Vascular macrophytes 2 614 Algae 24 931	3	2 560	5	86 033*

[1] From Fishbase; [2]Balian *et al*. (2008); [3]Martin and Davis (2001); [4]Algaebase.org and Balian *et al*. (2010)

* Mostly spirulina

Source: FishStatJ, 1 May, 2017

The first draft report on the *State of the world's aquatic genetic resources for food and agriculture* (SoWAqGR) (FAO, forthcoming) confirmed the importance of inland waters as a fishery resource for wild relatives of farmed species (Figure 9-2). Rivers supported the highest levels of fisheries based on wild relatives, with reservoirs and lakes ranked thrid and fourth. The SoWAqGR further revealed that many fisheries based on wild relatives are declining and that habitat loss and degradation were the main causes of the decline (see threats Section 9.4.4).

Inland waters still provide wild relatives to the growing aquaculture subsector with many farmed types derived from wild relatives. There are numerous farmed species that are taken directly from the wild for growout or for spawning. Wild relatives are also frequently used as a source of new genes in aquaculture breeding programmes.

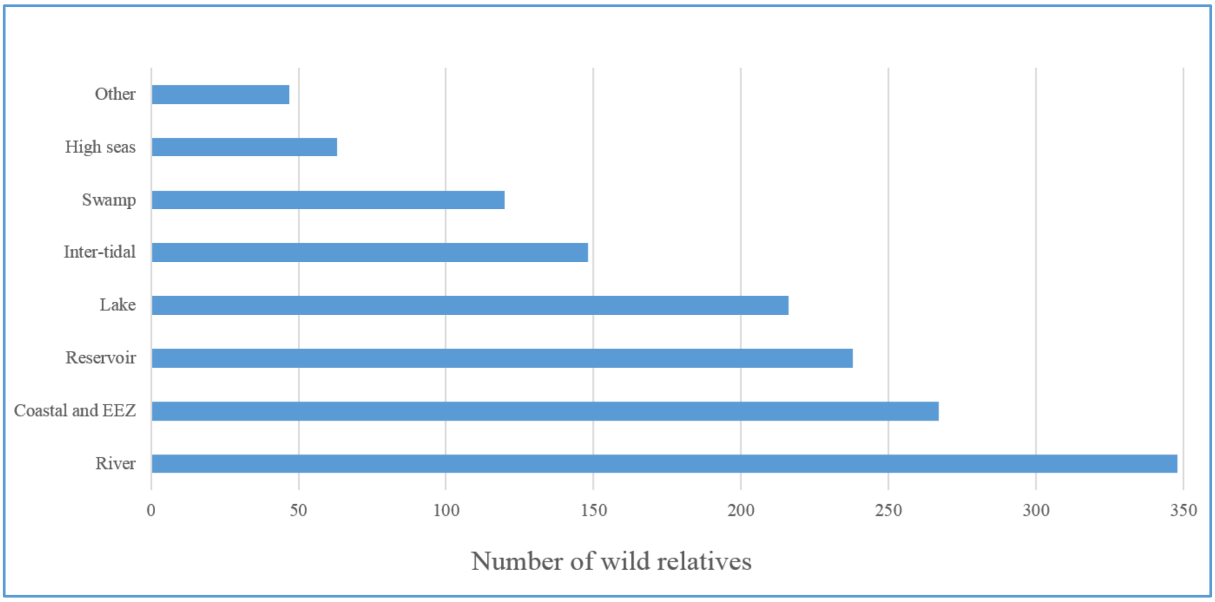


Figure 9-2 : Source of wild relatives of aquaculture species by habitat

Source: FAO (forthcoming)

The biodiversity of freshwater plants is extensive and often a significant part of people's diet. Except for rice, which has not been included in this analysis, practically no freshwater plants are reported to FAO and therefore not covered in FAO fishery (Table 9-2) or agriculture statistics.

Table 9-2: Freshwater macrophytes – indicative examples of freshwater macrophytes often overlooked by FAO statistics in fisheries and agriculture

Common name	**Species**	**Use(s)**
Emergent and submerged species – species normally grow in shallow water of less than 1 metre, with their vegetative growth above the water surface (emergent) or below water surface (submerged) and basally rooted into the soil substrate.		
Reeds Nutgrass/sedge Cattails	*Cyperous rotundus,* *Phragmites karka* *Typha angustifolia*	Roofing and housing construction material, making furniture, mats and basket ware, and as a pulp for waterproofing in house construction
Lotus	*Nelumbo nucifera*	Ornamental and spiritual icon, tubers and seeds eaten cooked
Wild rice	*Zizania aquatic*	Native American staple similar to rice
Yellow Burhead	*Limnocharis flava*	Eaten in soups, curries, salads and stir-fry dishes
Water chestnut	*Eleocharis dulcis*	Eaten raw or ground into flour
Water morning glory	*Ipomoea aquatic*	Widely cultivated for its leaves and shoots in a variety of food uses
Water mimosa	*Neptunia oleracea*	Eaten raw or as cooked vegetable
Watercress	*Rorippa nasturtium aquaticum*	Eaten as young sprouts or older plants as a vegetable
Water dropwort	*Oenanthe javanica*	Eaten as a vegetable
Floating species – no physical contact with the soil substrate below, although they do have an extensive root network that is suspended in the water column to a depth of 0.25 to 0.75 metre.		
Water hyacinth	*Eichornia crassipes*	Ornamental plant and as phytoremediation for water
Duckweed	*Lemna spp*	Aquaculture fish feed ingredient and as phytoremediation
Watermeal / duckweed	*Wolfia spp*	World's smallest flowering plant high in protein, similar uses to Lemna

Source: Leschen (2017)

The current literature on vulnerability, food security and ecosystem services has tended to emphasize cultivated foods (MEA, 2005; Barucha and Pretty, 2010). In complex rural food systems this tends to undervalue the wide range of biodiversity that is often utilized as food. It is easy to overlook a wide range of non-fish aquatic species, i.e. amphibians, invertebrates, reptiles and plants, crustacea and molluscs, that are often harvested in inland fisheries.

The use of aquatic biodiversity is particularly important in some countries, where there may be a dependency on open access aquatic resources for nutrition, income and as a source of resilience to food shocks. Aquatic wild food species can be found in or around other farming systems and production environments. An example is the harvesting of wild species from paddy fields (Table 9-3).

Table 9-3: Utilized biodiversity from Asian paddy fields

Taxa	**Number of species**	**Example species**
Crustaceans	11	Freshwater shrimp for food
Fishes	145	Common carp, tilapia for food
Molluscs	15	Freshwater mussels for food and ornaments
Reptiles/Amphibians	13	Frogs for food, snakes for medicine
Plants	37	Water spinach for food, lotus for food and ornament
TOTAL	**232**	

Source: Balzer, Balzer and Pon (2003) and Halwart (2008)

A wide variety of aquatic animal and plant species are used from these systems (Price 1997; Meusch *et al*. 2003; Halwart, 2008; Guttman, 1999). In several Asian countries where traditional rice cultivation is still practiced (e.g. Lao PDR, Cambodia, Indonesia, Thailand, Viet Nam, Myanmar and southern China) wild fish and other living aquatic species from in and around paddies contribute more than 50 percent of total protein intake as well as being a source of income (Balzer, Balzer and Pon, 2003; Halwart, 2008). In some cases, the value of the non-rice biodiversity is higher than the value of the rice (Muthmainnah and Prisantoso, 2016).

In forest areas, non-timber forest products (NTFP) are a key component of the ecosystem used by rural communities. However, fish and other aquatic biodiversity are often overlooked as a significant component of NTFP (Meusch *et al*., 2003). In Lao People's Democratic Republic, over 350 different aquatic species, including fishes from families Cyprinidae, Pangasiidae, Siluridae and Notopteridae as well as molluscs, crustaceans, snakes and amphibians were utilized (Foppes and Ketpanh, 2004) from forest areas. However, as with the biodiversity of rice fields, this resource is seldom recorded in official fishery statistics.

There has been speculation that high levels of biodiversity lead to higher levels of fishery production and increased ecosystem stability. Leveque (1995), focussing on freshwater lakes, found "no relationship between fish diversity and fishery production, and species richness does not appear to be a major determinant of basic production trends".

More recently, McIntyre *et al*. (2016) found that inland fishery catch was positively correlated with species richness in rivers, but found no causal relationship. Conversely, Brooks *et al*. (2016) studying a variety of habitats did report a causal relationship. These apparently contradictory findings raise questions as to whether the effect of species richness differs between inland fishery environments (lakes, rivers, mixed habitats). There may also be a latitudinal effect between temperate and tropical regions. In many tropical countries fishers harvest numerous species, often of small size whereas in temperate and developed areas fishers often target only a few large and valuable species. Europe, for example, was the only region in which increased aquatic biodiversity was not correlated with stable harvests. It is clear that the relationship between biodiversity and catch is complex. The authors mentioned in this paragraph, and others, have noted the lack of information on and awareness of freshwater biodiversity and their value as ecosystem services (See Section 3.3, ecosystem services); increased efforts are needed to address this gap.

9.1.3 THE HIGH DEPENDENCE OF AQUACULTURE ON WILD RELATIVES OF FARMED SPECIES

Wild relatives of farmed aquatic species play important roles in both aquaculture and capture fisheries. The majority of the reports (88 percent) in the *State of the world's aquatic genetic resources* indicated that wild relatives contribute to capture fishery production (FAO, forthcoming). Many of the wild relatives not fished were introduced species or fishes for which capture fisheries would be highly regulated, e.g. sturgeons because of their listing in CITES appendices.

The ninth step in the *Rome Declaration: ten steps to responsible inland fisheries*, is "Make aquaculture an important ally" (FAO/MSU, 2016). The alliance will be beneficial to both inland fisheries and aquaculture. However, aquaculture can have serious adverse impacts on biodiversity. Aquaculture will continue to grow and must do so with due regard for wild relatives of farmed species and biodiversity. The current list of farmed aquatic species reported to FAO contains over 500 species items from inland, marine and coastal waters. Farmed aquatic species are derived from an incredible taxonomic diversity that includes two kingdoms and over four phyla (chordata, mollusca, arthopoda and echinodermata). The country reports submitted for the *State of the world's aquatic genetic resources* (FAO, forthcoming) demonstrated that the "wild types" are the most common types used in aquaculture.

In addition to farming wild types, many aquaculture facilities depend on organisms from the wild for a supply of seed, juveniles and broodstock in aquaculture or hatchery facilities. Overall, 89 percent of countries reported that aquaculture depended on aquatic organisms collected from the wild to some extent (FAO, forthcoming).

The use of wild types in aquaculture reveals how dependent aquaculture still is on aquatic species found in natural ecosystems. However, countries reported numerous cases where the abundance of wild relatives was currently decreasing and is expected to decrease further in the future. The main reason for the change in numbers of wild relatives, as indicated by trends in catch, was change in habitat. Change in habitat could be both positive, e.g. rehabilitation of habitat, or negative, e.g. pollution. Climate change for example could increase the range and abundance of species well adapted to warm water, but would decrease abundance of species less tolerant to warmer temperatures. The country reports did not indicate that fishing pressure was a major cause for the change in abundance of wild relatives of farmed species. For many inland capture fisheries, factors outside of the fishing sector, e.g. draining wetlands and damming of rivers, have a much larger impact than fishing pressure (FAO, 2014).

Almost half (47 percent) of the responses summarized in the *State of the world's aquatic genetic resources* (FAO, forthcoming) indicated that deliberate stocking and escapes from aquaculture facilities had negative impacts on wild relatives. These responses were mostly related to the genetic issues of poorly managed stocking programmes and negative interactions of aquaculture stock with wild relatives. The negative interactions included inter-breeding of escaped farmed-types with wild relatives, transmission of disease, predation, and competition for resources and space. The *State of the world's aquatic genetic resources* indicated few positive impacts of purposeful stocking and escapees on wild relatives and those were largely based on the perceived positive impacts of culture-based fisheries and stocking to establish capture fisheries and species recovery programmes.

Furthermore, species transferred between regions for aquaculture purposes have resulted in the introduction of diseases, which have severely impacted aquaculture production or stocks of wild relatives. For example, the Noble crayfish (*Astacus astacus*) was decimated in the wild as a result of crayfish plague (*Aphanomyces astaci*), which was spread via the introduction of the signal crayfish (*Pacifastacus leniusculus*).

Numerous species in the wild have potential for use in aquaculture, either through captive breeding and domestication or by sourcing material from wild populations. Some of these new species for aquaculture are well established in other parts of the world. Some countries may want to begin aquaculture development with easy to farm species such as Nile tilapia, whereas other species are being developed in research or pilot scale operations. The top ten taxa for future use in aquaculture as indicated in the *State of the world's aquatic genetic resources* are: *Mugil cephalus; Macrobrachium* spp.; *Sander lucioperca*; *Epinephelus* spp; *Lutjanus* spp.; Milkfish; *Perca fluviatilis*; Holothuroidea; *Centropomus* spp.; and *Heterotis niloticus*. Seven of the ten species are freshwater or brackishwater species.

9.2 THE EXTENT OF GLOBAL FRESHWATER BIODIVERSITY

Although freshwater ecosystems cover less than 1 percent of the world's total surface area (Gleick, 1998) they are home to a disproportionately high amount of the world's biodiversity (about 126 000 plant and animal species) and provide (Balian *et al*., 2008) a wide range of vital ecosystem services such as flood protection, food, water filtration and carbon sequestration (Collen *et al*., 2014).

A discussion of freshwater biodiversity and fisheries, must also address aquatic ecosystems as these support aquatic biodiversity and habitat services that support productive inland fisheries. Inland aquatic ecosystems are being degraded and lost worldwide (see references in Cowx and Portocarrero Aya, 2011). The associated freshwater biodiversity and fishery resources are also being impacted, with freshwater fish considered to be the most threatened group of vertebrates used by humans (Ricciardi and Rasmussen, 1999; IUCN 2010).

This section examines the distribution and diversity of freshwater organisms, the ecosystem services they provide and the threats they face. Focus is on the species that provide food and livelihoods to humans.

9.2.1 THE AMOUNT OF FRESHWATER BIODIVERSITY AND WHERE IT IS FOUND

Freshwater biodiversity occurs in lakes, rivers, floodplains, swamps, and temporary pools on every continent except for Antarctica. Freshwater species can further be found extending into brackish waters (e.g. lagoons and deltas) and even coastal areas. For fish biodiversity, four general groups have been identified according to their tolerance to seawater. Freshwater species can be found in the first three categories (Note: these classifications also apply to other taxa (http://www.fishbase.org):

(1) exclusively freshwater;
(2) occurring in fresh and brackish waters;
(3) fresh, brackish and marine waters; and
(4) occurring exclusively in marine waters.

Reviews have stated that information on the freshwater fish biodiversity, their habitats and the ecosystem services they provide is incomplete. Additional freshwater biodiversity is continually being discovered by the more recent reviews (Collen *et al*., 2014). In proportion to global water surface area, inland waters support a disproportionate number of species of fish and many new species are being described each year (Valbo-Jorgensen, Coates and Hortle, 2009).

Freshwater biodiversity can also be found in aquaculture facilities. The species in aquaculture facilities may be very similar to that found in the wild, but they can also be quite different because of the influence of selective breeding (See Section 9.4.7 on non-native species)

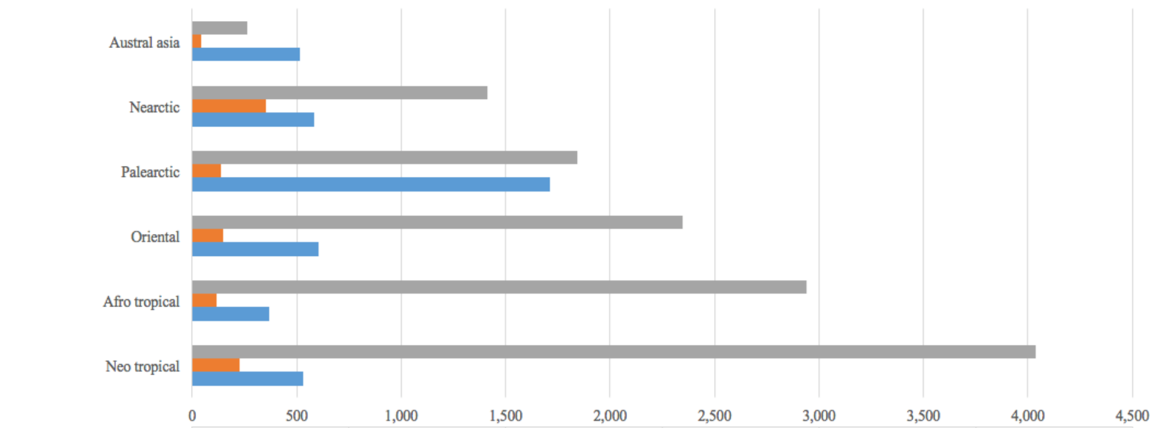
FishBase, in 2005, listed a global total of 28 900 marine, brackish and freshwater fish species of which about 15 000 or a little over half were primary or secondary freshwater species (Leveque *et al*., 2008). Noteworthy is the fact that the estimated 13 000 strictly freshwater fish species live in lakes and rivers that cover only about 1 percent of the earth's surface, whereas the remaining 16 000 species live in marine or brackishwater habitats covering over 70 percent of the earth's surface.

Freshwater fish species belong to 170 families (or 207 if peripheral species are also considered), however the majority of species occur in relatively few groups: the Characiformes, Cypriniformes, Siluriformes, and Gymnotiformes, the Perciformes (notably the family Cichlidae), and the Cyprinodontiformes (Leveque *et al*., 2008).

9.3 HOW IS BIODIVERSITY MEASURED?

9.3.1 BIOGEOGRAPHICAL ASSESSMENT OF BIODIVERSITY

On a biogeographical basis, strictly freshwater fishes (Figure 9-3) and genera are distributed as follows: 4 035 species (705 genera) in the Neotropical region; 2 938 species (390 genera) in the Afrotropical region; 2 345 species (440 genera) in the Oriental region; 1 844 species (380 genera) in the Palaearctic region; 1 411 species (298 genera) in the Nearctic region; and 261 species (94 genera) in the Australian region (Leveque *et al.*, 2008).



	Neo tropical	Afro tropical	Oriental	Palearctic	Nearctic	Austral asia
Freshwater Fish	4,035	2,938	2,345	1,844	1,411	261
Molluscs (excl. gastropods)	226	117	150	137	351	43
Gastropods	533	366	606	1,711	585	514

Figure 9-3: Biogeographical distribution of freshwater fishes and bivalve molluscs

Source: Balian *et al*., 2008

Bivalve molluscs are another important group of freshwater species often used for food and consisting of 1 209 species (Figure 9-3). Balian *et al. (*2008) found approximately 5 000 species of freshwater molluscs that represent about 7 percent of the global total of 80 000 described mollusc species. Gastropods comprise 80 percent of freshwater molluscs, whereas 20 percent are bivalves.

Approximately 6 percent of all insect species, over 100 000 species (Table 9-4), spend at least one of their life stages in freshwater. Aquatic insects are vitally important to aquatic food webs; they also provide food for fish, are vectors for human diseases, and serve as indicators of the health of aquatic ecosystems (Djikstra, Monaghan and Pauls, 2014). The biodiversity in Figure 9-4a is extremely important to ecosystem function. However, for the present analysis the coverage is focused on biodiversity that more directly contributes to human livelihoods and nutrition, and omits coverage of vast amounts of freshwater biodiversity. As with most other taxa, the biogeographic distribution of strictly freshwater biodiversity is highest in the tropical regions and lowest in the islands of Oceania (Figure 9-3 and Table 9-4).

Table 9-4: Freshwater animal diversity by biogeographic realm

Phylum	Biogeographic realm								World
	Pale-arctic	Ne-arctic	Afro-tropical	Neo-tropical	Orienta l	Austra-asia	Pacific Oceanic	Ant-arctic	
Freshwater fish	1 844	1 411	2 938	4 035	2 345	261			12 834
Mollusca	1 848	936	483	759	756	557	171	0	4 998
Crustacea	4 499	1 755	1 536	1 925	1 968	1 225	125	33	11 990
Insecta	15 190	9 410	8 594	14 428	13 912	7 510	577	14	75 874
Annelida	870	350	186	338	242	210	10	10	1 761
Arachnida	1 703	1 069	801	1 330	569	708	5	2	6 149
Collembola	338	49	6	28	34	6	3	1	414
Other vertebrates	349	420	1 057	2 006	1 329	433	8	1	5 401
Other phyla	3 675	1 672	1 188	1 337	1 205	950	181	113	6 109
Total	**30 316**	**17 072**	**16 789**	**26 186**	**22 360**	**11 860**	**1 080**	**174**	**125 530**

Source: Balian *et al.*, 2008

There are about 2 614 species of freshwater macrophytes, which is about 1 percent of the total number of vascular plants (270 000) so far described (Balian *et al.*, 2010). Macrophyte species richness is highest in the Neotropics with about 1 000 species, intermediate in the Oriental region, Afrotropical, and Nearctic regions with about 600 species each, and relatively low in the Australasian, Pacific and Oceanic Island and the Palaearctic regions with about 400 to 500 species each (Balian *et al.*, 2010). Many of these species are used for food and other applications as described below.

At the continental level, South America and Asia have the highest levels of freshwater biodiversity, as measured by number of fish species (Table 9-5).

Table 9-5: Freshwater and brackishwater fish species richness by continents or large sub-continental units (From Leveque et al. 2008 and based on Fishbase, September 2005).

	Freshwater		Brackish/Marine		Total freshwater and brackish	
Continent	**Families**	**Species**	**Families**	**Species**	**Families**	**Species**
Africa	48	2 945	66	295	89	3 240
Asia	85	3 553	104	858	126	4 411
Europe	23	3 30	36	151	43	481
Russian Federation	28	206	28	175	40	381
Oceania	41	260	74	317	85	577
North America	47	1 411	66	330	95	1 741
South America	74	4 035	54	196	91	4 231
Total		**12 740**		**2 322**		**15 062**

9.3.2 ASSESSING BIODIVERSITY BY ECOREGIONS[52]

When considering biodiversity within geographical boundaries (such as continents, subregions and countries), it is often more meaningful to use alternative biogeographic or hydrological groupings that are more meaningful for freshwater organisms. One approach is to provide a description of biodiversity according to hydrological basins and sub-basins. This gives a geographical boundary for where water will accumulate and drain, but may not adequately account for other physical and environmental factors such as elevation, temperature and physical barriers (cascades, plateaus) that define the ranges of certain species and prevent inter-mixing. Ichthyologists have identified such "ecoregions" as large areas encompassing one or more freshwater systems with a distinct assemblage of natural freshwater communities and species. Abell *et al*. (2008) defined 426 ecoregions around the world and have catalogued their species richness and endemism.

These ecoregions are grouped into general habitat categories (Figure 9-4a) that can be mapped onto regions and subregions (Figure 9-4b). South America has the highest level of species richness with an average of more than 200 species per ecoregion (Figure 9-4b). In all the areas, the standard deviation is very close to the average value for species richness indicating that the numbers of species in the ecoregions are very different from each other. Tropical and subtropical upland waterbodies and floodplains were the habitats with the highest levels of species richness (Figure 9-4a). Xeric and closed water basins, and the geographic areas containing many of these habitats had the lowest levels of species richness.

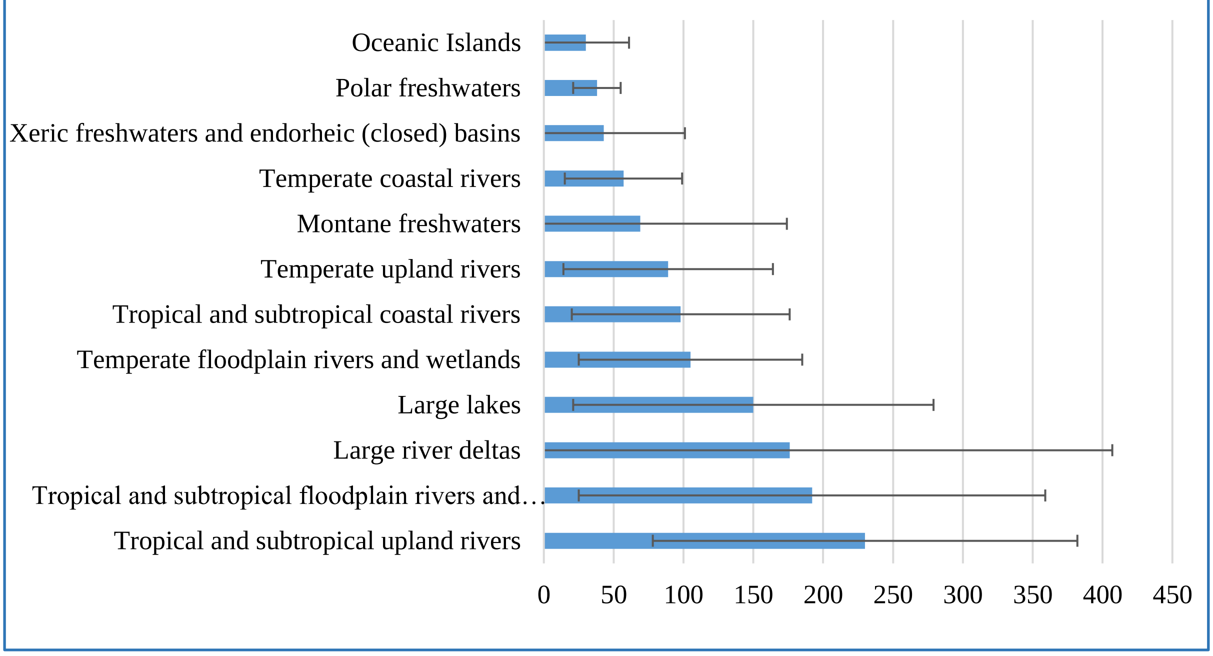


Figure 9-4a: Average species richness per ecoregion by habitat type

[52] Information on ecoregions and major habitat types was from Abell (2008) and kindly provided by Freshwater Ecosystems of the World (http://www.feow.org/). We are especially grateful to Michele Thieme (WWF), Carmen Ravenga (TNC), Paulo Petry (TNC) and Peter McIntyre (U. Wisconsin) for information on species richness and endemism.

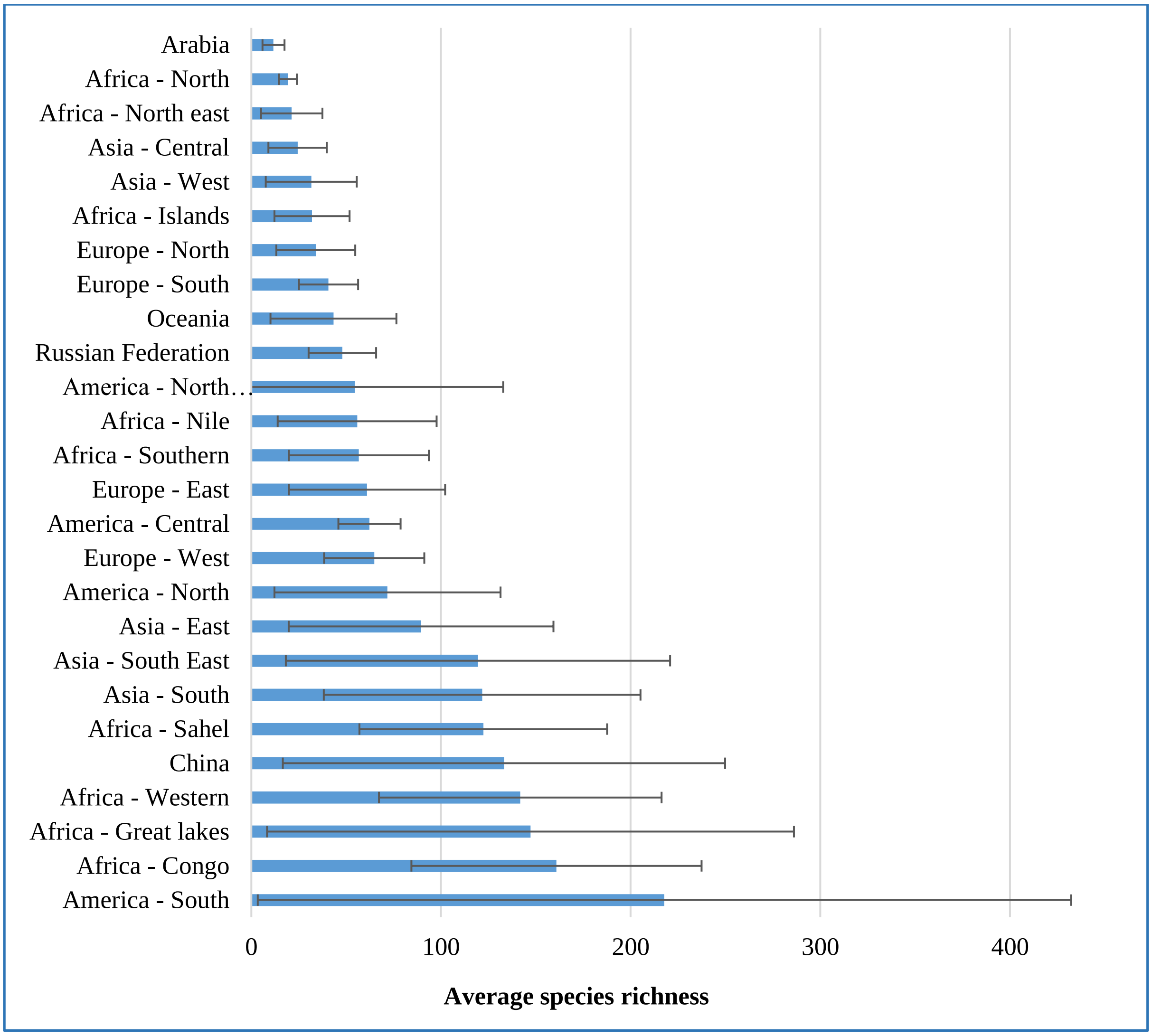


Figure 9-4b: Average species richness per ecoregion by subregion

9.3.3 ASSESSING ENDEMISM AS A MEASURE OF BIODIVERSITY

Another aspect of biodiversity is endemism, i.e. the species that are restricted to only one area. Endemism is highest in South America and follows a similar trend as species richness (Figure 9-5a). With regards to habitat, absolute numbers of endemic species are highest in tropical and subtropical waterbodies followed by large lakes (Figure 9-5b). However, this is partially influenced by the fact that tropical and subtropical ecoregions are more common.

The average number of endemic species per ecoregion included in the habitat type is highest in tropical and subtropical upland rivers, but large lakes emerge as significant habitats for endemism (Figure 9-5c). Perhaps the isolation and availability of microhabitats in large lakes promotes speciation of unique, i.e. endemic, organisms.

Endemism is also unusually high in some habitats. For example, in Eastern Africa, 632 endemic animal species were recorded in Lake Tanganyika and in South America, and there were an estimated 1 800 species of fish endemic to the Amazon River basin (Darwall and Revenga, forthcoming; Darwall *et al.*, 2005).

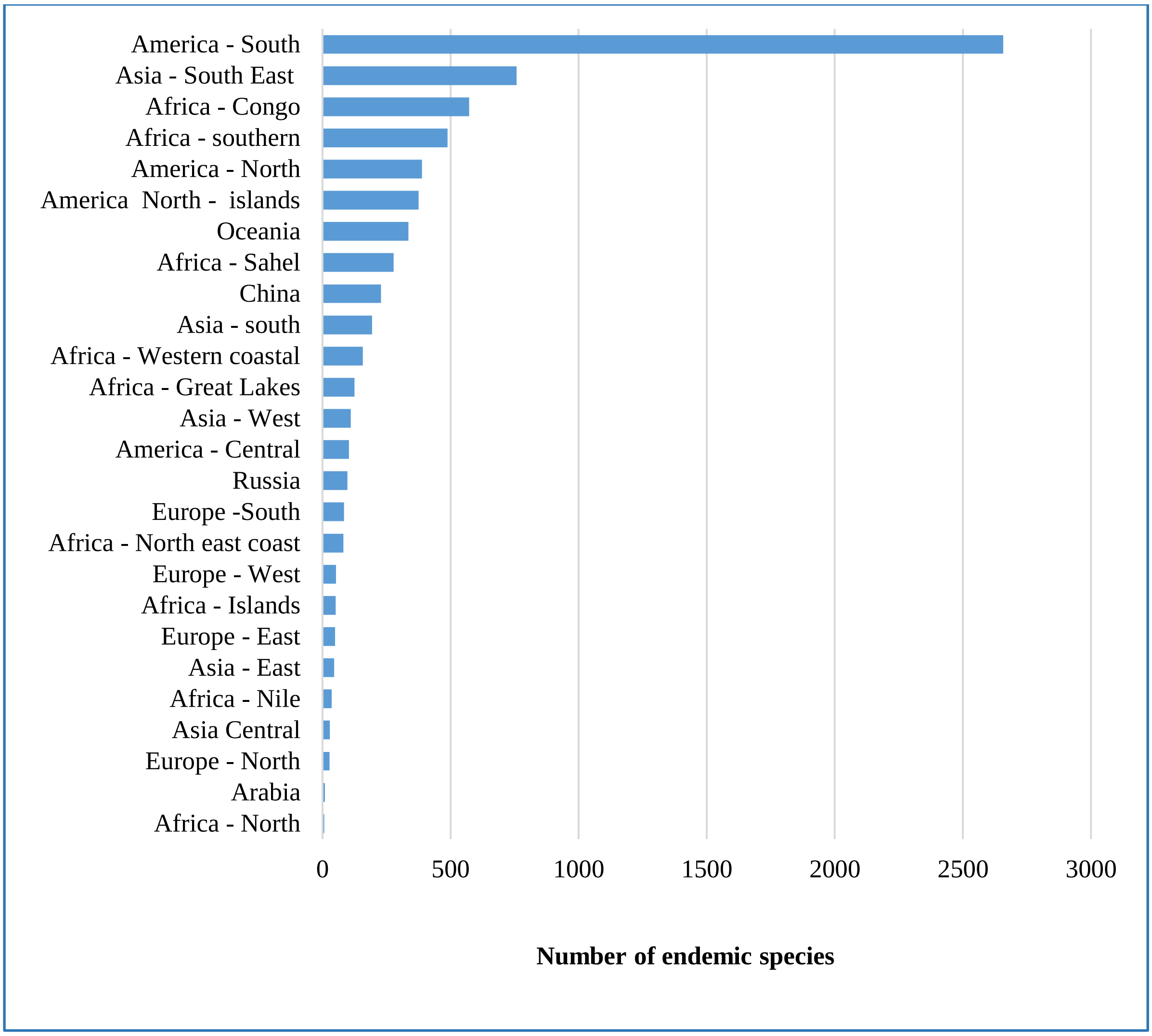


Figure 9-5a: Endemism in freshwater biodiversity by subregion

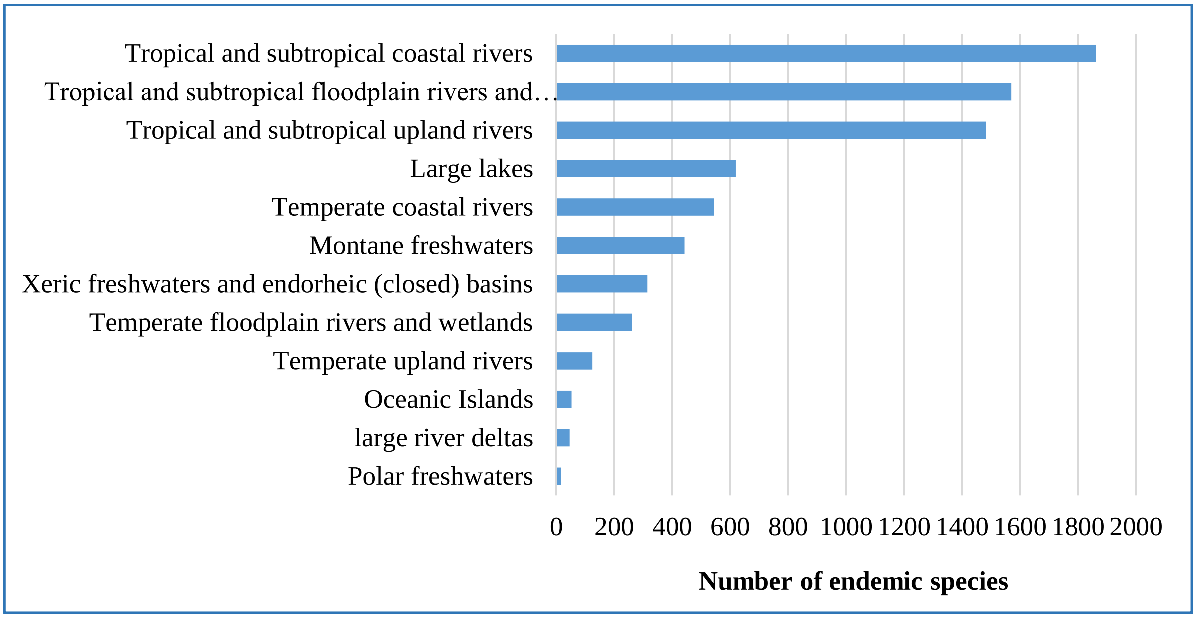


Figure 9-5b: Endemism in freshwater biodiversity by major habitat type

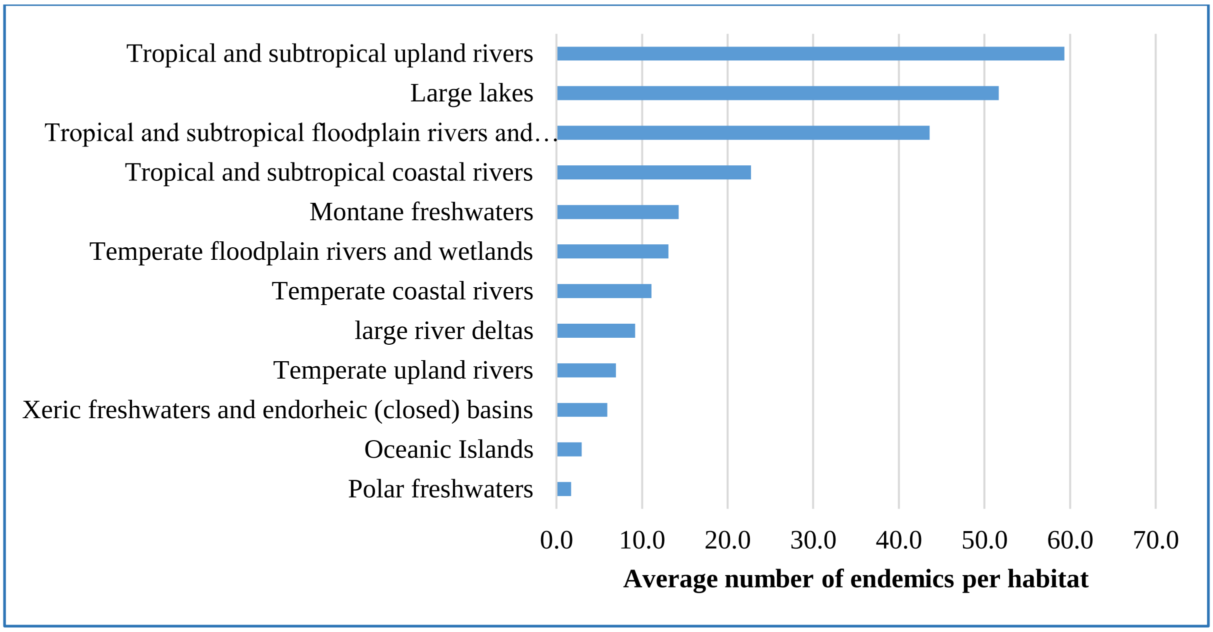


Figure 9-5c. Average endemism in freshwater biodiversity by major habitat type

Globally, there is a positive correlation between number of ecoregions in a geographical subregion and the number of endemic species in the subregion (Figure 9-6). However, the high standard deviation of species richness of ecoregions in a subregion (Figure 9-4b), and the positive correlation between number of ecoregions and number of endemics in a subregion demonstrate that ecoregions are very different from each other and are appropriate as a unit of study or management unit for understanding better how to use and conserve freshwater biodiversity.

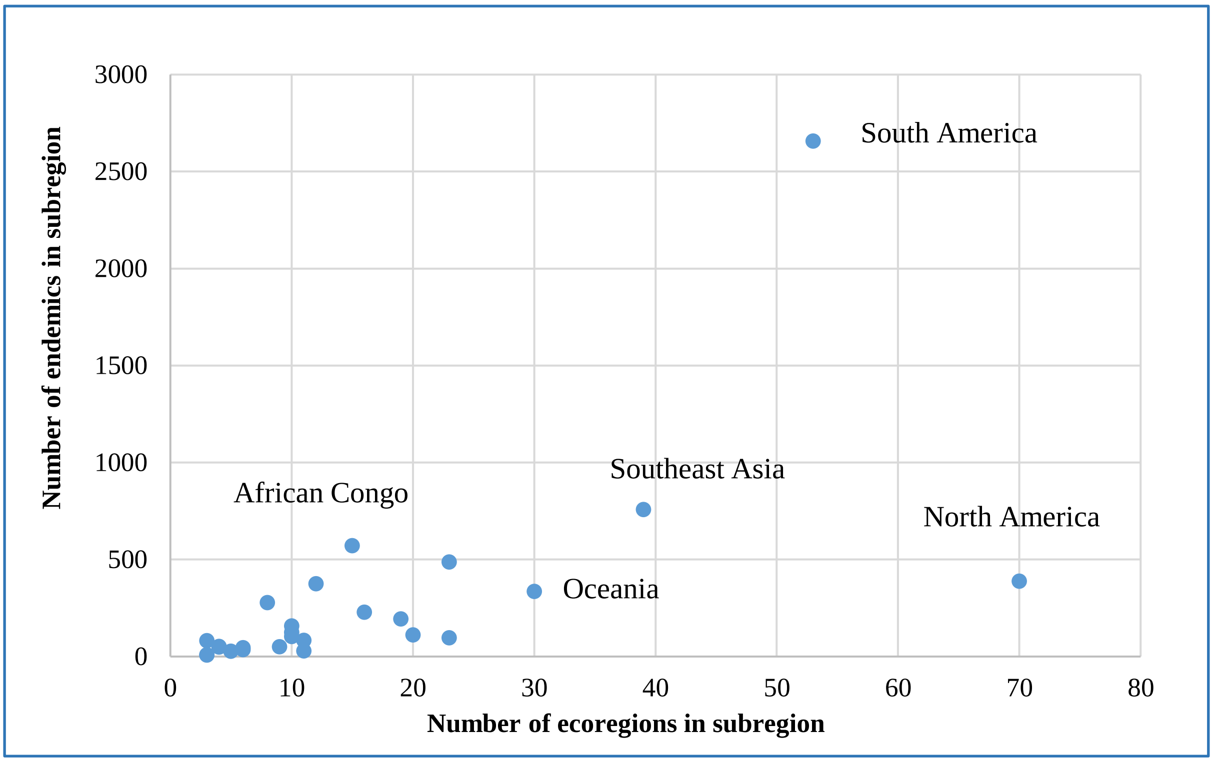


Figure 9-6: Number of endemic species as function of number of ecoregions

The difficulty with using ecoregions as management units is that they often are not practical to manage from a political or hydrographic point of view. River basins have been proposed as the more appropriate and practical management unit (Darwall *et al*., 2009). River basin authorities have been established for some major river systems,[53] but very few authorities have been established on specific ecoregions.

Useful future work could involve mapping ecoregions and their species richness and endemism onto the major river basins of the world. However, again, accurate information on the diversity of freshwater organisms is difficult to obtain. One of the problems is non-standard reporting. For example, some authors report biodiversity at the genus level, whereas others report at family and species level; some authors exclude species that live in both coastal and inland areas.

9.3.4 THREATS TO AQUATIC BIODIVERSITY

Inland ecosystems are very biodiverse. However, this diversity and its supporting ecosystems are under threat from natural and anthropogenic impacts (see references in Cowx and Portocarrero Aya, 2011; Ricciardi and Rasmussen, 1999; IUCN 2010; McIntyre *et al*., 2016). Freshwater habitats associated with 65 percent of the world's rivers were classified as moderately to highly threatened and threats are highest in areas that are most heavily settled by people (Vorosmarty *et al*., 2010). Rivers provide the majority of inland fishery catch and about 90 percent of the total inland fishery harvest is from river basins experiencing higher than average levels of threat (McIntyre *et al*., 2016).

The main stressors to inland waters are water resource developments, e.g. draining wetlands, irrigation schemes, dam impoundments, and pollution (Vorosmarty *et al*., 2010). Other general stressors include catchment disruption, e.g. addition of cropland and livestock, and biotic factors such as disruptive fishing practices, aquaculture and introduction of non-native species (Leveque *et al*., 2008; Vorosmarty *et al*., 2010). Some impacts of these stressors are listed in Table 9-6.

Table 9-6: Summary of anthropogenic impacts, including climate change on biodiversity

Typical impacts of habitat loss and degradation	Loss of wild habitat and water flows because of changes in rivers, wetlands and waterbodies caused by changing land use, watershed development and drainage of freshwater wetlands, which reduces the available habitat to sustain populations, impacts the function of habitats during critical seasons (over-wintering; dry season refuges).
	Physical obstruction and changing water flow regimes impacting upstream and downstream migration and reproduction of riverine species. Caused by damming of rivers and loss of connectivity in waterways (low water control structures, weirs, irrigation structures).
	Changing ecosystem quality (driven by land management, watershed management) leading to increased soil erosion and sediment loads in waterbodies. Directly affects species sensitive to poor water quality and can affect quality of spawning grounds or nurseries.
Impacts of pollution of waters	Direct effect of toxins and heavy metals from untreated industrial discharges, e.g. fish kills, feminization, inedible fish.
	Indirect effect of effluents from urbanization leading to eutrophication and changed water quality and food chains.
	Direct impact on fish through feminization effects (oestrogen-analogues in effluents).

[53] http://riverbasins.wateractionhub.org/

Table 9-6: Summary of anthropogenic impacts, including climate change on biodiversity

	Nutrients from agriculture runoff leading to eutrophication of waterbodies causing loss of more oligotrophic species; impact of increased nutrients can also be positive for those species adapted to highly productive waters.
	Pesticide runoff from agriculture directly affecting fish, or indirectly through ecosystem level impact on prey/food chains.
Impact of demand for seed or broodstock	Some aquaculture systems still rely on the wild relatives as the source of seed for stocking. This may be completely benign as in the form of capturing natural spatfall from molluscs (clams, oysters, mussels, cockles), or be considered harmful as wild stocks are "mined" for aquaculture, e.g. glass eel collection. The active fishing for seed for stocking may have greater impact if that activity takes place after there has already been significant mortality during recruitment. In this case there can be direct impacts on the wild population (e.g. collection of juveniles for ongrowing).
Impact of non-native species	Negative impacts include reduced biodiversity because of predation (e.g. Nile perch), competition (non-native salmon competing for spawning sites and food; zebra mussels competition for plankton with juvenile native fishes) and habitat alteration, e.g. (crayfish burrowing in substrate undermining riverbanks and levees). Positive impacts include increased species diversity and improved habitat (e.g. addition of grass carp to reduce aquatic weeds).
Impact of climate change	Inland biodiversity is often confined to specific river basins or streams (see endemism section above) and therefore cannot migrate as marine species can when habitat starts to degrade. Negative impacts include reduced numbers and range of populations because of habitat degradation, e.g. temperature increase and acidification. However, increased temperature and rainfall can increase biodiversity in some areas because of increased primary productivity and where species are limited by their cold-tolerance. Documented impacts of climate change on fisheries are heavily biased towards salmonids (Myers *et al.*, 2017).
Impact of overfishing	Excess fishing pressure can change the community composition of inland ecosystems by removing the larger, slower growing species (fishing down the food web) (Welcomme, 1985). Fishing also exerts a selective pressure on target species, e.g. early maturity and small size at age of first maturity, as well as on non-target species through by-catch and discards (although by-catch and discards are less of an issue in small-scale fisheries where most of the catch is used).
Impacts of disease	With the increased movement and trade of species for aquaculture and stock enhancement, there is an increase in the occurrence of pathogens and parasites in many inland ecosystems. Native species when improperly managed can become diseased and spread the disease to wild relatives. Examples of pathogens or parasites associated with non-native species include the crayfish plague introduced to Europe and Scandinavia from North America; EUS (Kamilya and Baruch, 2014) was first discovered in farmed fish in Japan and has since spread to other parts of Asia, North America and Africa. Incidence of Gyrodactylus in British Columbia, Canada has increased in wild salmon, but whether this is because of the presence of salmon farms or another environmental variable is unclear. The swimbladder worm (*Anguillicola crassus*) in eels introduced in the 1980s constitute a serious threat to indigenous stocks of eel in Europe. Asian eels are tolerant to the disease but Dutch analyses show that problems with spawning migration of European eels can occur if the infestation is serious enough.

The main threats to biodiversity, i.e. pollution and water resource development, also influence human water security. According to the Convention on Biological Diversity, 41 percent of the world's population lives in river basins under water stress (CBD, 2005). Remedial actions often address human water security needs while further threatening freshwater biodiversity through inappropriate policies and actions (Vorosmarty *et al.*, 2010).

Table 9-7: Types of pollution and their potential impact on biodiversity

Source of pollution	Typical pollutants	Impacts
Untreated or inadequately treated domestic sewage	Organic and inorganic, nitrogen and phosphates	Eutrophication and loss of water quality in waterbodies (ecosystem impact on wild relatives)
		Harmful algal blooms
	Some heavy metals and organic compounds	Sub-lethal effects on performance
		Oestrogen analogues causing feminization
Improperly stored solid waste	Leachates from landfill	A wide range of pollutants from urban and domestic garbage directly toxic to aquatic life
Industrial organic and inorganic wastes	Mining wastes (heavy metals suspended solids)	Direct toxicity Sub-lethal effects on performance
		Clogging of gills impacts on water quality Fouling of spawning areas
	Heavy metals, organic compounds in industrial wastewater discharges and their accumulation in sediments	Direct toxicity in acute cases Heavy metal accumulation (possible impacts on breeding performance in wild relatives (Pyle, Rajotte and Couture, 2005)
Agricultural run-off and wastes	Nutrient runoffs from agricultural fertilizers	Eutrophication and loss of water quality in waterbodies (ecosystem shifts) Loss of habitat impacts wild relatives
		Harmful algal blooms
	Pesticide runoff	Direct toxicity on wild relatives Indirect impacts on prey organisms
Soil erosion and sedimentation	Suspended solids/sediments	Clogging of gills impacts on water quality Fouling of spawning areas
	Acidity	Direct acidification impacts
Oil/gas exploration	Oil and oil dispersant Heavy metals and organic compounds in drilling muds and cuttings	Direct toxicity on wild relatives Indirect toxicity on prey (more infamous in the marine environment, but see Niger River)
Power generation	Waste heat (from industry and power generation)	Establishment of warm water invasive species Displacement of wild relatives
Aerosol and atmospheric pollution	Acid rain – acidified land and water un off mobilizes heavy metals	Direct toxicity of mobilized metals and acidity
	Dioxins – from industry/waste incineration	Accumulation in food chains with impacts on reproduction and performance of wild relatives Accumulation in fish used for fish meal
Radioactive waste	Radionuclide release from reprocessing or irresponsible disposal. Relatively point source	Accumulation of radionuclides in wild relatives

Information from countries reporting for the *State of the world's aquatic genetic resources for food and agriculture* (FAO, forthcoming) indicate that many populations of wild relatives of farmed aquatic species are decreasing. The main reason for the decrease was lass of habitat, most likely due to competition for resources, e.g. water and land, and habitat degradation. Pollution also has a profound negative impact on freshwater biodiversity and comes from a variety of sources (Table 9-7).

9.3.5 DECLINE IN BIODIVERSITY IN FRESHWATER ECOSYSTEMS

The stressors above have resulted in a significant loss of biodiversity in many freshwater ecosystems and these systems are one of the most altered and threatened because of human activities (Ricciardi and Rasmussen, 1999; Revenga and Kura 2003). Moyle and Leidy (1992) estimated that more than 20 percent of the world's 10 000 described freshwater fish species have become extinct, threatened, or endangered in recent decades. Freshwater environments tend to have the highest proportion of species threatened with extinction (MEA, 2005) and freshwater fish are the most threatened group of vertebrates used by humans (Ricciardi and Rasmussen, 1999).

The impact of increased human population on wild relatives of farmed species was predicted to be generally negative (65 percent) in the *State of the world's aquatic genetic resources for food and agriculture* (FAO forthcoming), with only seven percent of the respondents considering there would be positive effects. The consideration was that increasing populations and consequent demand for fish would drive overfishing of wild relatives. This would particularly affect the most vulnerable species if not managed effectively. Vulnerable species have life history traits such as late maturation, low fecundity and complex breeding or migratory characteristics. This breeding complexity also means that these species are challenging or prohibitively expensive to domesticate and breed in captivity (e.g. eel, marbled sand goby). This places additional pressure on the wild relatives as the sourcing of seed for aquaculture is typically through the capture of wild juveniles.

9.3.6 MEASURING THREATENED SPECIES AS AN INDEX OF THREATS TO BIODIVERISTY

The IUCN (2010) developed a Red List that is a compilation of the conservation status of numerous species both terrestrial and aquatic. According to the Red List, the absolute number of species that is vulnerable to extinction, threatened, endangered, critically endangered, extinct in the wild and extinct is highest in Asia followed by Africa (Figure 9-7).

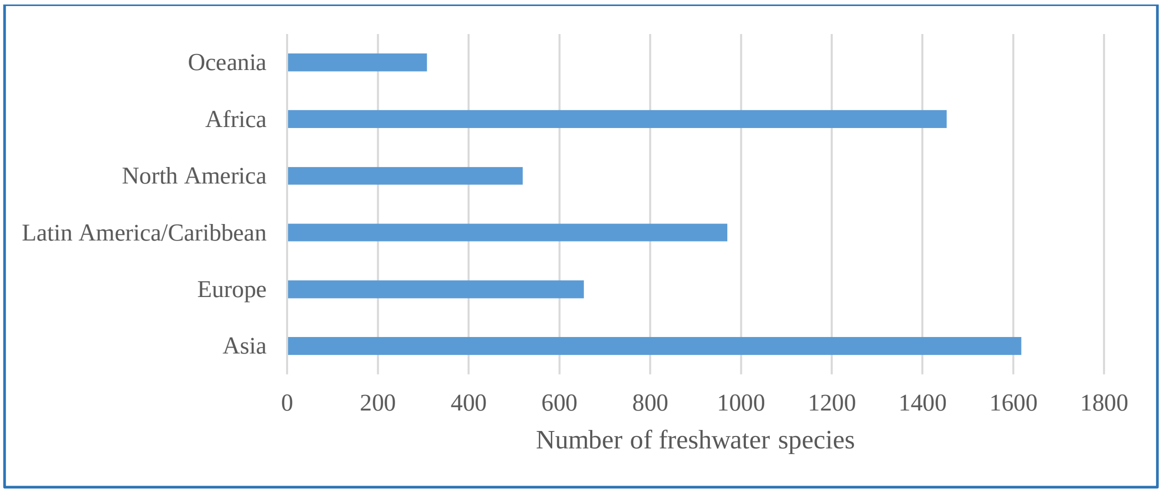


Figure 9-7: Freshwater species (by continent) that appear on IUCN's Red List as vulnerable, threatened, critically endangered, extinct in the wild or extinct

Source: IUCN, 2010

Other assessments of the conservation status of biodiversity have used different criteria for levels of endangerment and may include other freshwater-associated species, e.g. birds and mammals (e.g. WWF's Living Planet Index (WWF, 2016) and therefore may report different values for numbers of threatened and endangered species from those on the Red List. One reason for some discrepancies is that IUCN has not assessed the status of many freshwater species in remote habitats. For example one of the world's smallest vertebrates and the world's smallest fish species, *Paedocypris progenetica,* is restricted to natural peatlands in Indonesia that are being rapidly destroyed. It would appear that this unique species is under some threat because of habitat loss, but the conservation status is unassessed in the Red List. It is clear however, that freshwater biodiversity and ecosystems are being threatened.

In Africa, 21 percent of freshwater species are threatened with extinction and of those species, 91 percent are endemic (Darwall *et al.*, 2011). Fourteen percent of South American freshwater fishes are at some risk of extinction because of land use changes, dam construction, water divergence for irrigation, urbanization, sedimentation and overfishing (Barletta *et al*., 2010). The conservation status of South American freshwater fish faunas appears to be better than in most other regions of the world (Reis *et al*., 2016). In North America, approximately 39 percent of described freshwater fish species are imperilled: 230 species are vulnerable to extinction, 190 species are threatened, 280 species are endangered extant taxa, and 61 species are taxa presumed extinct or extirpated from nature (Jelks *et al*., 2008).

9.3.7 FISH INTRODUCTIONS AND MOVEMENTS

As in terrestrial agriculture, non-native aquatic species (also called alien or exotic species) contribute significantly to production and value in fisheries and aquaculture (Gozlan, 2008; Bartley, 2006). The *State of the world's aquatic genetic resources for food and agriculture* further highlighted the importance of non-native species in fish production (FAO, 2017). Non-native species can either increase or decrease biodiversity in an ecosystem or fishery depending on specific circumstances, such as type of introduced species, the fishery management regime in place and the overall health or characteristics of the receiving ecosystem.

To help maximize the beneficial aspects of fish introductions and minimize the adverse impacts, FAO maintains an information system, the Database on Introductions of Aquatic Species (DIAS), which contains over 5 000 records of introductions across national boundaries. The database may be accessed on compact disc (Bartley, 2006) and online[54] and is linked to FAO production figures and species fact sheets.[55]

Analysis of DIAS revealed that carps, trout, tilapia and oysters were the most widely introduced aquatic species. The draft *State of the world's aquatic genetic resources for food and agriculture* confirmed this general trend with the most often exchanged species (import and export) being *Oreochromis niloticus* followed by *Oncorhynchus mykiss*. Nine of the top ten introduced species were freshwater, diadromous or brackishwater species (Table 9-8).

Table 9-8: Top ten species exchanged by countries (includes both import and export)

Species	Number of exchanges
Oreochromis niloticus	79
Oncorhynchus mykiss	39
Penaeus vannamei	19
Clarias gariepinus	17
Cyprinus carpio	19
Acipenser baerii	13

[54] http://www.fao.org/fishery/topic/14786/en

[55] http://www.fao.org/fishery/factsheets/en

Colossoma macropomum	10
Macrobrachium rosenbergii	10
Penaeus monodon	10
Tilapia zillii	8

Source: FAO, 2017

Non-native species are often deliberately moved into new areas or they may be accidentally moved on fishing equipment, escapes from aquaculture or through natural dispersion when physical barriers have been removed, e.g. the Suez Canal in Egypt that allowed Lessepsian[56] migrations from the Red Sea into the Mediterranean Sea. The DIAS provides lists of known introductions according to purpose (Table 9-9).

Table 9-9: The purpose for introduction of inland fish species, with some examples

Type	% of DIAS records	Purpose of introduction	Example species
Unintentional introduction	4	Diffused from other countries	*Siluris glanis*, red clawed crayfish, *Pseudorasbora parva*
	9	Accidental/deliberate release	*Pseudarasbora parva, Northern snakehead, Xiphophorus hellerii , Gambusia holbrooki* Various ornamental species
Biological control	5	Snail control	Black carp
		Mosquito control	*Gambusia affinis, Poecilia reticulata*
		Other pest control	-
		Weed control	Grass carp
		Phyto-zooplankton control	Silver carp
Production	35	Aquaculture	Salmon, common carp, tilapia, whiteleg shrimp, pangassius, pacu, macrobrachium rosenbergii
	8	Fisheries	Icefish, Lake Tanganyika sardine, Nile perch, tilapia, common carp
	-	Fill ecological niche	Snow trout, silver barb, pacu
	-	Forage	?
Recreation/leisure	-	Bait	*Carassius auratus*, weatherloach, G*ambusia holbrooki*, *Perca fluviatilis, cyprinus carpio*
	6	Angling/sport	Brown trout
	11	Ornamental	Most cultured freshwater ornamental fish
Conservation, research	-	Off-site preservation	
	3	Research	Many species
Others	3	Other reasons	Zebra mussel in ballast water
	16	Unknown	-

Source: Adapted from Welcomme, 1992

In light of the fact that many species can move between fresh and saline waters, introductions here were analysed for all habitats, i.e. fresh, brackish and salt waters. Aquaculture was the most often cited reason for the introduction of non-native species (Figure 9-9). Several of the categories in DIAS that were

[56] Migration through the Suez canal

mentioned only a few times, e.g. "fill ecological niche" and "off-site preservation" were combined into "other".

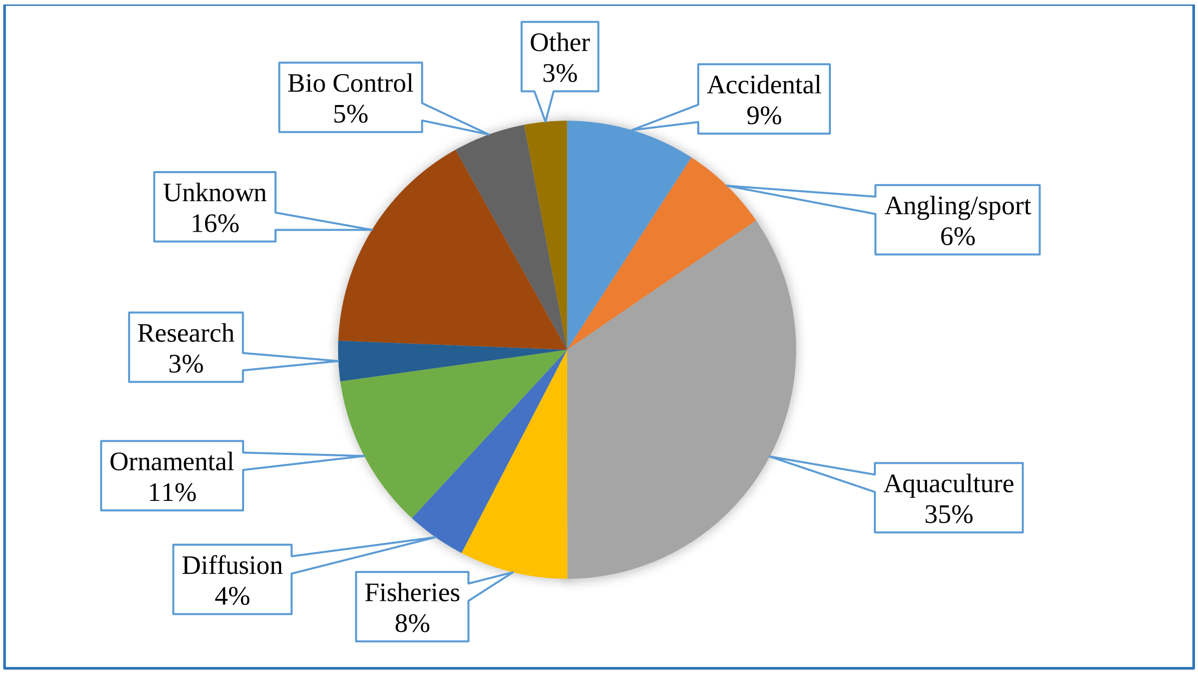


Figure 9-8: Reasons for the movement of non-native aquatic species

Source: DIAS

Previous analysis of DIAS (Bartley and Casal, 1998; Gozlan, 2008) revealed that the majority of introductions of aquatic species have had negligible environmental impact on the surrounding ecosystem or biodiversity. Not all introductions result in the establishment of the species. Some introductions have had serious adverse impacts, e.g. the golden apple snail in the Philippines or the crayfish plague in Europe that arrived with introduced crayfish from North America, whereas other introductions seem to have been benign. More recent analyses of DIAS with more records of introductions have indicated that the majority of ecological impacts have been adverse and that adverse ecological impacts have been greater than positive social and economic impacts (Figure 9-9). A very significant result from the analyses of DIAS is that the majority of recorded introductions have not been assessed. Quantifying the extent of the beneficial or adverse impacts is not currently possible from the information contained in DIAS.

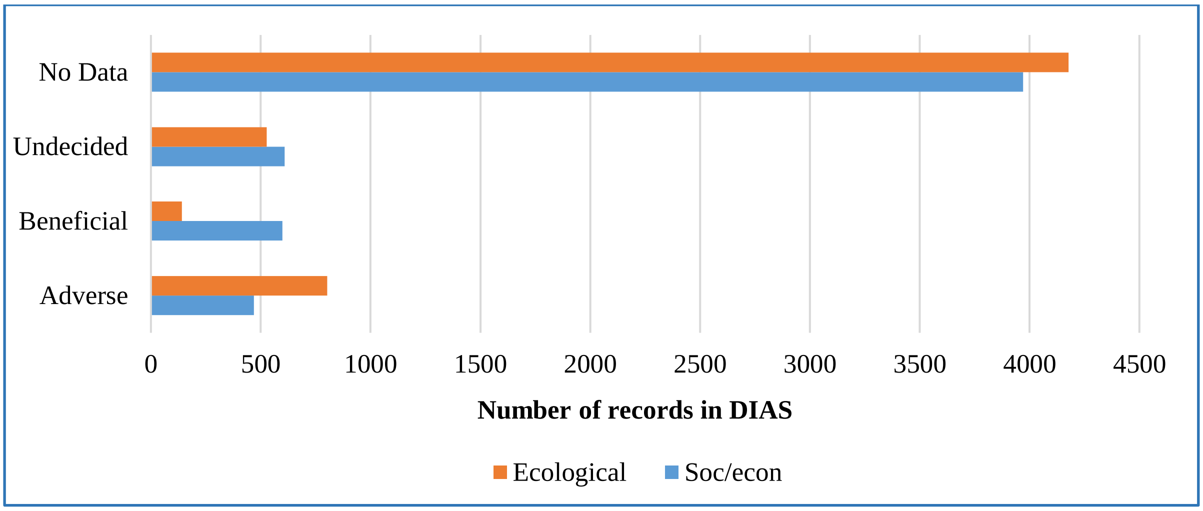


Figure 9-9: Reported ecological and social/economic impacts of non-native species

Source: DIAS

However, non-native species can become invasive and have been identified as one of the major threats to biodiversity throughout the world.[57] In order to minimize the risks and optimize the benefits from non-native species, the international community promotes codes of practice, the use of a precautionary approach to species introduction and risk analysis before an introduction is made (FAO, 1995; ICES, 2005). The codes of practice and risk analysis include social and economic benefits as well as environmental risk (see Bartley (2006) for a collection of documents and international guidelines on non-native species, including the DIAS).

As inland fisheries and aquaculture continue to develop around the world, non-native species, including newly domesticated and genetically improved species, will have a role to play in fish production and food security, however due consideration must be given to both the risks and benefits to both society and the environment. The precautionary approach and risk analysis depend on monitoring and assessing the impacts of non-native species. Unfortunately, these assessments are not usually undertaken, as can be seen from Figure 9-9, and an opportunity to provide more accurate information on the impacts of non-native species has been lost.

9.3.8 CONCLUSIONS

It is clear that inland aquatic biodiversity, including non-native species, contributes to livelihoods and improving the human condition. It is also clear that this valuable diversity is threatened. Evidence suggests that increased biodiversity does positively influence fishery production and stability; it thus becomes even more important to protect these valuable resources and the ecosystems that support them. Currently rivers provide the majority of inland fishery production, but those rivers are under threat (McIntyre *et al.*, 2016). With water abstraction for agriculture expected to increase by 70 to 90 percent by 2050 (Comprehensive Assessment of Water Management in Agriculture, 2007) and since many river systems' inland catches are positively correlated with river discharge, this increased withdrawal of freshwater will further stress freshwater biodiversity's ability to provide food and livelihood.

Inland aquatic biodiversity should be thoroughly incorporated into fishery and habitat management and policy, not only for the conservation of these resources, but also for their long-term impact on food security.

Recent surveys by McIntyre *et al*. (2016), Brooks *et al.* (2016), and Tedesco *et al.* (2017) and publicly available databases such as the Freshwater Ecosystems of the World, as well as the regular reporting of countries to FAO, are providing improved information and synthesis on what further actions and policies can be developed.

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[57] https://www.cbd.int/idb/2009/about/cbd/

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10 ASSESSING THE STATUS OF INLAND FISHERIES

The State of Fisheries and Aquaculture (SOFIA) is a biennial FAO report prepared for the FAO Committee on Fisheries (COFI) and is intended to provide a global overview of the food supply from fisheries and aquaculture, the state of these subsectors, and major trends and issues relating to them. Developing a robust approach to the assessment of inland fisheries is challenging for FAO, but a robust approach to assessment is necessary to provide:

- credible estimates of national and global inland fishery catch;
- an indication of the relative status of the world's inland fisheries (broken down by countries or river basins); and
- information on species, yields and issues in inland fisheries that can be used further as indicators of the state of biodiversity and ecosystem integrity in aquatic ecosystems.

In the absence of a management framework and systematic monitoring, catch statistics do not typically provide a particularly reliable indication of the status of an inland fishery, merely an estimate of their contribution to food supply. Long-term trend analyses of catch are also weak indicators of how well fisheries are managed and the sustainability of the fishing pressure. There are considerable challenges to deriving even an indication of the level of production from many of the world's inland fisheries, let alone detailed assessments as to the condition of the fisheries.

The status of individual fisheries may provide a clearer picture of how well the world's inland fisheries are managed, as well as their health or status. One possible way to derive an aggregate picture of the state of the world's inland fisheries resources is to review the state of major inland fishery basins. If these are tracked over time, it should be possible to see the trend in the number of basins across a number of fishery-relevant indicators (e.g. environmental drivers and fisheries production).

10.1 NATIONAL INLAND FISHERIES PRODUCTION

FAO national statistics provide an indication of fish production and consequently fish supply in individual FAO member countries. National inland fishery production statistics provide a record of the overall economic and nutritional contribution of inland fish to the country and is valuable as part of the normal processes of national statistical accounting. However, they are an aggregate figure for the country and attribution to the source of the production is not provided. The national production figure does not therefore provide much insight to the status of the fisheries that contribute to the production. These may be quite varied, ranging from streams and rivers through to floodplains, natural waterbodies, man-made impoundments, estuaries and wetlands. As an aggregate figure of all of the national freshwater fishery resources, the national figure cannot provide insight into:

- declines in one fishery (or subnational area) that may be matched by gains in another; or
- linkages to transboundary waters and the impacts that may arise from these.

Trend analysis is therefore highly constrained and no definite conclusions can be drawn about the status of the fisheries in a particular country other than that they appear to be generally increasing, decreasing or stable. In a few countries, inland fisheries are highly focused around a particular basin or resource and this may constitute the majority of national production. In such a case it may be possible to align the FAO statistics with the performance of a particular waterbody or river basin (e.g. Ayeyarwady/Irrawaddy River basin in Myanmar; the Gambia River in Gambia; the Sudd wetland in South Sudan).

More typically, inland fisheries take place across a wide range of resources and areas and gains in one type of fishery may be offset by losses in another (e.g. declining river and floodplain fisheries production may be balanced or even outweighed by increasing production from stocked waterbodies). This requires monitoring across a range of waterbody and fishery types.

10.1.1 THE CHALLENGE OF DERIVING INLAND FISHERY STATISTICS FROM SMALL-SCALE FISHERIES

The inland fishery subsector presents many challenges to obtaining reliable statistics and this has been explored extensively in previous FAO and related publications on inland fisheries (FAO, 1999; Coates, 2002; FAO, 2003; FAO/MRC, 2003; FAO, 2011; Lymer and Funge-Smith 2009; Welcomme and Lymer, 2012; Bartley *et al.,* 2015; Mills *et al.*, 2011; Welcomme, 2011).

Inland fisheries are typically characterized as small-scale, remote, dispersed and informal; these characteristics present challenges when monitoring and evaluating fish catches (Lorenzen *et al*., 2016). This means that validation of actual catches is extremely difficult without a comprehensive national inland fishery monitoring system. Typically, if there is any monitoring of inland fisheries, only the major landing sites (e.g. reservoirs and large waterbodies, or large trap fisheries) in the fisheries are monitored. Dispersed catches from smaller fisheries and extensive floodplain fisheries are generally estimated using crude approximation methods or simply rely on local or expert opinion.

The remote and informal nature of much of the inland fishery sector also creates difficulty in capturing the social and economic contributions from surveys. Fisheries-related activities are often undertaken as part of a diversified livelihood strategy, at times of need and away from home, and such activities are difficult to capture reliably in survey questions (Needham and Funge-Smith, 2014). As a result, significant portions of fish catches are often under-reported and the true value of the sector to society is often invisible (Lynch *et al.*, 2016).

There are a variety of reasons why inland fisheries are poorly monitored and why they are often overlooked or given low priority in national policy (Table 10-1).

Table 10-1: Reasons why inland fisheries receive limited official attention

MAIN REASON	UNDERLYING REASONS
Inland fisheries catches are often hidden or "invisible"	Inland capture fisheries landings tend to be low volume and widely dispersed
	Often no centralized landing site and fish are sold locally or consumed by households
	Catch is rarely recorded and production often underestimated (FAO, 2011)
	Catches in rivers and associated wetlands are easy to underestimate because the contributions of numerous fisheries on smaller tributaries and waterbodies are generally overlooked (Coates, 2002; Molden, 2007)
Governments do not consider inland fisheries important contributors to food security, GDP and livelihoods.	Monitoring of fisheries is typically only undertaken on commercial fisheries (to generate revenue) or at locations where substantive landings take place
	Only key inland fisheries are subjected to regular surveys
	Lack of monitoring/recording of fishing activities in river tributaries, minor waterbodies, small streams, floodplains
	The costs of monitoring small-scale fisheries are not returned in revenues to the state

Several studies have compared official statistics on fish catches with case studies and concluded that fish catches could be 0.5 to 5 times higher than official reports (Coates, 2002; FAO/MRC, 2003; Allan *et al.*, 2005; Hortle, 2007; World Bank, 2012; Welcomme *et al.*, 2010; Bartley *et al.*, 2015, Fluet-Chouinard, Funge-Smith and McIntyre, 2018). Some of the more extreme global estimations are considered to be unrealistic because of the underlying assumptions made in extrapolating case examples to the global scale (Welcomme, 2011; Bartley *et al.*, 2015). Typically, this is because of the difficulty in separating potential catch from actual catch as there are no direct estimates of fishing effort. In more recent work, population density has been used as a means to adjust estimates for potential fishing effort (Deines *et al*., 2017).

10.1.2 THERE MAY BE VARIATION IN INLAND FISHERY RESOURCES WITHIN COUNTRIES

There may be substantial variation in the available inland fishery resources within many countries. In Figure 10-1, the shading represents inland fish consumption by sub-national area. The darkest colouration, representing highest fish consumption in both Malawi and Lao People's Democratic Republic is highly correlated to the major fisheries resources in both countries (Lake Malawi and the Mekong River). Variability in inland fish consumption is a particular issue in large countries (such as Brazil, Canada, China, Democratic Republic of Congo, India, Russian Federation and the United States of America) where inland fisheries may be concentrated in a number of subregions of the country that possess particularly rich inland fishery resources. This pattern is also found in some smaller countries where inland fisheries resources may be particularly rich, feeding the local population near a large waterbody, swamp or river floodplain (e.g. Malawi, Cambodia, Lao People's Democratic Republic).

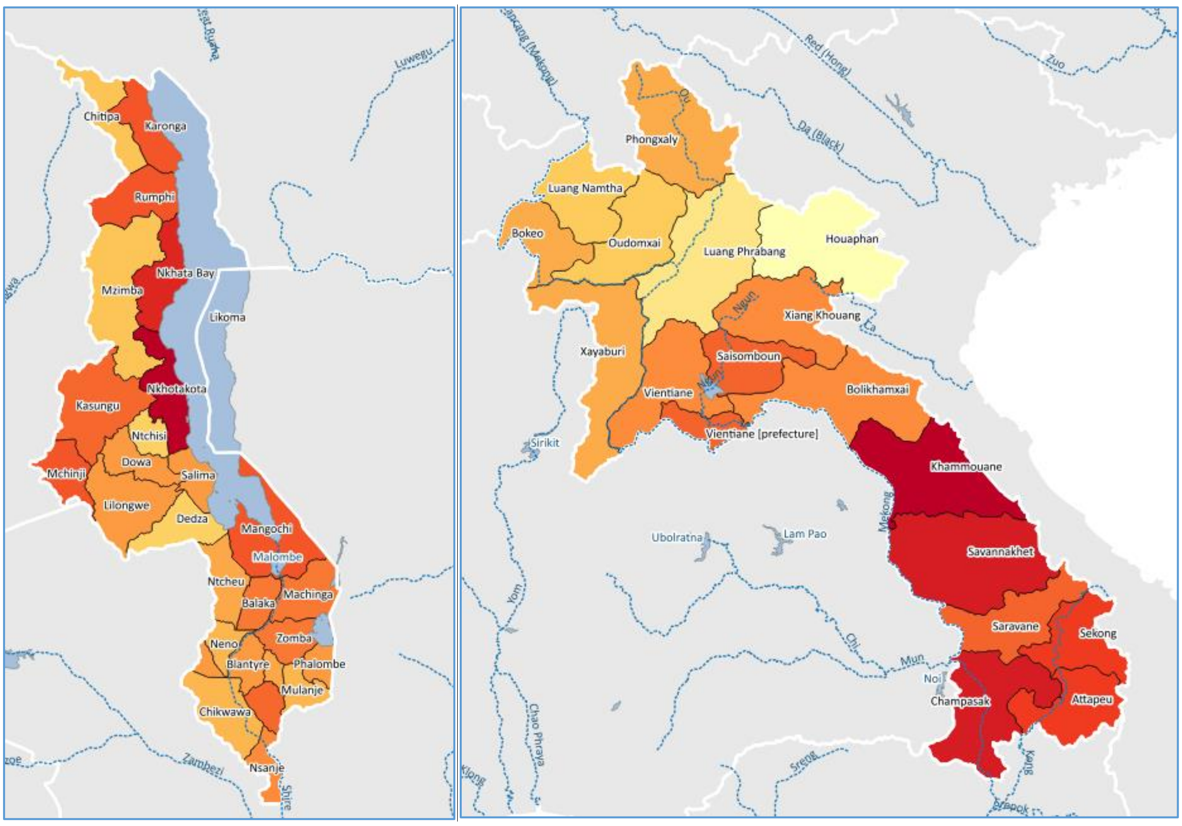

Figure 10-1: The difference in fish consumption within two landlocked countries (intensity of colour is relative consumption of freshwater fish)

Where this occurs, reporting and mapping of inland fisheries will average out the production across the whole country rather than indicate more localized inland fisheries. These localized fisheries may be very important to livelihoods, the economy and nutrition, but this will tend to be lost when presenting the information at the national level (note that a localized fishery may still represent a huge area such as the Brazilian Amazon or one of the Great African Lakes). This is less of an issue in smaller countries or those that have relatively homogenous inland fishery resources (e.g. a broad mix of rivers and floodplains or lakes and reservoirs across the country).

In the same manner, the presentation of the FAO Food Balance Sheet (FBS) or Apparent Fish Consumption data will also tend to hide important inland fishery contributions when presenting national level aggregated information. This is a limitation of national FBS data, which are unable to provide information on the variability within areas of a country or between different socio-demographic subgroups in the population (Kearney, 2010). These data are collected at subnational level and therefore access to this data can provide important insights into fish availability in specific areas where there is high dependency on inland fisheries.

10.1.3 POPULATION DENSITY HAS AN EFFECT ON THE LEVEL OF EXPLOITATION

Population density also varies across countries and this can have a significant effect on the extent to which inland fishery resources, if present, can be exploited. A good example of this is the difference between Southeast Asia and the Brazilian Amazon (Figure 10-2).

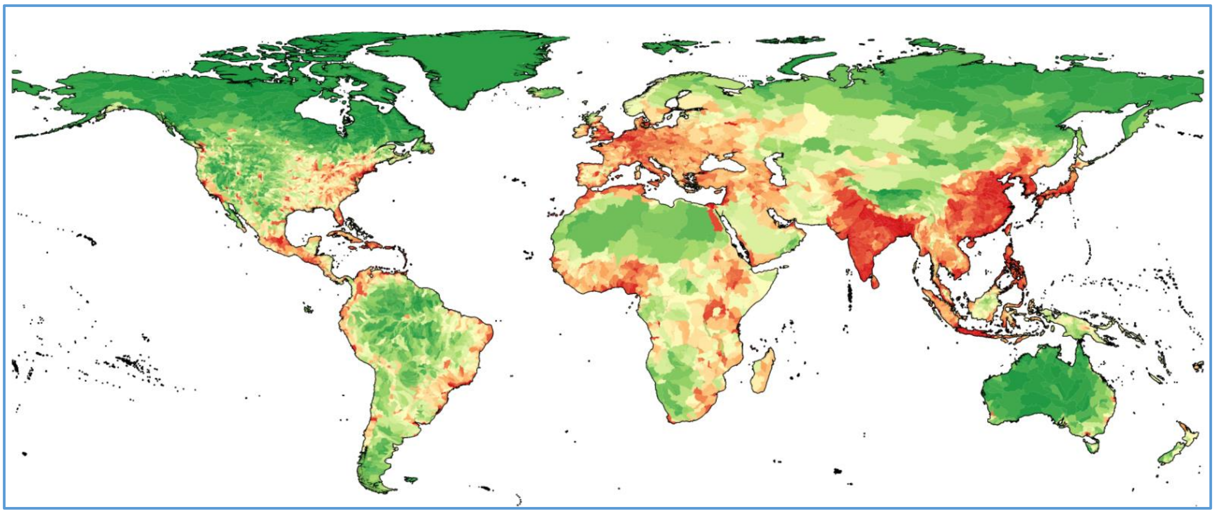

Figure 10-2: The difference in population densities across the world's hydrological sub-basins (Highest densities in red and lowest densities in dark green)

The tropical floodplain fisheries of Southeast Asia and the Brazilian Amazon are comparable in terms of their area, biological productivity and biodiversity, yet they are not comparable in terms of their inland fishery production. It is immediately apparent that the high population densities of Southeast Asia are quite different from the relatively low population densities of the Amazon. There are simply too few people in the Amazon to exploit the fisheries anywhere near to their maximum potential. Conversely, in Southeast Asia all waterbodies have relatively high population densities surrounding them, and there is a tremendous amount of fishing activity that occurs in waterbodies of all types. This also means that these fisheries are very probably exploited at or close to their maximum potential.

10.2 METHODS TO ESTIMATE INLAND FISHERY PRODUCTION

There have been a number of reviews of the FAO inland capture fishery production dataset and comparisons with other sources of information (Coates, 2002; Lymer and Funge-Smith, 2009; Welcomme and Lymer, 2012; Welcomme *et al.*, 2010; Welcomme 2011; World Bank, 2008; World Bank, 2012). For countries where issues have been identified with the reliability of inland capture production statistics, there can be considerable differences between reported and actual production (Coates, 2002; Kolding and van Zwieten, 2006). These reviews have variously looked at regions and countries and have generally concluded that the annual trend data for a number of countries could be unreliable for a number of reasons, resulting in a tendency to underestimate (frequently) or overestimate (occasionally) production.

An outcome of this general uncertainty is that it is increasingly difficult to report confidently on the global trends in inland capture fishery production. With growing global appreciation of the role and value of inland fisheries, it is becoming increasingly important to be able to identify the underlying causes and drivers of errors in inland fisheries statistics. These are summarized in Table 10-2.

Table 10-2: The underlying causes and drivers of errors in reported inland fishery statistics

<table>
<tr><th></th><th>Cause of the error</th><th>Effect on reported statistics</th></tr>
<tr><td rowspan="2">Patchy monitoring</td><td>Reported statistics only cover commercial catches. Subsistence or small-scale /artisanal catches are not covered by sampling programmes/surveys.</td><td rowspan="3">Underestimates inland capture production (unless excluded fisheries are an insignificant part of the fishery).</td></tr>
<tr><td>Reported statistics are estimates based on monitoring of a limited set of fisheries. Other fisheries, especially small waterbodies, are excluded or overlooked.</td></tr>
<tr><td rowspan="3">Under-reporting</td><td>Inadequate capacity (skills and resources) to undertake surveys.</td></tr>
<tr><td>Illegal fishing/poaching; small-scale fishing to feed households are not included in reported statistics.</td><td rowspan="2">Underestimates inland capture and recreational fishery production.</td></tr>
<tr><td>Retained recreational fish catches are not recorded or reported.</td></tr>
<tr><td rowspan="3">Misreporting or poor estimation methods</td><td>Reported production estimates are increased annually to meet projected production targets set in policy documents.</td><td>Overestimates production. These errors can become considerable if this happens for more than five years.</td></tr>
<tr><td>Reported production is based on assumed productivity of water resources, rather than any direct measurements of landings or fishers’ catches.</td><td>Either overestimation or underestimation. Errors arise because of wrong productivity estimate, or wrong water/habitat area estimate.</td></tr>
<tr><td>Country does not report for a number of years and then submits its report, based on an FAO estimate from preceding years.</td><td>Reinforces the FAO estimate, which may not reflect actual production. Results in a “drifting-off” of the production estimate.</td></tr>
<tr><td>No reporting</td><td>No regular report of inland capture fishery production is provided to FAO, requiring an estimate to be made based on other secondary data sources.</td><td>FAO estimate is based on secondary information and previous reports, which may already be subject to overestimation or underestimation.</td></tr>
<tr><td>Adjustments</td><td>Periodic large-scale adjustments are made to reported inland fishery production, based on updated fishery survey information or other data.</td><td>Adjustments may overshoot in either direction resulting in overestimation or underestimation.
This affects trend analysis.</td></tr>
<tr><td rowspan="2">Loss of monitoring programme</td><td rowspan="2">Collapse of a statistical monitoring programme because of economic or institutional changes in a country.</td><td>Estimates are based on historical data and the addition of an annual increment. This typically results in eventual overestimation.</td></tr>
<tr><td>Reduction in scale of monitoring results in loss of coverage and a tendency to underestimate.</td></tr>
</table>

With such widespread uncertainties, there is a need to find ways to validate or calibrate the reported inland capture fishery production (Bartley *et al*., 2015). There are a number of ways in which this can be undertaken:

- cross-validation of reported statistics using basin-level estimates based on historical reports and independent research studies (Section 10.3);
- estimation of inland fishery production based on household consumption and/or income and expenditure surveys (HCES) (Bayley, 1981; Hortle, 2007; Mills *et al*., 2011; Funge-Smith, 2016) (Section 10.5); and

- estimation of likely production based on productivity estimates of different aquatic habitats/resources (productivity/yield/area) , linked to a direct or indirect estimate of fishing effort (number of fishers/ catch/unit area). See Section 10.6 (Table 10-11).

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10.3 ASSESSING INLAND FISHERIES AT BASIN LEVEL

Rachel Ainsworth, Simon Funge-Smith and Ian Cowx

One of the challenges of integrating information relevant to inland fisheries is that the delineation of boundaries varies according to the information source. This is linked to the purpose for which the information is being used.

FAO country groupings are used to present inland fisheries statistics in this section. FAO fishery statistics are not recorded at fishery or basin/sub-basin level. They are reported to FAO as a national aggregate statistic that is compiled from a range of fisheries based on different habitats that are related to the size and geography of a country.

This means that the national figure will represent the fisheries of a number of basins and a range of fisheries spanning rivers, lakes, reservoirs, floodplains and wetlands. In many cases, inland fishery production areas are not wholly contained within a national boundary and are part of a larger transboundary river basin.

It is possible to group countries into a subregional cluster that reflects common climatic characteristics, or even at a level that reflects their shared water resources (e.g. countries within a basin). The presentation of fisheries production can be made as an aggregation of basins that more or less corresponds to the borders of a collection of countries. The biggest problem of attribution occurs where a basin, or sub-basin, lies across the boundaries of countries that are clustered in separate subregional groupings. Where this has occurred, basins are attributed to subregions where the greater part of the country corresponds to the basin.

10.3.1 ESTIMATING THE PRODUCTION FROM RIVER BASINS

River basin data collection

To determine the contribution of river basins to global fish production, 45 river and lake basins were chosen based on the perceived importance of their fisheries from a commercial (small scale), subsistence or recreational perspective, or as a combination of all three. Table 10-1 outlines the river basins studied according to each region as outlined by FAO.

Search engines such as Google Scholar, Web of Science, ProQuest, were used to find the most recent estimates of inland fishery catches for the chosen rivers and lakes from literature sources and governmental data. The reference and information therein was used to snowball the information sources and obtain as wide a range of data as possible. Google-translate was also used to search specific countries for catch information. The information was aggregated into regional fishery catches according to countries set out by FAO. Where transboundary rivers overlapped countries in different regions, the region with the most countries contributing to the basin was used. The regional river fish catches were compared against FAO official regional catch statistics. The aim of the study was to validate if the fish catches reported on a river basin level in each region were more accurate and reliable than those reported to FAO, as FAO has long suspected that the data reported are underestimated.

Table 10-1: Basins profiles covered in this review, by subregion

Subregion	River basins and large waterbodies		
Africa – Great lakes	Lake Victoria* Lake Malawi	Lake Turkana	Lake Tanganyika*
Africa – Southern	Zambezi River Lake Kariba	Limpopo River	Okavango River
Africa – Nile river basin	Nile River*		
Africa – West coast	Niger River*	Volta River	
Africa – Sahel	Lake Chad*	Gambia River	Senegal River

Table 10-1: Basins profiles covered in this review, by subregion

Subregion	River basins and large waterbodies		
Africa – Congo basin	Congo River*		
America – South	Amazon River* Tocantins- Araguaia River	Magdalena River Orinoco River	La Plata River Lake Titicaca
America – North	Mississippi- Missouri River	Great Lakes Basin	Yukon River
Asia – South	Indus River*	Ganges River	Brahmaputra River
Asia – Southeast	Mekong River* Tonle Sap Lake*	Irrawaddy River* Salween River*	Mahakam River Red River*
Asia – Central	Caspian Sea*	Ural River	
China	Yangtze River* Amur River	Yellow River	Pearl River*
Europe – Eastern	Danube River		
Europe – Northern	Finland (country profile)		
Oceania	Murray- Darling	Sepik River	
Russian Federation	Volga River	Ob-Irtysh River	

*Major river basins and waterbodies with an estimated annual fish catch ≥100 000 tonnes

It is apparent that the world's inland capture fisheries are concentrated in the tropical and subtropical latitudes of the world (Figure 10-1), with a few notable exceptions (e.g. Northern Russia/Siberia, North American Great Lakes, Finland, Paraguay/Plata River in South America). The country distribution of inland fisheries catches is determined by the main waterbodies, such as lakes, rivers and floodplains, especially where there are higher population densities of rural people able to exploit these resources, or where the local climate or economy hinder the cultivation of crops or livestock.

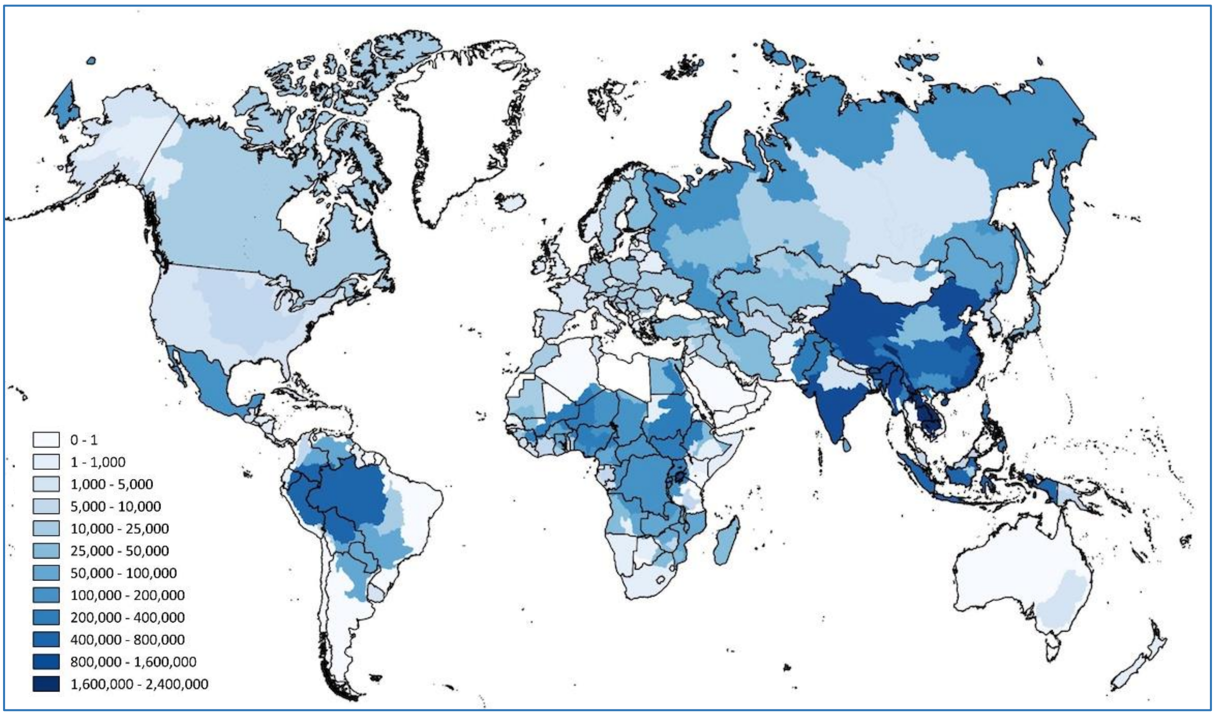

Figure 10-1: The global inland fishery production in major river basins

The largest inland fisheries are in Southeast Asia and the African Great Lakes. Of the major river basins studied, 15 (marked with * in Table 10-1) each had an estimated annual fish catch ≥100 000 tonnes, and three (Mekong, Irrawaddy and Lake Victoria) had an estimated catch of above one million tonnes.

Fisheries in rivers in North America, Eastern Europe, the La Plata River and Murray–Darling River are almost exclusively, if not completely, recreational based. Fisheries in the Russian Federation, Central Asia and China are mainly commercial with the other rivers containing primarily commercial and subsistence fisheries, but also possibly having small recreational sectors.

The Mekong River is the largest inland fishery in the world, with an estimated annual catch of 2.32 million tonnes, which supports the livelihoods of some 60 million people in the lower Mekong basin (Hortle and Bamrungrach, 2015). However, these fisheries statistics are considered an underestimation because of the difficulties in surveying these highly dispersed fisheries, the huge number of active fishers operating and the unknown number of people that fish for subsistence.

The Irrawaddy River is the second largest fishery and is contained entirely within Myanmar. The fish catch reported in 2014 was an estimated 1.20 million tonnes, but is contentious. Fish catches have consistently increased by about 10 percent each year since records began in 1985, even after Cyclone Nargis destroyed the fisheries sector in the Irrawaddy delta in 2008. These data have been questioned by FAO and inland catches over the last ten years (2006–2015) have been revised downwards (FAO, 2017a). Nonetheless, the catch is considered an underestimate because rice paddy fisheries are not included in fisheries statistics.

Lake Victoria is the largest inland fishery in Africa with an estimated fish catch in excess of one million tonnes. The introduction of Nile perch has been described as the saviour of the fishery, which led to the growth of exports important to the economy, but conversely has contributed to the extinction of about 200 native species, although this is the subject of debate (van Zwieten *et al*., 2016).

Relatively little is known about the inland fisheries of the Amazon River, but reported yield is surprisingly low at 0.65 million tonnes for such a large basin; this is most likely an underestimate because of the size and remoteness of the basin constraining any viable collection of catch data. These scenarios are potentially enacted in all inland fisheries throughout the world.

Not all the major inland fisheries are covered in this review, but that does not imply that the fish catches from these rivers are any less significant, or are unimportant. Unfortunately, fisheries information for these waterbodies, and many other smaller waterbodies, was not sufficient, or not available in sufficient detail, to warrant individual river basin assessments. In addition, fisheries surveys have not been carried out on some rivers, or the only available catch data were considerably out of date, raising concerns about their reliability.

Using secondary sources of data to validate FAO fishery data

The summarized regional data is lower than that reported by FAO, but within 14 percent of the total (Table 10-2).

Table 10-2: Regional FAO and river basin fish catch (tonnes)

Sub- Region	FAO reported total (tonnes)	River basin estimated total (tonnes)	Percentage difference (%)
Asia	5 304 612	5 279 097	0
Africa	2 860 131	2 553 432 to 2 573 403	-10 to -11
China	2 281 065	974 463	-57
North America	570 515	870 967	+53
Russian Federation	285 090	102 923	-64
Europe	150 017	59 291	-60
Oceania	18 030	6 432 to 8 432	-64
Arabia	0	0	0
TOTAL	**11 469 460**	**9 846 605** to **9 868 576**	**-14**

Considering that the basin approach does not cover the entire inland fishery catch of the world, this is a reasonable convergence at a global level but hides significant variation at the regional level. It does not indicate a considerable hidden catch, which is revealed by the use of the consumption figures modelling approach in the next section (Section 10.5).

When the comparison is made at a subregional level, there is considerably less convergence with the FAO reported figures. With the exception of South America, the estimates of fish catch from the major inland river basins found in the literature, were considerably less than the FAO reported fishery statistics (Table 10-3).

Table 10-3: Regional totals from FAO and river basin estimates (tonnes)

Subregion	FAO reported total 2015 (tonnes)	River basin estimated total (tonnes)	Percentage difference between FAO report and basin estimate
Africa – Great Lakes	1 053 694	1 426 829	+35
Africa – Southern	229 651	129 639 to 134 110	-42 to -44
Africa – Nile river basin	354 949	261 980	-26
Africa – West coast	568 094	408 091	-28
Africa – Sahel	307 385	187 890 to 197 890	-36 to -39
Africa –Congo basin	304 020	139 003 to 144 503	-53 to -54
Africa – Islands	25 940	-	-
Africa – North	16 198	-	-
Africa – East coast	200	-	-
Regional total	**2 860 131**	**2 543 432** to **2 563 403**	**-10** to **-11**
America – South	362 481	840 879	+132
America – North	47 356	30 088	-37
America – Central	156 345	-	-
America – Islands	**4 333**	**-**	**-**
Regional total	**570 515**	**870 967**	**53**
Arabia	0	0	
Regional total	**0**	**0**	**0**
Asia – South	2 591 358	1 062 324	-59
Asia – Southeast	2 427 041	4 100 216	69
Asia – Central	90 441	116 557	29
Asia – West	148 571	-	-
Asia – East	47 201	-	-
Regional Total	**5 304 612**	**5 279 097**	**-0.5**
China	2 281 065	974 463	-57
Regional total	**2 281 065**	**974 463**	**-57**
Europe – Eastern	63 663	24 746	-61
Europe – Northern	45 096	34 545	-23
Europe – Western	27 921	**-**	**-**
Europe – Southern	13 337	**-**	**-**
Regional total	**150 017**	**59 291**	**-61**
Oceania	18 030	6 432 to 8 432	-53 to -64
Regional total	**18 030**	**6 432** to **8 432**	**-64**
Russian Federation	285 090	102 923	-64
Regional total	**285 090**	**102 923**	**-64**
TOTAL	**11 469 460**	**9 836 605** to **9 858 576**	**-14**

Available information covered most of the larger waterbodies, but catches for small lakes, coastal streams and lagoons generally have gone unrecorded and the selection of only 45 river basins means catch from other river systems is excluded. For example, major rivers and lakes such as the Rufiji River (5 500 to 7 500 tonnes/year), Kainji Lake (6 000 tonnes/year), Casamance River (15 000 tonnes/year), Yenisei River (4 470 tonnes), Lena River (3 000 to 4 000 tonnes/year), Amu Darya River (1 000 to 3 000 tonnes/year), Fly River (5 000 to 10 000 tonnes/year) and floodplain fisheries in Bangladesh which accounted for about 800 000 tonnes in 2015-16. These systems are known to support major inland fisheries, and are excluded in this account, because of the focus on major systems. In the case of Bangladesh, this an artefact of splitting the Ganges system from the Ganges-Bramaputra-Meghna complex.

Furthermore, there are many hundreds of freshwater coastal lagoons, for instance, in West and Southern Africa, where fish catches go unreported. Lagos lagoon (Nigeria) is an example where fish catches in excess of 4 000 tonnes/year have been recorded (Vanden Bossche and Bernacsek, 1991). In addition, fish catch from small perennial coastal streams which are not part of any basin in West Africa are estimated at 30 700 tonnes (Béné and Heck, 2005). If the average fish catch from each lagoon is about the same as Lagos lagoon, then there is a significant portion of production going unreported. Armed conflict and political instability over much of the continent (Sahelian region, Congo basin, Sudan) has also impacted fish surveying, through the withdrawal of research and monitoring in affected areas (Jolley, Béné and Nieland 2001; Béné *et al.*, 2003).

Despite FAO fisheries statistics being slightly higher than the river basin production, the fishery statistics, particularly for Southeast Asia and South Asia, are thought to be underestimates. Subsistence fisheries are hugely important in Asia, but the majority of this harvest is not accounted for in fishery statistics, as it is difficult to cover the huge diversity of gears and highly dispersed fishing activities (Hortle, 2009).

There is generally poor coverage of inland fishery statistics collection in India and Pakistan, leading to a potentially considerable underestimate in South Asia. For example, statistics for the Ganges and Brahmaputra rivers are drawn from only two registered landing centres (Allahabad and Uzan Bazar) although Bangladesh reports catches from these floodplain fisheries separately. Fisheries are thus characterized by limited information about fish stocks, and little or no stock assessment is carried out (Khan, 2016). This under-reporting does raise questions regarding understanding of trends and consequent policies and management of these fisheries. For example, official reports in Pakistan suggest that fisheries catches are increasing in the Indus basin, whereas information from the literature would conclude that catches are declining. Unfortunately, there is no comprehensive fish assessment to resolve this conflicting view (Khan, 2016).

In Central Asia, river basin fish production was higher than the FAO production. Despite this, fishery production in Central Asia is thought to be underestimated. The majority, if not all, riparian states on the Caspian Sea under-report fish catches because of problems with tax avoidance by fishers, but also the majority of the catch is illegal and is sold on black markets and not registered in official data (World Bank, 2004).

In China, fish catches are presented by province. Fish catches were apportioned according to the percentage area of each basin inside each province. There are unique challenges with treating the reported national data from large countries such as China. Provincial level statistics are aggregated into the national account, preventing detailed attribution by the different productive regions or basins. Alongside potential under-reporting or over-reporting, there are additional challenges in interpreting trends in China, where there are periodic adjustments made to data. After the Second Chinese National Agricultural Census in 2006, the fishery total for that year was downgraded 14 percent, and although subsequent data were revised, this raises questions regarding reliability of the data. Kang *et al.*, (2017) identified a general lack of freshwater fisheries studies in China, and suggested a platform should be created to exchange more detailed data and improve fishery reporting.

In Africa, river basin fishery production estimates accounted for 90 percent of the FAO reported fish catch. There are many problems linked to methods of data collection and inconsistencies in the data collected that impact on the accuracy of the data collection. For instance, data collection in the United Republic of Tanzania and Uganda is constrained by lack of funds and staffing, with a consequent lack of confidence in the catch statistics recorded. This is also true for Zambia, where the Department of Fisheries recognizes that fishery data collection is handicapped by a lack of resources for effective surveying (Tweddle, 2010). There is also a complete absence of time series data and regular monitoring for many rivers (e.g. Gambia and Senegal Rivers), preventing the assessment of the state of fisheries within basins. In basins where monitoring does occur, this is largely inconsistent and sporadic. In Egypt, fish catches are only reported from 21 of the 695 registered landing sites on the Nile River, thus fishery statistics are unreliable because of the sparsely distributed official landing sites and countless unregistered landing sites (Hamza, 2014; Samy-Kamal, 2015). This could also be true for most of the major river basins in Africa, which cover vast isolated areas.

Fishery estimates from major inland rivers in South America were higher than the FAO estimated production. This is likely because official catch estimates mainly come from larger fish markets sparsely located around the basins; subsistence fisheries and smaller isolated markets were not included in officially reported data. Fisheries statistics are difficult to obtain in South America because of the isolated nature of many fishing communities, the large variety of fish caught and the sparseness of official landing sites (Junk, 2007). In Colombia, there are inconsistencies regarding fish data collection. Official data are presented by month, but in 2016 data were only collected between July and December, and in 2014 data were collected from January to June and November and December. Such variation in fisheries data collection does not serve as an accurate basis to assess the state of fishery resources, which are declining in the Magdalena River basin (SEPEC, 2017).

In North America, fisheries are primarily recreational, although it is considered that a considerable proportion of this catch is retained for home consumption (Cooke *et al.*, 2017; see also Chapter 8 on recreational harvest). These recreational harvests are not currently included in FAO fish statistics. Data (Table 10-3) are only representative of the commercial fishing, which is small scale and only present on large rivers and lakes, and is not representative of the majority of fishing activities in the country.

The river basin fish production that can be determined from reports is only 36 percent of that reported to FAO. Major freshwater lakes and reservoirs are centres for fish production in the Russian Federation (Table 10-3). The combined fish production in the Russian Federation’s Lagoda, Pskov-Chudskoye, Ilmen, Onega and Baikal Lakes was 12 430 tonnes, and the fish catch in its reservoirs (Rybinsk, Kuibyshev, Tsimlyanskoya and Saratov) was 16 140 tonnes in 2014 (Environmental Protection Act Annual Report, 2017). However, fishing activities have increased dramatically since the dissolution of the Union of Soviet Socialist Republics, and catches from major inland rivers and official data are thought to be underestimated. Illegal fishing is prolific in the Russian Federation and the illegal harvest could be two or three times the legal fish harvest (Novomodny, Sharov and Zolotukhin, 2004).

Fish catch from major inland river basins in Europe represent 40 percent of the FAO fishery production value and reflects the poor coverage of freshwater fisheries production in the literature (Cowx, 2015). The majority of fishing activities are recreational, but on large inland waterbodies some commercial fishery operations remain. In Eastern Europe the economic crisis and changes to administration of fish resources in some countries led to a reduction in fish catches and proliferation of illegal fishing (Aps, Sharp and Kutonova, 2004). Similarly, in Serbia over the last ten years, fishers have not been required to report their fish catches, and the level of poaching and illegal fishing has been increasing, suggesting the catch data may not be reliable (Smederevac-Lalić *et al.*, 2011). Recreational fishing is not included in official statistics in Europe, but could account for an extra 33 percent above reported catches (Movchan, 2015), suggesting that both the FAO and major rivers fish production could be underestimated.

In Oceania, inland fisheries in Australia and New Zealand are almost entirely recreational, which may not be accounted for in official statistics. The presence of major river fisheries in other areas of Oceania are not well known or studied. It is possible that fishing is important for isolated rural communities, such as in the Sepik River basin in Papua New Guinea where fisheries are a locally important food source. However, the perceived unimportance of freshwater fisheries in this region has meant that studies on inland fisheries are lacking or out of date.

A consistent issue when consulting literature sources, particularly for African rivers, was that data are out of date and refer to periods as far back as the 1960s and 1970s, but there are simply no more recent fishery estimates available. Such historical data should be treated with caution, and it must be acknowledged that these data may not reflect the current state of the fisheries concerned.

10.3.2 GLOBAL INLAND FISHERIES REASSESSMENT

Fishery production from the 45 river basins studied (Table 10-1) constituted 86 percent of the FAO 2015 inland fisheries production, being 1.6 million tonnes below the total global production of 11.47 million tonnes. The missing global fishery production could be accounted for in fish catches from other major or minor waterbodies not included in this study, and smaller perennial or coastal rivers and waterbodies that are not part of any specified river basins (Section 10.1.1). The fishery production at a country level that is not accounted for on a river basin level in this report could be considered "missing fishery production". For example, fisheries production from the Ganges and Brahmaputra Rivers in India accounted for 4 459 tonnes, whereas fishery production in India in 2015 was 1.35 million tonnes, which suggests a "missing fishery production" in India of 1.34 million tonnes.

To account for this missing fishery production, the river fishery values per country were subtracted from the FAO 2015 fishery production for each country and presented as missing country fish production in Table 10-4.

In addition, fish production from countries not included in this analysis (countries from Central America, Caribbean, Eastern and Western Asia, Western and Southern Europe, North Africa and East Africa regions) could also be considered "missing fishery production". To account for this, the FAO 2015 fishery production from these missing countries was added to the missing country fish production for each region in Table 10-4, to establish the potential global inland fisheries production.

Table 10-4: River basin production + additional fish production (from Table 10-3), missing country fish production and combined potential inland fish production based on river basin fish production and missing country fish data (tonnes)

Subregion	River basin total + additional fish catch (tonnes)	Missing country FAO fish data (tonnes)	Potential inland fish production (tonnes)
Asia	5 280 287 to 5 282 287	2 484 052	7 764 339
Africa	2 652 087 to 2 679 558	786 979	3 439 066 to 3 466 537
China	1 014 963	1 261 821	2 276 784
Americas	870 967	214 061	1 085 028
Russian Federation	138 963 to 145 423	192 601	331 564 to 337 484
Europe	82 852 to 84 562	109 993	192 845 to 194 555
Oceania	11 932 to 18 932	12 991	24 923 to 31 923
Arabia	0	0	0
TOTAL	**10 064 051** to **10 113 192**	**5 062 499**	**15 114 609** to **15 256 650**

Comparing the potential inland fish production (15.1 million to 15.2 million tonnes) (Table 10-4) with the FAO 2015 production by region (Table 10-3), the potential global inland fishery production is higher than the FAO 2015 estimate of 11.5 million tonnes. Although higher than the FAO 2015 estimate, it is believed that the readjusted estimate in Table 10-4 may still be an underestimation of actual inland fish production. Subsistence fishing is rarely included in fish statistics, and there is a lack of freshwater fisheries studies and monitoring in each region and illegal and unreported fishing continues to be a growing problem.

10.3.3 EQUIVALENT REPLACEMENT OF INLAND FISHERIES

From an ecosystem perspective, using river basins as units for reporting on the status of inland fisheries is the ideal. This is because of the physical and ecological inter-relationships between fisheries within basins and the basin level impacts of water and land management on fisheries production.

If a basin is wholly contained within a country (or a country wholly contained with a basin) then this may be representative of the status of a country's inland fishery. More typically, a basin is shared by a number of countries, and the status of an inland fishery within a basin will be a reflection of the impacts of several countries' activities, typically in an upstream–downstream continuum. This also means that the threats to the fishery and its management may require both national and collective action and may also have transboundary implications.

The scale of impact on inland fisheries depends on the intensity of the activity and the current state of the environment. Inland fisheries are impacted by both self-generated factors (overfishing and management) and external factors such as agriculture, hydropower, pollution and climate change (Welcomme *et al*., 2010).

The downstream impacts of hydropower dams are an example of an anthropogenic threat that has far-reaching transboundary implications. Dams are a barrier to movement, disrupting connectivity both along the river and with floodplains and preventing migratory species from completing their lifecycles. It has been estimated that the development of 11 dams on the mainstem of the Mekong River in Lao People's Democratic Republic and Cambodia could reduce annual fish catches in Cambodia and Viet Nam by 44 percent and 42 percent respectively (DHI, 2015). In China, the completion of the Three Gorges Dam has resulted in a 30 to 50 percent decrease in catch of important carp species in the Yangtze River (Xie *et al.*, 2007).

Water pollution might be locally severe within a basin, but there are also regions and countries where pollution is widespread. The potential impact of this on fish consumers is poorly reported.

The introduction and spread of non-native fisheries, often through stock enhancement practices or illegal introductions, is also having a consider impact on fisheries globally (Gozlan *et al.*, 2010). For example, the introduction of 11 exotic species into the Murray–Darling River has led to the collapse of native fish populations, and native populations are 10 percent of their pre-European settlement levels (Murray Darling Basin Ministerial Council 2003; Australian Government, 2004). Similarly, non-native species are making increasing contributions to capture fisheries, but could potentially compromise sustainable native fisheries.

Intense fishing pressure remains a major problem to the long-term sustainable management of fisheries and maintenance of productive ecosystems. The open access nature of many inland fisheries has led to intense fishing pressure and proliferation of unsustainable fishing practices. This has resulted in fishing down the foodweb, although not necessarily a reduction in overall productivity. Once a system has experienced heavy fishing pressure it can be difficult to recover, especially as other pressures on the system reduce its resilience. For instance, late maturing sturgeons are particularly vulnerable to high levels of fishing. Intense fishing pressure in the 1970s, damming of major migration rivers and illegal fishing for sturgeon caviar led to a collapse in sturgeon catches in the former Soviet Union from 8 200 tonnes in the 1970s to just 94 tonnes in the Russian Federation in 2007; although the illegal catch is suspected to be three to four times this amount.

10.3.4 FOOD REPLACEMENT METHODOLOGY – WHY FOOD REPLACEMENT?

The impacts of anthropogenic pressures that are facing inland fisheries, compounded with additional threats of climate change are almost entirely negative and will result in decreasing fishery productivity. As has been highlighted earlier (see Chapter 4), the major inland fisheries of the world are important for local or regional food and nutritional security, and it is important to understand how their decline or loss will affect dependent rural communities. This covers both the impact on food security, primary protein and nutrition, as well as the environmental impacts of alternative food production systems that would be required to replace the loss of this inland fishery production.

The valuation of natural resources is of increasing interest, particularly as part of improved environmental accounting and valuation of ecosystem services, however there has been limited application of this to inland fisheries.

Monetary valuation may be applicable to distinct commercial fisheries, where the loss of fish might be easily considered as loss of export value, loss of fishing days and an increase in food prices. However, large commercial inland fisheries that can be so well defined are generally rare. Subsistence fishing and local market fish production are rarely conducted all year round and often form part of a broader livelihood. As such, imposing monetary values on fish does not necessarily reflect the true value of the contribution of fisheries. (The economic value of inland fisheries is explored in detail in Chapter 5).

There have been some examples of the attempt to quantify the environmental implications of replacing fisheries (Orr *et al.*, 2012; Lymer *et al.*, 2016). The approach is based on the quantification of the effect by which the loss of fisheries would require replacement with alternative forms of food (either directly as fish from aquaculture, or indirectly as protein derived from other forms of livestock of plant-based sources). All of these cultivated replacements would require an expansion of land under cultivation and an increase in water use. The question is whether a particular basin or region has the available agricultural land and water to allow such an expansion of production. Furthermore, alternative food sources may not provide the same nutrients as fish, impacting regional nutritional security.

10.3.5 EQUIVALENT FOOD REPLACEMENT

Replacement foods were selected according to foods that are already produced within the regions. In this regard, food replacement is modelled independently for each region, and represents a upscaling of existing food production. Replacement foods could theoretically be imported into the regions, but it is recognized that reliance on imports may not be economically feasible (Gephart *et al.*, 2017). The replacement estimates should be treated as approximations, as they are based on estimated fishery production values, most of which are considered underestimations of actual fishery production.

Estimates for inland fish replacement were calculated based on the total regional production from FAO statistics and the river basins in each region. On a regional level, replacement values were modelled on a 100 percent loss to estimated fishery production. Although it is extremely unlikely that all of a regions inland fishery would be lost, this represents a worst-case scenario showing the maximum impact of replacing fish with alternative foods.

Fish data

Nutritional data, water footprint (m^3/tonne), land use (tonne/hectare) and carbon emissions (kg of carbon/kg of product) for replacement food sources were obtained from various literature sources. Water use for capture fisheries is negligible, as no additional water inputs are required for capture fishery production. Water use in aquaculture systems varies according to intensity of production, amount of feed required and type of aquaculture system. Land-use in aquaculture depends on the type of production system and the species being cultured. As there are few studies related to land use in aquaculture, the land yield values were based on individual studies in a specific area or country. The carbon emissions from capture fisheries were taken as the average carbon emissions from several freshwater fish species. Carbon emissions from capture fisheries stem from gear construction, fuel use from boats and refrigeration.

Replacement food data

The water footprint values were taken as a global average consisting of blue (surface water), green (rainfall) and grey water footprints (resultant polluted water). Land yield values for livestock for each continent were used and an average taken as the global value because of differences in stocking densities in livestock production systems. The global average land yield values for agricultural crops (rice, wheat and maize) were obtained from FAOSTAT. The carbon emission intensity values for livestock were based on global emissions from livestock production calculated by Gerber *et al.*, (2013). The values carbon emissions from agriculture (wheat and corn) were generated from three sources, namely machinery used for cultivation, production and application of fertilizers, and the soil organic carbon that is oxidized following soil disturbance (West and Marland, 2002).

Kilocalorie replacement

Estimated inland fisheries production data were converted into kilocalories (kcal) by converting catch data (tonnes) into grams using a conversion factor of 1.8. Replacement food production was calculated by converting kilocalorie content of 100g of replacement food into kilojoules using a conversion factor of 4.1868 (adapted from Phouthavong, 2015) (Equation 1).

$$\boldsymbol{Kilojoule\ content_{(food\ source)} = kcal\ content_{(food\ source)}} \times 4.1868$$

(Equation 1)

The quantity of alternative foods to replace kilocalories from inland fish production was calculated using the regional FAO and river basin fish production (tonnes), in conjunction with the kilojoules content of fish and the kilojoules content of each replacement item (Equation 2).

$$\boldsymbol{Replacement\ energy\ [t]_{(food\ source)} = \frac{(fish\ production[t] \times kilojoule\ content\ of\ fish}{Kilojoule\ content_{(food\ source)}}}$$

(Equation 2)

Using the estimated fishery production, the amount of alternative foods to replace kilocalories from fish production was calculated.

Water demand for equivalent kilocalorie replacement

The amount of replacement foodstuff with equivalent energy content (grams) was calculated by dividing the fish production (kilocalories) by energy conversions (Equation 3) per replacement food source (Equation 4). The equivalent energy content (grams) was converted into tonne equivalent energy values.

$$\boldsymbol{Energy\ conversion_{(food\ source)} = \frac{Kilojoule\ content\ per\ 100g_{(food\ source)}}{Kilojoule\ content\ per\ 100g\ for\ fish\ (4,731.084)}}$$

(Equation 3)

$$\boldsymbol{Replacement\ food\ equivalent\ energy\ content_{[grams]} = \frac{Fish\ production_{\ [kilocalories]}}{Energy\ conversion_{\ (food\ source)}}}$$

(Equation 4)

To calculate the equivalent water demand to replace fish production, the equivalent energy content (tonnes) of alternative foods was multiplied by the water footprint of replacement food sources (Equation 5).

$$\textbf{Replacement water quantity}\ [m^3] = \textbf{Replacement food equivalent energy content}_{[t]} \times \textbf{Water footprint}\ [m^3]_{(food\ source)}$$

(Equation 5)

Land requirements

The increases in arable and agricultural land needed to replace kilocalories from capture fisheries harvest was calculated differently for crops and livestock. Land yield values for crops were in tonnes per hectare. To calculate the hectares required to produce agricultural crops, the equivalent energy content (t) per replacement food source was multiplied by the land yield of replacement food sources (Equation 6). The equivalent quantity of land in hectares calculated from Equation 6 was converted into kilometres (km^2). The amount of land as a proportion of arable land within each region was calculated.

$$\textbf{Replacement water quantity}\ [m^3] = \textbf{Replacement food equivalent energy content}_{[t]} \times \textbf{Water footprint}\ [m^3]_{(food\ source)}$$

(Equation 6)

For livestock, land requirements were calculated using land yields that were different for each continent. Land requirements were calculated by multiplying the equivalent energy content (t) (calculated in Equation 4) per replacement food source with the corresponding livestock's land yield for the corresponding region (Equation 7), which gave the equivalent production of replacement food source per year (t). This was then converted into kilograms (kg) and then into kilometres using a conversion factor of 0.00015. For livestock, the amount of pastureland as a proportion of total pastureland within each region was calculated. For aquaculture, the inland water area in each region was used.

$$\textbf{Livestock and Aquaculture: Replacement food source equivalent}\ [t\ per\ year] = \textbf{Replacement food equivalent energy content}\ [t]_{(food\ source)} \times \textbf{Land yield}_{(mean\ of\ protein\ source\ continental\ land\ yield)}$$

(Equation 7)

Greenhouse gas emissions

Additional greenhouse gas emissions from replacement food sources were established using tonne equivalent values (Equation 4). Using the carbon emissions from replacement food sources (kg of carbon/tonne) (Equation 8). This was then converted into tonnes. Fish production was converted into kilograms (kg), and the emissions from inland fisheries were established as per Equation 8. The additional carbon emissions from replacement food sources compared to estimated carbon emissions from capture fisheries were established.

$$\textbf{Equivalent carbon emissions}\ (kg) = \textbf{Tonne equivalent value}_{(food\ source)} \times \textbf{Carbon emission}\ (kg\ per\ tonne)_{(Food\ source)}$$

(Equation 8)

Aquaculture, livestock and crop production increases required to replace inland fish

In 2015, total inland fish production was estimated to be 11.47 million tonnes (FAO, 2017a). To fully replace the kilojoules of energy from inland fisheries production, the production of alternative food sources would need to be increased (Table 10-5, details in Annex 7-1).

Aquaculture species, although similar in kilocalorie content to capture fisheries, would require significant increases in production as replacement values are equivalent to 6.78 million tonnes to 8.76 million tonnes, or a 1.6, 1.5 and 15 times increase in current global production for common carp, tilapia and rainbow trout, respectively. Notably the 2015 production was 4.3 million tonnes, 4.7 million tonnes and 0.6 million tonnes for common carp, tilapia and rainbow trout respectively (FAO, 2017b).

Chicken production would require an increase of 11.72 million tonnes to replace kilocalories from fish, which is equal to 11.7 percent of global production in 2014 (global production was 100.3 million tonnes in 2014). Beef production would require an increase of 7.2 million tonnes the equivalent of 11 percent of global production to replace kilocalories from capture fisheries (2014 beef production was 65 million tonnes). Pork production would require the smallest production increase to replace capture fisheries (3.7 million tonnes), which is equal to 3.2 percent of global production (2014 production was 117.2 million tonnes).

Table 10-5: Increased production of food commodities to replace the energy (kilocalories) provided by current global inland fish production (details in Annex 7-1)

Commodity	Additional production required to replace inland fish production (million tonnes)	Proportion of food production required to replace existing contribution of inland fish food production (%)	Global production of commodity Million tonnes (year)
Carp	+6.93	160	4.3 (2015)
Tilapia	+6.78	193	4.7 (2015)
Rainbow trout	+8.76	1563	0.6 (2015)
Chicken	+ 11.72	10.9	100.3 (2014)
Beef	+7.20	11	65 (2014)
Pork	+ 3.72	3.2	117 (2014)
Rice	+9.97	1.3	741 (2014)
Wheat	+17.98	2.5	729 (2014)
Maize	+15.07	1.4	1 037 (2014)

Agricultural crops have lower nutrient content compared to fish, and the replacement values are high for rice, wheat and maize (9.97 million tonnes, 17.98 million tonnes and 15.07 million tonnes respectively). However, in terms of global production, the replacement values are small (1.3 percent, 2.5 percent and 1.4 percent respectively) (2014 production was 741 million tonnes, 729 million tonnes and 1 037 million tonnes for rice, wheat and maize respectively).

Increased water demand required by production to replace inland fish

Replacement of kilocalories from capture fisheries with terrestrial livestock would place a higher demand on water resources than replacement with crops and aquaculture (Table 10-6, details in Annex 7-2. Global replacement of capture fisheries with beef would have the largest impact on freshwater resources, requiring 200 km^3 of water to produce replacement beef (Table 10-6). This amount is equal to 7.2 percent of global agricultural water use, which was estimated at 2.77×10^{12} m^3 (FAO, 2016). Water demand for replacement pork production was smallest amongst livestock species, with 41 km^3 required to replace fisheries, and 92 km^3 required to replace fisheries with chicken, which is equal to 1.5 percent and 3.3 percent of global agricultural water use, respectively. These high replacement values reflect the large amount of water needed to produce feed.

Table 10-6: Water (km^3) and land (million km^2) required to replace inland fisheries and percentage of total agricultural water use and global pasture/ agricultural land and inland water area (details in Annex 7-2 and Annex 7-3)

Replacement food	Water for replacement of kilocalories (km^3)	Percentage of global agricultural water use (%)	Land required to replace fisheries (million km^2)	Percentage global pasture/ agricultural/ inland water area
Carp	+39	1.4	+1.7	37
Tilapia	+37	1.3	+3.2	70
Rainbow trout	+70	2.5	-	-
Beef	+200	7.2	+3.4	10
Pork	+41	1.5	+1.1	3.3
Chicken	+92	3.3	+0.8	2.1
Rice	+40	2.2	+0.9	1.7
Wheat	+60	1.4	+1.6	3.1
Maize	+33	1.2	1.1	2.2

Replacement of fisheries with aquaculture would require larger inputs of water than capture fisheries, with 39 km^3, 37 km^3 and 70 km^3 required for common carp, tilapia and rainbow trout respectively (equivalent to 1.4 percent, 1.3 percent and 2.5 percent of global agricultural water use). This is because of the larger inputs of natural resources such as feeds and wastewater recycling.

Replacement of fisheries with wheat would require the largest water requirements from agricultural crops (60 km^3), compared with 40 km^3 for rice and 33 km^3 for maize (equivalent to 2.2 percent, 1.4 percent and 1.2 percent of agricultural water use). From a water use perspective, replacement of fisheries with crops would have a lesser impact on freshwater resources than livestock. However, crops have an inferior nutrient content compared with fish or animal protein sources and from a nutritional perspective replacement of kilocalories from fish with crops may even exacerbate micronutrient deficiencies (Ainsworth and Cowx, 2018).

Increased cultivated land area required by production to replace inland fish

Under a scenario of total inland fisheries loss, alternative food sources would require a significant expansion in land area to accommodate food production. Beef would require the largest land expansion of 3.4 million km^2 (Table 10-6, details in Annex 7-3), which is equivalent to 10.3 percent of pastureland globally (2014 pastureland area was 33.15 million km^2) (FAO, 2017b). Replacement land for pork production would also high, with 1.1 million km^2 required to replace fisheries (equivalent to 3.3 percent of pastureland area). Replacement chicken production would have the smallest land demand of 0.8 million km^2 (equivalent to 2.1 percent of global pastureland). As aquaculture practices and efficiencies are still not well developed in many parts of the world, land expansion to accommodate increased aquaculture production is high. Replacement farmed tilapia production would require 3.2 million km^2 and farmed common carp, 1.7 million km^2, which is equivalent to 70 percent and 37 percent of the global inland water area respectively (inland water area 4.5 million km^2). However, improved aquaculture best practices, efficiencies and expansion in pond aquaculture could see these values reduced.

Replacement crop production would require the largest land conversion for maize production, that is 1.6 million km^2, which is equivalent to 3.1 percent of the global agricultural land area (2014 agricultural land area was 49 million km^2). Replacement rice and wheat production would require an expansion of 0.9 million km^2 and 1.1 million km^2 respectively, which is equivalent to 1.7 percent and 2.2 percent of global agricultural land, respectively.

Increased carbon emissions resulting from production increases to replace inland fish

Using the methodology set out earlier, carbon emissions from global inland fisheries production were estimated at 43 million tonnes. This comes from gear construction, fuel use, transportation and refrigeration. The net increase in carbon emissions that would be required to replace inland capture fisheries by producing the equivalent amount of food is shown in Table 10-7 (Details in Annex 7-4).

Agricultural crops would have the largest emissions increase of 3.5 billion tonnes to 9.3 billion tonnes (rice, wheat and maize), which is equivalent to 8.2 to 13.7 times the agricultural emissions for crop production (2014 rice and maize cultivation emissions were 70 million tonnes and 423.4 million tonnes respectively). If fisheries were replaced with livestock (beef, pork and chicken) net increases in emissions would range between 4.5 million tonnes and 823.4 million tonnes (Table 10-7). Aquaculture replacement would have the smallest net increase in emissions of 3.3 million tonnes to 32.9 million tonnes, which is equal to <0.1 to 0.6 percent of global agricultural emissions.

Table 10-7: Net increase in carbon emissions from replacement of capture fisheries with replacement foods (million tonnes) (details in Annex 7-4)

Replacement food	Net increase in carbon emissions (million tonnes)	Percentage proportion of total carbon emissions
Tilapia	+3.3	<0.1
Rainbow trout	+33	0.6
Beef	+823	49
Pork	+4.5	2.5
Chicken	+71	122
Rice	+9 342	1 375
Wheat	+3 468	819
Maize	+6 013	6 012

Note: Percentage values indicate the proportion of emissions to total emissions per food source according to FAOSTAT. As there are no values for aquaculture emissions, the total emissions for agriculture were used.

Global and regional implications for replacing inland fish

At a global scale there would appear to be sufficient land and water available to accommodate replacement of the loss of inland fisheries by alternative foods. However, on a regional scale this is not the case. Replacement of capture fisheries by region indicates that for some areas the water demand and land requirements to replace fisheries will not by feasible. For instance, the replacing fisheries in the African Great Lakes with beef would require the equivalent of 2.2 times the current regional agricultural water use, with the remaining foods requiring 36 to 100 percent of the current total water demand for the region. In a region where increasing prevalence of drought and changing environmental conditions have increased the occurrence of crop and livestock failures, an increase in water demand for food production may not be feasible, and ultimately may lead to human water scarcity.

Similarly, in South Asia, water replacement demands are high (45 km^3 for beef), but appear modest in terms of total agricultural water use as the replacement value is only equivalent to 4.9 percent of the current total for South Asia. This would suggest that replacement by beef production would not be environmentally damaging. However, water scarcity is a growing concern as all countries in South Asia are suffering from absolute water scarcity, chronic water scarcity and regular water stress (according to definitions of water stress by Falkenmark and Widstrand, 1992). Therefore, additional water demands for food production could further increase the levels of water scarcity in these countries.

In Southeast Asia, which has the largest fish production, there is not sufficient land area to replace capture fisheries. Replacement of fisheries with beef or pork would require a 1.4 to a 4.2 magnitude increase in pastureland area already in use within the region. With one of the world's fastest growing populations in Southeast Asia, and existing land pressures, there is unlikely to be sufficient land to replace inland fisheries production with beef or pork (unless feeds are imported from other regions).

As the FAO 2015 global inland fisheries production is likely an underestimation, the replacement values probably under-represent the actual increases in production that would be required.

Livestock is the biggest human land use, and has a large influence on land degradation. At a global scale there is considered enough land to meet the demand for food (Godfray *et al.,* 2010), however, suitable agricultural land is generally limited, and there may be severe regional constraints on available land. Aquaculture and livestock production generally implies ownership of land or water (Welcomme *et al.,* 2010), as well as feeds, which may be too expensive or unavailable to the poor.

Livestock production emits 14.5 percent of global greenhouse gas emissions (Bailey *et al.,* 2014), and rice production is a significant source of methane emissions, as anoxic conditions in flooded soils release biogenic methane (Datta *et al.,* 2009). By contrast, land-use emissions associated with inland capture fisheries are relatively small, as the majority of fish harvested are consumed or sold locally, and fishing activities are based on manual labour with small transportation costs (Welcomme *et al.,* 2016).

Fish are rich sources of micronutrients, and aquaculture has been promoted as a viable alternative for lost capture fisheries (Welcomme *et al.,* 2010). However, aquacultured fish do not necessarily provide the same dietary micronutrient intake as wild caught fish, which are often eaten whole (Roos *et al*. 2007). Accessibility remains a challenge as the poorest fishers can still access quality nutrition from wild capture fisheries, but would have to purchase fish from aquaculture.

Access to cultured fish is not the same as that for wild caught fish. Poor subsistence fishers and farmers are unlikely to gain the same amount of food or economic benefit from aquaculture as they do from capture fisheries (Allison, 2011). A change in diet from one of high diversity (i.e. consuming many species of fish), to one of low diversity (consuming little or no fish) could reduce the diversity and quantity of fish being consumed. Replacement of specific micronutrients would require more land and water than replacing protein alone, and some micronutrients may not be replaceable by other food sources (Lymer *et al.,* 2016).

Finally, these estimations do not account for associated environmental impacts that accrue from land-use conversion, erosion, soil degradation, nutrient runoff and other poor agricultural practices that are common across the developing world. Soil loss and associated siltation of rivers, reduced flows in rivers, and excess use of fertilizers leading to eutrophication are just a few of the impacts that are likely to proliferate, all of which are associated with further loss of ecosystem services to rural and regional economies. The loss of inland fisheries will be just as detrimental to the environment for the millions that depend on the sector, and acknowledging the cost to food security and food supply of replacing inland capture fisheries will be important for recognizing the global importance of this diverse sector.

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10.4 INLAND CATCH ESTIMATES DERIVED FROM HOUSEHOLD SURVEYS

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Household survey data can provide information that is more accurate than fishery landing estimates. These can range from direct food consumption monitoring to indirect recall methods of food consumption and expenditure surveys. Household surveys can also provide in-depth information on fish consumption patterns by geographic area and socio-demographic groups, as well as provide further information on fish species consumed. However, surveys can have limitations on reliability of recall, identifying the source of fish and conversion factors of fish weight.

Studies have investigated fish consumption from a variety of data sources to understand in more depth the importance of fish to food and nutritional security and for validation of data (Hortle, 2007; Needham and Funge-Smith, 2014).

Hortle (2007) analysed 20 consumption surveys in the lower Mekong basin (LMB) and found that surveys showed higher levels of fish consumption than official FAO estimates. The surveys revealed the "hidden fish" that was under-reported in official statistics because of the informal nature of small-scale fisheries, and enabled a more accurate calculation of the fish yield from the basin (Hortle, 2007). Fish contributed between 47 and 80 percent of total animal protein intake and constituted an important part of the diet in the LMB, particularly in areas with abundant freshwater resources (Hortle, 2007).

A wider study by Needham and Funge-Smith (2014) exploring fish consumption patterns in Asia and the Pacific region also found disparities between data sources on fish consumption. For some countries such as Cambodia and Bhutan, consumption surveys also revealed higher fish consumption than official statistics, which could have been because of under-reporting in official statistics for fish catches or fish trade (Needham and Funge-Smith, 2014).

For a few countries, consumption surveys showed lower fish consumption levels than official statistics, such as for Indonesia, which may have been because of differences in rates used to convert dried fish weight to fresh fish weight (Needham and Funge-Smith, 2014). In India, consumption surveys were also important in revealing the extreme differences in fish consumption between areas because of religion, food preferences and access that official statistics masked (Needham and Funge-Smith, 2014).

In other regions, such as East and Southern Africa, fish consumption surveys also shed new light on small-scale fisheries and the importance to food and nutritional security. For landlocked Malawi whose fish supply is predominately from inland capture fisheries, the national 2010/11 Third Integrated Household Survey showed annual fish consumption to be 11.6 kg/capita for the average Malawian diet (Verduzco-Gallo, Ecker and Pauw, 2014), which is larger than the FAO reported apparent annual fish consumption of 5.5 to 6.7 kg/capita for the same period (FAO, 2017). In Brazil, the national dietary survey revealed that fish consumption is particularly high in the north compared with other regions and the national average (Souza *et al.*, 2013).

Consumption surveys showed higher estimates of the contribution of fish to total protein in diet for 70 percent of the selected countries when compared to official statistics. One reason could be the tendency to underestimate freshwater and coastal small-scale fisheries because of the challenges in monitoring them. The data show that for many developing and low-income-food-deficit countries, fisheries can contribute to more than 10 percent of total protein intake, and as much as one-third in places such as Ghana and Cambodia.

Although the share of fish to total micronutrients in diet is not reported, fish consumption data can also help us understand the importance of fish in providing micronutrients. Lymer *et al. (*2016) undertook detailed analyses of the nutritional contributions, protein and micronutrients, of inland fish consumed by populations around the lower Mekong River basin. Fish provided important levels of zinc, vitamin A, iron and calcium, especially in small fish species that are often eaten whole and contribute significantly to annual requirements of nutrients (Lymer *et al.*, 2016). The study also concluded that replacing protein from fish with other animal sources would require substantial increases in land use and water withdrawal, highlighting fish as a conserving and efficient source of nutrition (Lymer *et al.*, 2016).

Thus, for understanding food and nutritional security, a combination of consumption data sources is required. Consumption survey data can provide information on the "hidden fish" that arises because of the informal nature of small-scale fisheries and the difficulty in monitoring them. In addition, survey data can provide important information on preferences and subnational variation in fish consumption patterns, as fish are often particularly important to subsets of a population (Needham and Funge-Smith, 2014). However, more accurate fish trade information is required to understand the sources and types of fish consumed and their availability. In Zambia and Malawi for example, the amount of fish traded informally across borders is larger than the amount of fish exports officially recorded (Mussa *et al.*, 2017).

10.4.1 USING HOUSEHOLD CONSUMPTION AND EXPENDITURE SURVEY (HCES) DATA TO MODEL INLAND FISH CATCH

Data on fish consumption collected by national household consumption and expenditure surveys (HCES) are a potential alternative source of data for countries that lack an effective fishery monitoring system (Hortle, 2007; Mills *et al*., 2011; Funge-Smith, 2016). These surveys are administered by national authorities, and record per capita daily fish consumption (g per person per day) over recall periods of one or two weeks (Smith, Dupriez and Troubat, 2014). HCES may be more statistically representative of geographically dispersed fishery activities and landings than periodic monitoring of a limited number of (commercial/larger-scale) landing sites or gear (De Graaf *et al*., 2015; Funge-Smith, 2016).

HCES record all fish consumed (although species or source may not be detailed in the survey) and the consumption of fish recorded in HCES must be adjusted to distinguish between wild-caught freshwater fish from aquaculture, trade and marine sources, and to account for wastage or discarded weight from preparation of whole fish for sale and consumption (Funge-Smith, 2016).

This approach was first used to estimate inland capture fishery production in the lower Mekong basin (Hortle, 2007). An extension of this method using household surveys was undertaken by Lymer *et al.* *(*2008). HCES data for 24 countries were analysed to derive an estimate of national inland capture fishery production. The production estimate was generated from the household surveys by converting consumption weight of fish to live weight and then removing the contribution of aquaculture and marine fishery products, as well as imports and exports. The 24 countries analysed collectively account for 43 percent of the total global inland production for the year 2014 and include 17 of the 35 largest inland fish producers in the world according to officially reported statistics (FAO, 2017).

Fluet-Chouinard, Funge-Smith and McIntyre (2018) undertook the most comprehensive study to date, covering 42 countries and comparing the inland fishery catch derived from HCES with officially reported production statistics provided to FAO. The HCES were undertaken over an annual period, surveying an average of 0.44 percent of their population (S.D. = 0.55) and totalling 548 433 households studied between 1997 and 2014. These low-income and middle-income countries are distributed across South America, Europe, Africa, and Asia and accounted for 53.2 percent of reported global inland catch in 2008, and include 23 of the 31 largest reported national catches. To estimate inland catch from consumption surveys, the study excluded fish from marine harvests, converted processed weight to live weight equivalents, and subtracted supplies of freshwater fish from aquaculture and trade. Comparing HCES-estimated catches to the FAO statistics from the same years reveals the magnitude of under-reporting and the contribution of these hidden harvests to food security.

The results of the study indicated that total inland fish catch was 9.23 million tonnes (confidence interval (CI) was 7.12 million tonnes to 11.42 million tonnes across the 42 countries analysed (Table 10-7). The total reported catches for these 42 countries in the same years, was only 5.60 million tonnes. This implies an aggregated under-reporting of 64.8 percent (CI of 27 percent to 104 percent). This difference is remarkably close to a previous estimate (70 percent) derived from a more limited number of case studies developed for the *Hidden harvest* study (World Bank, 2012).

Table 10-7: Inland fishery catch in 42 countries with household consumption surveys modelled on 2008 data (millions of tonnes)

Measure	Value	Comments
Aggregated inland fishery catch for 42 countries reported to FAO (2008)	**5.60 million tonnes**	Represents 53.2 percent of all inland fishery production reported to FAO
Mean aggregate inland fishery catch for 42 countries estimated from household consumption surveys	**9.23 million tonnes** (CI 7.1 to 11.4 million tonnes)	Composite figure (1999 to 2014) according to survey data
Difference factor	**64.8 percent** (CI 27% to 104%)	Difference between reported production and production estimated from household survey
Adjusted 2008 catch (61 countries, 2008)	**17.1 million tonnes**	Based on extrapolation of model to additional 19 countries in the same socio-economic range. These countries represent 83 percent of catch reported to FAO

The individual countries' results revealed positive and negative differences between the HCES-based catches and FAO reported inland catch from the same year (31 countries with a total of 4.38 millions tonnes and 11 countries with a total of 0.74 million tonnes) The results were strongly driven by only a few major countries' production (Bangladesh, Democratic Republic of Congo, and Zambia), which contributed 42 percent of the total underestimated catch.

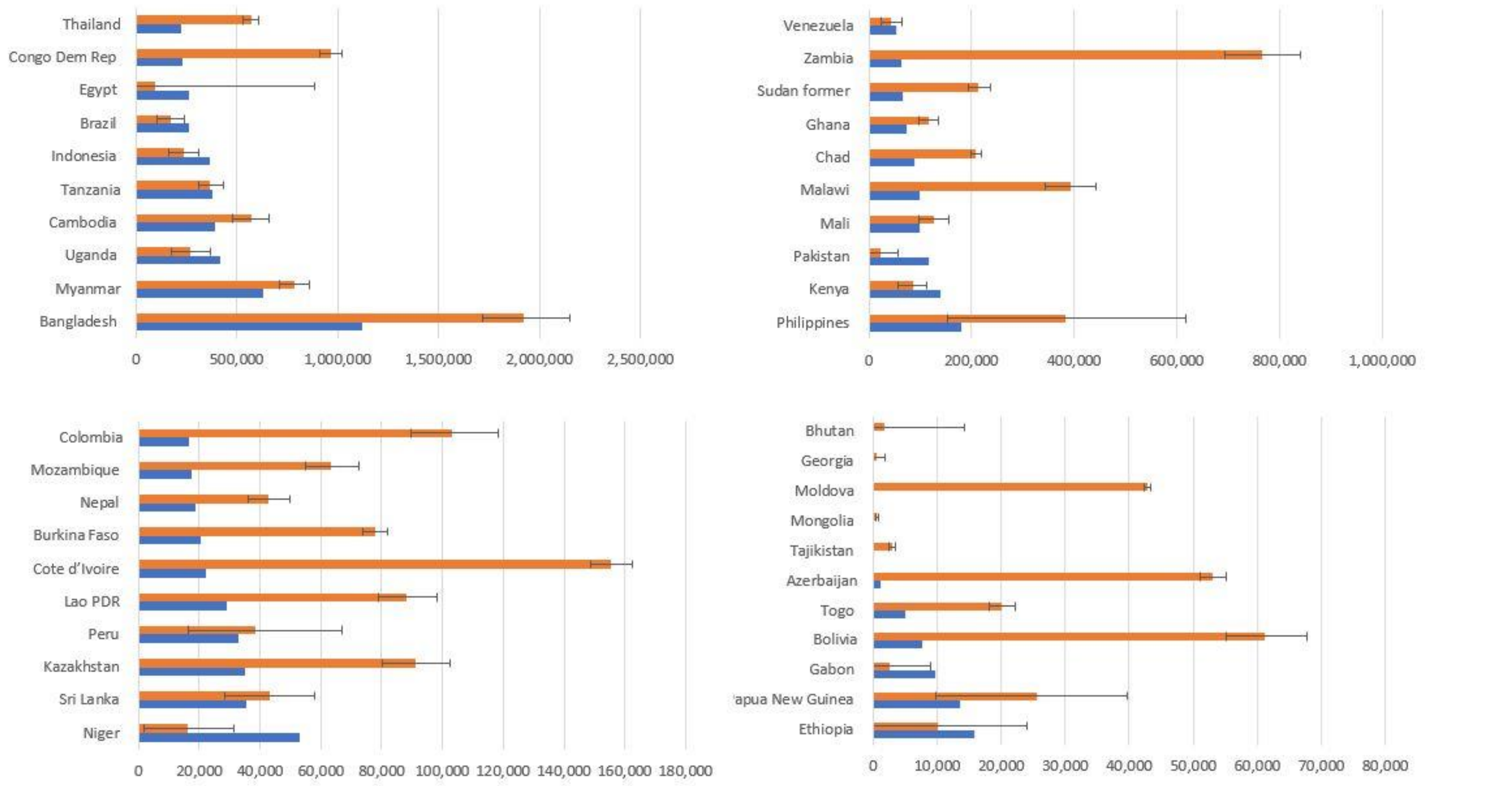
The estimates derived from the 42 countries where HCES-based catch estimates were meaningful provided the basis to explore the extrapolation to the global scale for an adjusted inland catch. The full model was applied to an additional 19 countries that lay in the same socio-economic range as those countries used in the HCES model. This brought the total to 61 countries accounting for 83 percent of reported global catch in 2008 (Table 10-7 above).

The adjusted estimate for total global capture of wild freshwater fishes in 2008 based on this method is 17.1 million tonnes, as compared to FAO's aggregated reported figure of 10.3 million tonnes. This global underestimation is still likely to be conservative as the model uses conservative assumptions and retained catch from recreational fishing is not included. The unreported catch revealed by this method is equivalent to the total animal protein intake of 36.9 million people (CI was 30.8 to 43.4 million people), bringing the equivalent of all animal protein consumption for inland fisheries to 119.1 million people (CI was 99.4 to 142.7 million people) in 36 countries where protein consumption was available.

The nutritional importance of this hidden supply of fish is particularly important, as the missing fish are consumed primarily in countries with low-protein diets. The country results of this analysis are presented in Table 10-8 below and plotted in Figure 10-5.

Table 10-8: Results of the household survey validation model for inland capture fishery production

Country	Survey year(s)	Inland fish catch			
		FAO FishStatJ (tonnes)	HCES modelled (tonnes)		
			Value	Lower	Upper
Armenia	2012	861	-3 725	-4 359	-3 065
Azerbaijan	2011	1 061	53 103	46 631	60 216
Bangladesh	2010	1 119 094	1 925 040	1 719 388	2 149 881
Bhutan	2010	1	1 772	1 249	2 320
Bolivia	2009	7 568	61 198	51 821	71 194
Brazil	2008-09	261 280	170 783	141 308	201 280
Burkina Faso	2013-14	20 500	77 740	66 586	89 114
Cambodia	2009	390 000	575 901	515 824	642 860
Chad	2009	88 000	208 919	171 524	245 076
Colombia	2006-07	16 648	103 197	84 503	127 410
Congo DR	2004-05	231 772	964 636	890 517	1 038 959
Côte D'Ivoire	2002	22 000	155 328	106 285	204 324
Ecuador	2005-06	250	-2 947	-12 677	9 605
Egypt	1997	261 167	96 915	26 120	172 661
Ethiopia	1999-00	15 858	10 027	8 097	12 042
Gabon	2005	9 700	2 507	503	5 133
Georgia	2011	27	492	-981	2 146
Ghana	1998-99	74 500	116 819	97 592	136 434
Guatemala	2006	2 360	-1 300	-2 444	119
India	2010	1 444 153	-1 078 164	-1 629 689	-410 653
Indonesia	2011	368 578	236 934	6 447	470 814
Kazakhstan	2011	34 896	91 267	72 677	113 041
Kenya	2005-06	140 199	84 912	70 411	100 035
Lao PDR	2008	29 200	88 292	69 353	108 944
Malawi	2010-11	98 298	392 902	323 944	461 211
Mali	2009	100 000	125 735	114 873	136 503
Mexico	2008	108 853	-7 952	-22 588	11 042
Moldova	2012	50	42 832	34 326	52 042
Mongolia	2008	88	610	495	732
Mozambique	2002-03	17 500	63 411	41 130	91 681
Myanmar	2006	631 120	783 617	687 136	884 504
Nepal	2003	18 888	42 584	29 051	57 726
Niger	2011	53 173	16 355	13 797	18 886
Pakistan	2010-11	115 348	21 755	2 473	43 113
Papua New Guinea	2001-06	13 500	25 573	9 860	39 614
Peru	2003-04	32 940	38 475	29 781	48 894
Philippines	2008	179 491	383 810	-228 742	1 175 263
Sri Lanka	2006-07	35 290	42 986	36 330	50 036
Sudan former	2009	66 000	212 803	185 623	241 149
Tajikistan	2007	225	2 997	2 517	3 501
Tanzania	2007	380 625	368 678	318 169	423 751
Thailand	2011	224 708	570 877	499 534	646 710
Togo	2006	5 000	20 124	14 054	26 619
Uganda	2005-06	416 758	269 710	228 532	309 403
Venezuela	2004-05	53 846	43 354	39 320	47 748
Zambia	2002-03	63 000	764 573	668 945	846 685



Source: Fluet-Chouinard, Funge-Smith and Mcintyre (2018)

Figure 10-5: Modelled inland fish catch versus reported inland fish catch (Blue bar is FAO catch, the orange bar is the modelled estimate)

10.4.2 LIMITATIONS OF THE HCES MODEL AND WHERE IT CAN WORK WELL

The HCES model approach did not work for all countries. In some cases the model returned negative inland fishery production. This was typically in those countries where inland fishery production was rather low, but freshwater aquaculture production was extremely high (China, India Viet Nam). In several cases the HCES-based estimates of inland fisheries catch were positive, but substantially lower than that reported (e.g. Pakistan, Brazil, Indonesia). Problems with the model increase with situations where there is substantial unknown/unrecorded import or export of freshwater fish, over–reporting of aquaculture production, limited detail in the household survey, for example recording only ”fish” instead of more detailed types/species or product forms. In such cases the fish could then be attributed to aquaculture or fisheries, or to marine or inland species.

The HCES model can help to establish the likely level of production, where estimates may have drifted off or hidden production cannot be directly measured. A summary of situations/country context where this approach can be applied effectively with some level of confidence is provided in Table 10-9.

Table 10-9: Country contexts that allow the inland capture fishery production model to be applied effectively, or where it will be subject to error

<table>
<tr><th>Likely to work well</th><th>Weak and liable to error</th></tr>
<tr><td>Survey data has reasonable detail of the fish products enabling their attribution to inland capture fishery</td><td>Survey data has limited detail preventing clear separation between inland and marine, fishery and aquaculture products</td></tr>
<tr><td rowspan="3">Substantial inland fisheries, with high levels of engagement across the country</td><td>Small inland fishery</td></tr>
<tr><td>Inland fishery highly focussed in one region of a large country, avoidance of regions that are hard to access</td></tr>
<tr><td>Inland fishery mainly recreational fishing</td></tr>
<tr><td rowspan="2">Limited or no aquaculture</td><td>Significant commercial aquaculture production (freshwater or marine)</td></tr>
<tr><td>Significant, but hidden rural small–scale aquaculture production</td></tr>
<tr><td>Little economic power to import fish</td><td>Developed economy with significant import of fish product</td></tr>
<tr><td rowspan="2">Limited or no fish exports</td><td>Large unrecorded cross-border exports of freshwater fish.</td></tr>
<tr><td>Weak import/export statistical data</td></tr>
<tr><td>Landlocked or insubstantial marine fishery</td><td>Large coastline, significant marine fishery</td></tr>
</table>

From this table it is clear that the situation faced by many LIDCs is quite applicable to the contexts where the model will work effectively. This is coincidental with the fact that it is these countries that often have the highest dependence on inland fisheries and the lowest capacity to monitor and estimate their production.

Even when the approach may not work well at national level, it may still be possible to use it at subnational level if disaggregated data exists. The HCES approach can use subnational results in situations where aquaculture, marine fishery, imports and exports can be reasonably quantified or dismissed. This may allow the estimation of production for subnational areas that have significant inland fisheries to be quantified and may contribute to basin estimations where a basin may only cover parts of a country. This approach was used by Hortle (2007) to establish the inland fishery production of the lower Mekong basin.

The current model developed used HCES from dates that centred around the year 2008. A limitation of the HCES approach is that national surveys are not synchronized, thus the estimate derived will be an aggregate figure across a number of years. Despite this limitation, the estimate is still better than no data at all, which is the case for a number of countries.

Future re-estimates may also allow the HCES modelled production approach to indicate a trend in fishery production. This would be possible if the HCES surveys are repeated across a sufficient number of countries every five or ten years. One advantage here is that the trend does not require synchronization of the countries and each country could be compared with its previous HCES-derived production estimate. As a minimum, the HCES allows an indication in the changing trend in inland fish consumption and therefore remains a potentially powerful tool to support understanding of the role of inland fisheries in data poor countries.

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10.5 ESTIMATING POTENTIAL PRODUCTION USING YIELD MODELS

Simon Funge-Smith and David Bunnell

The global area of freshwater lakes, reservoirs, and wetlands is estimated at more than 7.8 million km^2 (Lehner and Döll, 2004). Lakes and reservoirs represent 31 percent of the area with floodplains accounting for 32 percent. Other wetland types are a further 33 percent (Table 10-10). Rivers represent less than 5 percent of the total water area and may drain parts of these other freshwater resources. Although the river area is relatively small, the drainage of other productive floodplains and wetlands and the volume and flow is responsible for their high fishery productivity.

Table 10-10: Area (km^2) of global water resources by type and continent

Continent	Area (Km^2)								%
	Lakes	**Reserv-oirs**	**Rivers**	**Flood-plain**	**Flooded forest**	**Peat-land**	**Non-perma-nent wet-land**	**Total**	
Asia	898 000	80 000	141 000	1 292 000	57 000	491 000	357 000	3 316 000	42
South America	90 000	47 000	108 000	422 000	860 000		2 800	1 529 800	20
Africa	223 000	34 000	45 000	694 000	179 000		187 000	1 362 000	17
North America	861 000	69 000	58 000	18 000	57 000	205 000	26 000	1 294 000	17
Europe	101 000	14 000	5 000	53 000		13 000	500	186 500	2
Australia	8 000	4 000	500				112 000	124 500	2
Oceania	5 000	1 000	1 000	6 000			100	13 100	0.2
TOTAL	**2 186 000**	**249 000**	**358 500**	**2 485 000**	**1 153 000**	**709 000**	**685 400**	**7 825 900**	**100**
% Total area	**27.9**	**3.2**	**4.6**	**31.8**	**14.7**	**9.1**	**8.8**	**100**	

Adapted from: DeGraaf *et al*, 2015, based on data from Lehner and Doll, 2004

There are about 117 million inland lakes larger than 0.002 km^2 (2 000 m^2), which account for a surface area of approximately 5.0 million km^2 (*Verpoorter et al.*, 2014). In 2015, it was estimated that permanent bodies of water had an aggregate area of 2.78 million km^2 and that 86 percent of this area (2.4 million km^2) was more or less fixed in one location (Pekel *et al.*, 2016). These figures also indicate that about 5.0 million km^2 of the world's waterbodies are not permanent and will vary seasonally or between years. This variation has considerable implications for the productivity of inland fisheries and increases the complexity of directly estimating harvest at the global scale (Welcomme *et al.*, 2010).

As many inland fisheries occur in remote and developing regions that are difficult to access and assess, and much of the fish harvest may be consumed for subsistence, historically there has been a lack of reporting or monitoring of catches. The number of waterbodies fished is vast, as is the area they cover, making comprehensive fisheries assessments impractical.

Table 10-11: Summary of studies that have attempted to use productivity as a means to estimate likely or potential yields from inland fisheries

Study	Type of estimate (global/regional)	Comments
African lakes Henderson and Welcomme (1974)	Evaluated the relationship between morpho-edaphic index (MEI) and fish catch in 31 African lakes. The model predicted catch in kg/ha = 14.3136 MEI = 0.4681	The model described the relationship for lakes that were approaching or had reached their maximum level of exploitation. With increasing numbers of fishers/km^2 the individual catch rose up to a fisher density of 1.5 km^2 and then probably decreased. Deviations in the model were partly accounted for by differences in the numbers of fishermen operating in the lakes.
North America, Northern Europe, Japan, Kenya Downing, Plante and Lalonde (1990)	Biological production of lake systems. Linked fish production with phytoplankton, but not morpho-edaphic index.	Mainly temperate regions.
Africa Van den Bossche and Bernacsek (1990)	Developed earlier estimates of productivity (mostly from the work of Welcomme, 1972, 1979) to give a figure of **1.99 million to 3.22 million metric tonnes** for Africa.	This can be compared with the current reported production for Africa of 2.86 million tonnes.
Africa Crul (1992)	Proposed a mean yield per fisher about **2.3 tonnes/year** for a combined series of lakes and reservoirs in Africa; and **2 tonnes/year** for reservoirs only.	These estimates can only be applied in fisheries that are not overfished or degraded. They also presume fishers are not using any form of high efficiency fishing method.
African lakes Lae, Lek and Moreau (1992)	For a total of 59 lakes, developed a predictive model for fish yield related to six environmental characteristics (catchment area over maximum area, fishing effort, conductivity, depth, altitude and latitude). The model fitted predicted and measured data well.	The model was trained using existing data, with a view to application in fisheries that were not monitored to the same level and might provide an indication of yield.
African countries Turpie (2000) cited in Neiland and Béné, 2008	Estimated production for a number of African fisheries and used Welcomme's early observations that floodplains yield about **34 kg to 40 kg/ha.**	The approach was used to validate other estimates of fishery production.
Global Welcomme (2011)	Used a simple empirical relationship between lake area and fishery yield to generate an estimate of annual global lake fishery harvest of more than **93 million tonnes**.	Recognized to be a crude, over-estimate as it used tropical productivities applied to temperate lakes and did not account for fishing effort. (Welcomme, 2011; DeGraaf *et al*., 2015)
Africa and Asia Kolding and van Zwieten (2012)	Looked at how lake hydrodynamics affects productivity. Derived relative fluctuation index (RLLF) and its relationship with fish yield in range of tropical lakes and reservoirs in Asia and Africa.	Builds on classic morpho-edaphic index (MEI) for lakes and the dynamic flood pulse concept (FPC) for rivers and floodplains

Table 10-11: Summary of studies that have attempted to use productivity as a means to estimate likely or potential yields from inland fisheries

Study	Type of estimate (global/regional)	Comments
Lower Mekong Basin Hortle and Bamrungrach (2015)	Used three different categories of fishery habitat for the lower Mekong basin and applied a range of estimated fish yields. The estimated range of LMB yield was **1.3 million to 2.7 million tonnes per year.**	Assumes that wetlands of all types are exploited uniformly and produce within the estimated yield range. This result was in the same range as the production calculated from household consumption surveys.
Africa Kolding *et al.* (2016)	Used a simple productivity model to estimate African production to be in the region of 20 million tonnes based on the area of water resources and an estimate of typical productivity of **150 kg/ha.**	This did not account for fishing effort and so it is more accurately described as a potential yield. This can be contrasted with the current reported production for Africa of only 2.86 million tonnes.
Global Lymer et al. (2016)	Extrapolated the average yield from different habitats (e.g. lakes, rivers, wetlands) across continents and generated an area-scaled annual global "theoretical" total yield of **72 million tonnes.**	This figure is not an estimate of the fish caught, it is an estimate of the fish that might be available for capture should sufficient fishing effort be applied.
Global lakes Deines *et al.* (2017)	Model using remotely sensed data to provide a global estimate of inland fish harvest from freshwater lakes and reservoirs using a combination of metrics: chlorophyll *a* as a proxy measure for productivity; application of known catches for lakes and reservoirs in the respective countries and latitudes; Adjustment for population density.	Figure is only for the global waterbodies over 10 ha and does not include rivers and floodplains.

One method of estimating likely or potential fish catch uses water productivity (or fish catch) and water area as a predictor (Henderson and Welcomme, 1974; Ryder, 1982). The morpho-edaphic index (MEI) of a waterbody is an indicator of primary productivity and this has been applied as a reasonable predictor of lake yields in some situations (Table 10-11). It was applied with some success to African tropical inland fisheries systems (Henderson and Welcomme 1974; Toews and Griffith 1979; Youngs and Heimbuch, 1982; Marshall, 1984; DeGraaf *et al.*, 2015). An attempt to apply this at the global scale resulted in an extreme estimate (93 million tonnes), which was admittedly too high, because of the effect of applying mainly tropical productivities to the huge freshwater resources in northern latitudes (Welcomme, 2011).

The broad application of productivity indicators or typical catch rates to a global area encounters problems because of the different productivities between tropical and temperate or arctic freshwaters, and the differences in degree of utilization of the waters for fisheries (DeGraaf *et al.*, 2015). These differences arise as result of differing population densities, states of economic development and need for food versus recreation and accessibility. Therefore estimates that derive potential harvest based on the water productivity must be interpreted with caution because it is typically not possible to realize the full potential harvest for a wide range of reasons (Table 10-12).

Table 10-12: Reasons why the use of estimates of productivity may overestimate actual catch

MAIN REASONS	UNDERLYING REASONS
The fishing effort may be low	The fish may be inaccessible because of remote locations (e.g. remote lakes and rivers in North America, Russian Federation)
	Low population density of fishers
	Urbanized or non-agricultural populations in developed countries do not fish
	Recreational fisheries may not be food fisheries and may involve catch and release (there are notable exceptions, e.g. Finland)
	The fishery may be in a conflict zone, constraining access
Economic factors	Fish yields may be so low to make it unattractive/uneconomic to fish
	The market/price for fish may be poor, limiting the economic incentive to fish
	Lack of preservation limits the amount of catch that can be consumed or marketed
Socio-cultural factors	Many developed countries do not have significant inland fisheries and tend towards fishing for recreation (catch is not retained)
	Cultural norms of vegetarianism, taboos on fish capture/animal welfare
Productivity is highly seasonal and linked climatic factors	Peak catch is during monsoon flooding or drying out of harvesting areas (especially in swamps and floodplains). The productivity is highly linked to extent and duration of water coverage (this is also an access issue)
	In higher latitudes (e.g. subarctic) snow and ice may restrict fishing activity

More recent estimates have been made using a database of production from lakes and rivers and modelling this by assigning these figures across the water resources of the world. This model is more tuned to the regional variations that resulted in the large estimates of previous cruder estimations. Deines *et al.* (2017) developed a model using remotely sensed data to provide a global estimate of inland fish harvest from freshwater lakes and reservoirs. Using a combination of chlorophyll *a* as a proxy measure for productivity and applying known catches for lakes and reservoirs in the respective countries and latitudes, a predictive model of lake harvest was derived. This alone would give very high figures as it would assume that all of the waterbodies included in the model were fished at the catch rate applied. An additional adjustment was required to compensate for the likely level of fishing effort that might be occurring on each waterbody. This sort of statistic does not exist, so a proxy measure (population density within 100 km of the waterbody) was applied as a means to factor down the catch in those waterbodies that were in sparsely populated areas.

The results did demonstrate that there was a potentially higher yield than that reported, but that additional work needs to be done to improve the likely catches according to fishing effort to derive meaningful results at country level. The model developers recommended that there was a need to invest in a standardized and simple measure of effort across inland waterbodies (e.g. number of fisher-days) to derive a better understanding of dependence on inland fisheries generally, and also to provide improved input for the model.

The authors further recognize that many of the world's small lakes lie northwards of 50° latitude (Verpoorter *et al*., 2014) in areas of low population density and that their contribution to the global inland fisheries yield is probably lower than that predicted by simple area-based models (Welcomme, 2011). The lake modelling work was confined to 80 000 waterbodies larger than 0.1 km^2, and did not include rivers, floodplains and other wetlands. These habitats are know to sustain considerable inland fisheries and thus there is a need for considerably more effort to be applied to developing credible ways to link habitat area-yield models with fishing effort across a broader range of inland fisheries environments.

There are also limitations on the models where a fishery is largely recreational and the fish caught may or may not be retained. Therefore, it is possible that a fish could be caught more than once. In this situation typical retention rates (e.g. 50 percent of all fish caught retained and consumed) need to be applied to the catch rates or fishing effort estimate for the waterbody if a production figure is to be derived.

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ANNEXES

ANNEX 1: SUBREGIONAL DETAILS OF INLAND FISHERIES CATCH

Subregion	Inland capture fishery catch (tonnes) (2015)	Inland fishery production (kg/cap/year) (2013)	Total renewable surface water (km3/yr)	Fish production per unit of renewable surface water (tonnes/km3/yr)	Global inland fishery catch (%) (2015)	Global renewable surface water (%)
Africa Great Lakes	1 053 694	6.11	226	4 669	9.2	0.4
Africa – West Coast	568 094	4.08	1 394	408	5.0	2.6
Africa – Nile River basin	354 949	3.85	261	1 358	3.1	0.5
Africa – Sahel	307 385	2.01	251	1 226	2.7	0.5
Africa – Congo basin	304 020	1.57	2 419	126	2.7	4.6
Africa –Southern	229 651	1.40	589	390	2.0	1.1
Africa – Islands	25 940	1.01	332	78	0.2	0.6
Africa – North	16 198	0.18	36	453	0.1	0.1
Africa – East Coast	200	0.01	22	9	0.0	0.0
AFRICA TOTAL	**2 860 131**	2.56	**5 529**	**8 716**	**24.9**	**10.5**
America – South	362 481	0.90	17 883	20	3.2	33.9
America – Central	156 345	0.73	1 060	148	1.4	2.0
America – North	47 356	0.15	5 805	8	0.4	11.0
America – Islands	4 333	0.09	76	57	0.0	0.1
AMERICA TOTAL	**570 515**	0.57	**24 824**	**233**	**5.0**	**47.1**
Arabia	0	0.00	5	0	0.0	0.0
ARABIA TOTAL	**0**	0.00	**5**	**0**	**0.0**	**0.0**
Asia – South	2 591 358	4.68	3 444	752	22.6	6.5
Asia – Southeast	2 427 041	1.46	6 237	389	21.2	11.8
Asia – West	148 571	0.77	384	387	1.3	0.7
Asia – Central	90 441	0.63	395	229	0.8	0.7
Asia – East	47 201	0.23	563	84	0.4	1.1
ASIA TOTAL	**5 304 612**	1.99	**11 023**	**1 841**	**46.2**	**20.9**
China	2 281 065	1.63	2 739	833	19.9	5.2
CHINA TOTAL	**2 281 065**	1.63	**2 739**	**833**	**19.9**	**5.2**
Europe – Eastern	63 663	1.22	731	87	0.6	1.4
Europe – Northern	45 096	0.42	910	50	0.4	1.7
Europe – Western	27 921	0.09	804	35	0.2	1.5
Europe – Southern	13 337	0.09	597	22	0.1	1.1
EUROPE TOTAL	**150 017**	0.24	**3 042**	**194**	**1.3**	**5.8**
Oceania	18 030	0.50	1 314	14	0.2	2.5
OCEANIA TOTAL	**18 030**	0.50	**1 314**	**14**	**0.2**	**2.5**
Russian Federation	285 090	1.84	4 249	67	2.5	8.1
RUSSIAN FEDN. TOTAL	**285 090**	1.84	**4 249**	**67**	**2.5**	**8.1**
GLOBAL	**11 469 460**	**1.64**	**52 726**	**11 898**	**100**	**100**
EXCLUDED COUNTRIES	0	0.00	227	0	0.0	0.4

ANNEX 2: DETAILED CHARACTERIZATION MATRIX SCORES BY FISHERY (SECTION 1.5)

Sub-region	Fishery	Passive gear	Active gear	Mechanization	Size of fishing vessel	Motorized or not	Day/multiday	Fishing area / water body type	Storage / preservation	Labour / crew	Fishing unit / ownership	Time commitment	Disposal of catch	Utilization of catch / value	Integration into economy and / or management
Africa, Congo basin	Lake Kivu kapenta	N/A	1	0	2	1	2	3	0	1	0	3	2	1	1
African Great Lakes	Lake Albert Muziri and Ragoogi	N/A	1	0	2	1	2	3	0	3	2	3	2.5	1	1
	Lake Albert Nile perch	1	0	0	2	1	2	3	0	3	2	3	3	3	1
	Lake Malawi gill net	1	N/A	0	2	1	2	3	0	1	0	1	2	1	0
	Lake Malawi small purse seine	N/A	1	0	2	1	2	3	0	1	0	1	2	1	0
	Lake Malawi pair trawl	N/A	3	0	2	3	2	3	0	3	2	1	2	0.5	1
	Lake Malawi stern trawl	N/A	3	3	3	3	2	3	0	3	2	1	2	0.5	2
	Lake Malawi Maldeco stern trawl	N/A	3	3	3	3	2	3	1	3	3	1	2	0.5	3
	Lake Tanganyika gill net and longline	1	N/A	0	2	1	2	3	0	0	0	3	2	1	0
	Lake Tanganyika kapenta	N/A	1	0	3	2	2	3	0	3	2	3	2.5	1	0
	Lake Victoria dagaa	N/A	1	0	2.5	1	2	3	0	3	2	3	3	2.5	1
	Lake Victoria Nile perch	1	N/A	0	2.5	1	2	3	0	3	2	3	3	2.5	1
	Lake Malawi beach seine	N/A	1	0	0	0	2	3	0	1	0	1	2	1	0
Africa, Nile Basin	Lake Nasser trammel net and gill net	1	N/A	0	2	1.5	2	3	1	0.5	0	3	2	1	2
West Coastal Africa	Lake Volta winch boat	N/A	1	0	2	1.5	2	3	0	3	2	3	2	1	0
Southern Africa	Cahora Bassa kapenta	N/A	1	0	3	2	2	3	0	3	3	3	3	1	2
	Lake Kariba kapenta	N/A	1	1	3	1.5	2	3	0	3	3	3	2.5	1	2

Sub-region	Fishery	Passive gear	Active gear	Mechanization	Size of fishing vessel	Motorized or not	Day/multiday	Fishing area / water body type	Storage / preservation	Labour / crew	Fishing unit / ownership	Time commitment	Disposal of catch	Utilization of catch / value	Integration into economy and / or management
Southeast Asia	Myanmar inn fishery	3	N/A	0	0	0	2	2	0	3	2	3	2	1	3
	Tonle Sap dai	3	N/A	3	0	0	2	3	0	3	2	1	2.5	1	2
	Tonle Sap gill net	1	N/A	0	1	1	1	3	0	0	0	1	2	1	2
Central Asia	Caspian Sea kilka	N/A	2	3	3	3	2	3	1	3	3	3	3	3	2
	Caspian Sea sturgeon	1	N/A	0	2.5	2	3	3	1	3	2	0	3	3	2.5
North Europe	Estonian Lake Peipus gill net and trap net	1	0	0	3	3	2	3	1	2	3	3	2.5	2	3
	Finland Vendace trawl fishery	N/A	3	3	3	3	1	3	1	1	0	3	3	0	2
North America	Laurentian Great Lakes trap net	1	N/A	0	3	2.5	1	3	3	0	0	1	2	1	2
	Laurentian Great Lakes trawl	N/A	3	3	3	3	2	3	1	3	2	1	2	1	2
	Laurentian Great Lakes gill net	1	N/A	3	3	2.5	2	3	3	3	2	1	2	1	2
South America	Brazilian Amazon canoe and mothership	1	N/A	0	3	2	2	2	1	1	0	1	2.5	2	0
	Brazilian Amazon estuary trawl	N/A	3	3	3	3	2	2	1	3	2	1	3	2	2
	Lower Paraná sábalo	1	0.5*	0	1	1	1	2	0	1	0	0	3	1	2

ANNEX 3: METHODOLOGICAL APPROACH FOR INDIVIDUAL FISHERY PRODUCTION ESTIMATES (SECTION 1.6)

LAKE VICTORIA NILE PERCH FISHERY

The Nile perch fishery is largely driven by export of fillets as well as swim bladders, in addition to the factory processing of frames for fish meal. Thus, it was assumed that all of the reported catch is associated with a highly commercialized fishery, even though some is likely consumed locally. Lake-wide production estimates were obtained from Mkumbo and Marshall (2015) for 2011. Frame surveys (Kolding et al. 2014) indicate that gillnets and longlines represent the vast majority of fishing gears targeting Nile perch on the lake, so it was also assumed that catches from other gears, such as beach seines, were negligible.

LAKE VICTORIA DAGAA FISHERY

Mkumbo and Marshall (2015) reported a catch of 457 000 tonnes of dagaa in 2011. However, not all of this catch could be included in the commercial inland fisheries estimate as some dagaa is also consumed locally. See the discussion in this annex of "African lakes small pelagics fisheries".

LAKE KIVU KAPENTA FISHERY

Lake Kivu does not have reliable catch data for recent years, however Snoeks et al. (2012) estimated total production of the sardine fishery based on 2007 and 2008 catch data for all fisheries from Rwanda only. Total fisheries landings were 5 742 tonnes and 6 692 tonnes from 2007 and 2008 respectively. Applying assumptions that the sardine fishery (kapenta) accounted for 85% of the total catch and that Rwanda landings account for about 60% of the total landings for the Lake, total kapenta catch for the lake is estimated to be around 9 000 tonnes (Snoeks et al. 2012). These estimates are consistent with the catch of Lake Tanganyika Sardine (kapenta) reported by Rwanda to FAO, which presumably originate nearly exclusively from Lake Kivu. More recently, Rwanda reported 17 714 tonnes of Lake Tanganyika sardine (kapenta) for 2016. Lacking a more recent understanding of fishing activity by Congo Democratic Republic, only the 2016 catch of kapenta reported by Rwanda was included. However, not all of this catch could be included in the commercial inland fisheries estimate as kapenta is also consumed locally. See the discussion in this annex of "African lakes small pelagics fisheries".

LAKE TANGANYIKA KAPENTA FISHERY

Country level catch data reported to FAO to estimate Lake Tanganyika kapenta production could not be used to indicate lake-level production volume due to the multiple countries harvesting from the lake, which may also derive kapenta from other water bodies. Furthermore, kapenta catch is not disaggregated from other small pelagics (e.g. dagaa in Tanzania). An estimate of the total production of kapenta from Lake Tanganyika was obtained from Kimirei (2008) (figure 1) for the early 2000s. Not all of this catch could be included in the commercial inland fisheries estimate as kapenta is also consumed locally. See the discussion in this annex of "African lakes small pelagics fisheries".

LAKE ALBERT MUZIRI AND RAGOOGI FISHERY

The results of a 2012 catch assessment survey indicate an estimated 78 000 tonnes and 51 000 tonnes of muziri and ragoogi catch, respectively, representing around 80% of the total catch for Lake Albert (NaFIRRI 2012). Not all of this catch could be included in the commercial inland fisheries estimate as kapenta is also consumed locally. See the discussion in this annex of "African lakes small pelagics fisheries".

LAKE KARIBA KAPENTA FISHERY

An estimate of 18 000 – 19 000 tonnes total production of kapenta from Lake Kariba was obtained from Kinadjian (2012) (figure 2). This estimate is slightly higher, although fairly consistent with total dagaa/kapenta catches reported by Zimbabwe and Zambia to FAO for the same year. FAO statistics show a slight increase in dagaa/kapenta produced by these two countries since 2011.

CAHORA BASSA KAPENTA FISHERY

Mozambique reported 11 922 tonnes of dagaa/kapenta production to FAO for 2016. It is relevant to note that recent reports suggest sharp declines in kapenta production from Cahora Bassa for 2017.

AFRICAN LAKES SMALL PELAGICS FISHERIES

The total production estimated from the African lakes small pelagics fisheries is between 787 236 tonnes and 791 028 tonnes (see discussion and table x-x in chapter x). Given informal trade in dried fish from Malawi and Zambia alone could equate to greater than 200 000 tonnes and that dagaa harvested farther north is also largely destined for extended value chains, a total estimate of 400 000 tonnes for the highly commercialized fishery would represent a quite conservative estimate. An upper estimate of 600,000 would also still be within reason.

LAKE ALBERT NILE PERCH FISHERY

The results of a 2012 catch assessment survey indicate an estimated 8 619 tonnes of Nile perch catch, representing around 6% of the total catch for Lake Albert (NaFIRRI 2012).

LAKE MALAWI STERN, MALDECO STERN, AND PAIR TRAWL FISHERY

The Lake Malawi stern, Maldeco stern, and pair trawl fisheries all target small cichlids, such as Lethrniops spp., Copadichromis spp., and Oreochromis spp. (chambo). Their total estimated production is estimated at 5 600 tonnes per year (Phiri et al. 2013). While the Maldeco company reports producing between 1 820 and 3 290, it was not possible to disaggregate the rest of the pair and stern trawl catch from the total. Nonetheless, since all three fishing operations scored within the range of large-scale inland fisheries, the total of 5 600 tonnes was included. This production was not included in the total highly commercialized production because the fish is sold locally and only minimally processed.

CAMBODIA TONLE SAP DAI FISHERY

The dai fishery in Tonle Sap is the only gear in that system for which separate production statistics are provided. Government statistics for 2016 indicated 13 950 tonnes of production from the dai fishery. It was not possible to obtain separate production estimates for other gear such as the barrages and fence traps utilized in Tonle Sap fisheries. However, since the dissolution of industrial fishing lots in 2014 (Ratner et al. 2017), it is unlikely that the current state of the barrage and fence trap fisheries could be characterized among the larger-scale inland fisheries or that these fishing gears even remain in operation to the same extent. Thus, the production data for the dai fishery may provide a reasonable representation of the total current large-scale fisheries production from Tonle Sap.

MYANMAR INN (LEASABLE) FISHERY

Tezzo et al. (2016) estimate that between 22% and 45% of total inland fisheries production for Myanmar is attributable to the inn fishery. This range is equivalent to between 189 959 tonnes and 388 552 tonnes for 2015.

CASPIAN SEA KILKA FISHERY

Of the countries with access to the Caspian Sea, only Turkmenistan, Iran, and Russia registered reported or estimated catch of kilka to FAO (reported as Black and Caspian Sea sprat from inland waters). Of those countries, Iran reported the highest production of 22 429 tonnes in 2016, followed by Turkmenistan, which has produced an estimated 14 680 tonnes annually since 2005. Russian Federation only produced 1 509 tonnes of Black and Caspian Sea sprat and Azerbaijan reported just 316 tonnes. In the case of Russia, some of the reported Black and Caspian Sea sprat production likely originates from the Sea of Azov. Because the proportion of the catch originating specifically from the Caspian Sea fishery could not be determined, the production of Black and Caspian Sea sprat from Russia was excluded. The resulting total production estimate from the Caspian Sea kilka fishery is 37 425 tonnes, which may be an underestimate due to exclusion of catch from Russia.

CASPIAN SEA STURGEON FISHERY

In the Caspian Sea sturgeon fishery, the likely high rates of illegal fishing and trade (van Uhm and Siegal 2016; Strukova et al., 2016) make estimating sturgeon production particularly challenging. While reported harvests of sturgeon from inland waters in 2015 totaled 158 tonnes, this almost certainly underrepresents the actual catch. Data on the caviar trade offer one potential source for triangulating sturgeon production, but these data are also sparse. There are two recent reports on caviar trade, one focusing only on Bulgaria and Romania, as these are the countries considered to have viable sturgeon populations (Jahrl 2013), and one covering the EU (Engler and Knapp 2008). The report to the European Commission reported a total of 646 tonnes of legal wild sturgeon harvests, based on FAO statistics, and 24 tonnes of legal global caviar imports over the same period (Engler and Knap 2008). This suggests a conversion ratio of total volume wild caught sturgeon to volume caviar imported into the EU of just under 27. The same analysis reported 79 kg of illegal caviar seizures in the EU in 2006. Applying the ratio of 27 implicates that this volume of caviar could correspond with roughly two tonnes of illegal sturgeon harvests. The average illegal caviar seizures from 1999 to 2007 was 828 kg, potentially corresponding to about 22.4 tonnes. Thus, 22.4 tonnes of estimated illegal sturgeon catch were added to the FAO official statistics of sturgeon production for 2015, representing about 14% of legal harvests.

Clearly, seizures represent just a portion of actual levels of illegal trade. According to Strukova et al. (2016), illegal harvests in Iran during the period of 2003 to 2007 represented up to 20% of reported catch and increased to up to 30% of reported catch in 2008-2009. The same authors report that for the Russian Federation, illegal catch was 2000% of reported legal catch, amounting to 1 671 tonnes in 2007. Furthermore, these estimates may not represent the current reality due to sturgeon governance changes since the 1999-2007 period. Namely, Russia banned all capture sturgeon fishing in 2007 with the other Caspian nations following suit in 2014 (van Uhm and Siegal, 2016). It is unclear whether this may have led to increased or decreased illegal harvests.

FINLAND VENDACE TRAWL FISHERY

The Natural Resources Institute Finland reported 1 373 tonnes of catch from the Vendace commercial trawl fishery in 2014.

ESTONIAN LAKE PEIPUS GILL NET AND TRAP NET PERCH AND PIKE-PERCH FISHERY

The Estonian Ministry of Rural Affairs reported 814 and 417 tonnes of perch and pike-perch, respectively, for 2015.

NORTH AMERICA LAURENTIAN GREAT LAKES COMMERCIAL FISHERIES

Obtaining estimates for the two large-scale Laurentian Great Lakes fisheries (the trawl fishery and the gill net fishery) presented a challenge because catch data disaggregated by gear type was not available. A 2012 Great Lakes and Mississippi River Interbasin Study reported average annual total commercial catch from all five Great Lakes of 19 345 lbs, equivalent to 8 774.74 tonnes (U.S. Army Corps of Engineers 2012). This total includes contributions from all commercial gears. Another study of the whitefish fishery, one of the main commercial fisheries of the Great Lakes, reported that the fishery is comprised by 444 gill nets, 130 trap nets, and only a few other gears such as trawls and pound nets, indicating that gill nets represent about 75% of the licensed commercial gear for the whitefish fishery. Note that the matrix score for the trap net fishery falls below the threshold for large-scale fisheries. Given the predominance of gill nets in the commercial fishery and the apparently minimal role of trawls, but also acknowledging the lack of CPUE data upon which to base a more accurate production estimate for gear types, a wide production estimate range for the commercial trawl and gillnet fishery combined is 4 000 to 8 000 tonnes, or between 45% and 90% of total commercial production for the five lakes. This range was applied to the estimate for total large-scale inland fisheries production. Although this catch is commercial, it was not possible to determine the degree to which it is actually sold into a value chain that extends beyond the immediate local level, so it was not included in the total estimate for commercial inland fisheries production. However, within the broader Laurentian Great Lakes fisheries, the Lake Erie multi-species commercial fishery for perch and walleye is certified by the Marine

Stewardship Council, producing 2 656 tonnes for a specialized value chain. This volume was included in the estimate for total inland commercial fisheries catch.

LOWER PARANA SABALO FISHERY

In 2016, Argentina reported 17 190.86 tonnes of sábalo exports to Colombia, Bolivia and Brazil, with small amounts destined for the United States and Paraguay (Ministerio de Agroindustria, 2016). In the same year, FAO reported the same volume of production from Argentina for "Procholids, not otherwise identified". Given that sábalo is a procholid (Prochilodus lineatus), the reasonable assumption is that this FAO statistic pertains to reported sábalo production from Argentina, indicating that all reported production is exported. Therefore, this volume was included in the global estimate of highly-commercialized inland fisheries production.

BRAZILIAN AMAZON ESTUARY TRAWL FISHERY

The trawl fishery operating in the Brazilian Amazon targets primarily the migratory catfish piramutaba (Brachyplatystoma vaillantii), dourado (Bracyplatystoma flavicans), surubim (Pseudoplatystoma fasciatum) and filhote (Brahyplatystoma filamentosum) for export. According to a recent report by M. Ruffino, the average annual catch of piramutaba by the industrial fleet is 11 076 tonnes, just over 60% of the total piramutaba production. Since no estimate was found for the industrial trawl fishery's proportional contribution to catch of other catfish species, they were not included in the large-scale production estimate, although piramutaba constitutes 81-92% of the industrial catch. However, since these species are not consumed locally but instead destined for export (largely to Colombia) and to some other states in Brazil (Carolsfield et al. 2003), their total catches are included in the estimate for total commercial inland fisheries production.

INLAND FISHERIES USING CERTIFICATION OR ECOLABELS

A number of inland fisheries have obtained certification through schemes such as the Marine Stewardship Council's sustainable seafood certification scheme that aim to allow producers to access niche markets or obtain price premiums. The production of these fisheries was included in the total estimate for commercial inland fisheries production. These fisheries include the Bratsk Reservoir perch fishery, the Irikla Reservoir perch fishery, the Lake Hjalmaren pike-perch fish trap and gill net fishery, the Lake Malaren and Lake Vanern pike-perch fishery, and the Waterhen Lake walleye and northern pike gill net commercial fishery. These fisheries had some of the smallest production volumes, ranging from 50 to 2 565 tonnes.

FISHERIES FOR THE ORNAMENTAL FISH TRADE

Official statistics for ornamental fish catch and trade are scarce. If reported at all, ornamental fish production may be included in non-specific categories such as 'freshwater fish, not elsewhere included". Phiri et al. (2013) reported 11 781 kg of aquarium fish exports for Lake Malawi in 2010. However, there are other unaccounted for ornamental fish catches. For example, in the Brazilian Amazon, there is substantial trade of the cardinal tetra (Paracheirodon axelrodi) for export to the United States, Europe, and Asia (Ruffino 2014).

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ANNEX 4: SUPPLEMENTAL DATA FOR CHAPTER 4 – NUTRITIONAL CONTENT OF FRESHWATER FISH AND OTHER FOODS (PER 100 G)

Scientific name	Common (local) name	Prot-ein	Total lipid (fat)	Total satur-ated	Total poly-un-saturated	EPA	DHA	Ca	Fe	Zn	Vit A	Notes	Source
Channa striatus	Snakehead		0.99	0.34	0.475	<0.001	0.133					raw, whole, Thailand	2
Channa marulius	Gojar snakehead	17.1	0.3					9.3	0.43	0.6	-	raw, edible, Bangladesh	8
Channa striatus	Snakehead (shol)	18.7	0.3					96	0.41	0.73	-	raw, edible, Bangladesh	8
Channa punctata	Spotted snakehead (taki)	18.3	0.6					766	1.8	1.5	139	raw, edible, Bangladesh	8
	Snakeheads	**18.03**	**0.55**	**0.34**	**0.48**	**<0.001**	**0.13**	**290**	**0.88**	**0.94**	**139**		
Oreochromis spp.	Tilapia	20.8	1.7	0.77	0.476	0.007	0.113	10	0.56	0.33	0	raw, edible	1
	Tilapia	**20.80**	**1.70**	**0.77**	**0.48**	**0.01**	**0.11**	**10**	**0.56**	**0.33**	**0**		
Macrobrachium nipponense	Freshwater prawn		1.13	0.37	0.02	0.008	0.061					raw, whole, Thailand	2
Metapenaeus monoceros	FW prawn harina chingri	17.6	1					550	2.7	1.3		raw, edible, Bangladesh	8
Macrobrachium malcolmsonii	FW prawn najari icha	15.7	2.2					1 200	13	3.3		raw, edible, Bangladesh	8
	FW prawn	**16.65**	**1.44**	**0.37**	**0.02**	**0.01**	**0.06**	**875**	**7.85**	**2.30**			
Tenualosa ilisha	Hilsa	16.4	18.3					220	1.9	1.2	20	raw, edible, Bangladesh	8
Tenualosa ilisha	Hilsa jatka (juvenile)	19	7.7					500	2.5	1.8	14	raw, edible, Bangladesh	8
	Anadramous fish	**17.70**	**13.00**					**360**	**2.20**	**1.50**	**17**		
Mastacembelus pancalus	Barred spiny eel (guchi)	17.9	2.6					491	2.7	1.3	78	raw, edible, Bangladesh	8
Esomus danricus	Indian flying barb (darkina)	15.5	3.2					891	12	4	660	raw, edible, Bangladesh	8
Esomus Longimanus	Mekong flying barb (chanwa phlieng)							350	45.1	20.3	100 to 500	raw, edible. Cambodia	4, 5
Puntius ticto	Ticto barb (puti)							992	3	3.1	500 to 1 500	raw, edible. Bangladesh	3
Amblypharyngodon mola	Mola	17.3	4.5					853	5.7	3.2	2 503	raw, edible, Bangladesh	8
Helostorna temmineki	Kissing gourami							432*	5.3	6.5	100 to 500	raw, edible, Cambodia	4, 5
Rasbora tomieri	Changwa mool							700*	0.7	2.7	1 500	raw, edible, Cambodia	4, 5
Anabas testudineus	Climbing perch		0.99	0.34	0.384	0.001	0.088					raw, whole, Thailand	2
Puntius brevis	Swamp barb		0.9	0.31	0.314	0	0.047					raw, whole, Thailand	2
Rasbora bompensis	Black line rasbora		0.86	0.33	0.319	0.002	0.083					raw, whole, Thailand	2
Mastacembelus armatus	Baim	17.9	1.7					449	1.9	1.1	27	raw, edible, Bangladesh	8
Glossogobius giuris	Bele, bailla	16.6	0.4					790	2.3	2.1	18	raw, edible, Bangladesh	8
Colisa fasciata	Boro kholisha	15.2	2.5					1 700	4.1	2.3	46	raw, edible, Bangladesh	8

Scientific name	Common (local) name	Prot-ein	Total lipid (fat)	Total satur-ated	Total poly-un-saturated	EPA	DHA	Ca	Fe	Zn	Vit A	Notes	Source
Pseudambassis ranga	Chaa	15.5	3.8					1 153	2.1	2.6	336	raw, edible, Bangladesh	8
Gudusia chapra	Indian river shad (chapila)	15.5	3.8					1 063	7.6	2.1	73	raw, edible, Bangladesh	8
Chela cachius	silver hatchet chela (chela)	15.2	2.4					1 000	0.84	4.7	132	raw, edible, Bangladesh	8
Osteobrama cotio cotio	Dhela	14.7	3.8					1 200	1.8	3.7	918	raw, edible, Bangladesh	8
Hyporhamphus limbatus	Halfbeak (ekthute)	17.9	1.7					1 300	1.5	3.6	98	raw, edible, Bangladesh	8
Lepidocephalichthys guntea	Peppered loach (gutum)	17.2	3.9					950	3.3	2.5	76	raw, edible, Bangladesh	8
Puntius sophore	Jat Punti	15.7	7.2					1 042	2.2	2.9	54	raw, edible, Bangladesh	8
Corica soborna	Ganges river sprat (kachki)	11.9	1.9					476	2.8	3.1	78	raw, edible, Bangladesh	8
Xenontedon cancila	Freshwater garfish (kakila)	17.1	1.2					610	0.65	1.9	91	raw, edible, Bangladesh	8
Eleotris fusca	Dusky sleeper (kuli, bhut Bailla)	16.9	1.2					980	0.79	2	37	raw, edible, Bangladesh	8
Nandus nandus	Mud perch (meni, bheda)	16.7	1.7					1 300	0.84	1.6	60	raw, edible, Bangladesh	8
Botia dario	Bengal loach (rani, bou)	14.9	10.6					1 300	2.5	4	24	raw, edible, Bangladesh	8
Macrognathus aculeatus	Lesser spiny eel (tara baim)	17.2	2.6					457	2.5	1.2	83	raw, edible, Bangladesh	8
Small freshwater fish	Small freshwater fish	16.48	2.51					759	9.7	5.65	1 272	Lao PDR, Thailand, Cambodia, Viet Nam	7
	Small freshwater fish	**16.16**	**2.87**	**0.33**	**0.34**	**0.00**	**0.07**	**914**	**5.08**	**3.67**	**389**		
Mystus cavasius	Gangetic mystus (golsha)	16.8	5.1					120	1.8	1.3		raw, edible, Bangladesh	8
Ailia coila	Gangetic ailia (kajuli, Bashpata)	17.1	12.6					110	0.82	1.2	37	raw, edible, Bangladesh	8
Clarias batrachus	Walking catfish (magur)	16.5	1.3					59	1.2	0.74	25	raw, edible, Bangladesh	8
Ompok pabda	Pabdah catfish (modhu Pabda)	16.2	9.5					91	0.46	0.9		raw, edible, Bangladesh	8
Heteropneustes fossilis	Asian stinging catfish (Shing)	19.1	1.9					60	2.2	1.1	32	raw, edible, Bangladesh	8
Mystus vittatus	Tengra	15.1	4.6					1 093	4	3.1	12	raw, edible, Bangladesh	8
	Catfish spp.	**16.80**	**5.83**					**256**	**1.75**	**1.39**	**27**		
Carp	Carp	17.83	5.6	1.08	1.431	0.238	0.114	41	1.24	1.48	9	raw, edible	1
Large freshwater fish	Large freshwater fish	18.49	4.16					310	5.03	1.59	163	Laos, Thailand, Cambodia, Viet Nam	7
Notopterus notopterus	Featherback (foli)	20.5	0.6					230	1.7	1.6		raw, edible, Bangladesh	8
	Larger fish	**18.94**	**3.45**	**1.08**	**1.43**	**0.24**	**0.11**	**194**	**2.66**	**1.56**	**86**		
Catla catla	Catla	14.9	0.7					210	0.83	1.1	22	raw, edible, Bangladesh	8
Cirrhinus mrigala	Mrigal	18.9	1.1					960	2.5	1.5	15	raw, edible, Bangladesh	8
Labeo rohita	Rohu	18.2	3					51	0.98	1	13	raw, edible, Bangladesh	8
Cyprinus carpio	Common carp	16.4	2.9					37	1.1	2.2		raw, edible, Bangladesh	8
Ctenopharyngodon idella	Grass carp	15.2	1.1					54	0.46	0.91		raw, edible, Bangladesh	8

Scientific name	Common (local) name	Prot-ein	Total lipid (fat)	Total satur-ated	Total poly-un-saturated	EPA	DHA	Ca	Fe	Zn	Vit A	Notes	Source
Hypophthalmichthys molitrix	Silver carp	17.2	4.1					903	4.4	1.4		raw, edible, Bangladesh	8
Pangasianodon hypophthalmus	Thai pangas	16	17.7					8.6	0.69	0.65	31	raw, edible, Bangladesh	8
Pangasianodon hypophthalmus (juvenile)	Thai pangas (juvenile)	18.6	1.4					59	2.7	1.1	12	raw, edible, Bangladesh	8
Oreochromis niloticus	Tilapia	19.5	2					95	1.1	1.2	10	raw, edible, Bangladesh	8
Oreochromis niloticus (juvenile)	Tilapia (juvenile)	19	2.6					120	1.6	1.4	21	raw, edible, Bangladesh	8
Amblypharyngodon mola (cultured)	Mola	14.7	4.6					1 400	19	4.2	2 226	farmed, raw, edible, Bangladesh	8
Barbonymus gonionotus	Thai silver barb	18.4	4.4					270	1.6	1.8	12	raw, edible, Bangladesh	8
Catfish	Catfish	15.6	7.59	1.77	1.568	0.067	0.207	9	0.5	0.74	15	farmed, raw, edible	1
	Cultured species	**17.12**	**4.09**	**1.77**	**1.57**	**0.07**	**0.21**	**321**	**2.88**	**1.48**	**238**		
Pampus argenteus	White pomfret (foli chaa)	17.2	0.9					31	0.34	0.66		raw, edible, Bangladesh	8
Stolephorus tri	Spined anchovy (kata Phasa)	17.6	2.1					1 500	1.6	3.1		raw, edible, Bangladesh	8
Johnius argentatus	Silver Pennah croaker (lal poa)	18.1	2.4					1 900	1.7	2.1		raw, edible, Bangladesh	8
Scomberomorus guttatus	Indo-Pacific king mackerel (maita)	20.5	1.1					34	0.49	0.7		raw, edible, Bangladesh	8
Platycephalus indicus	Bartail flathead (murbaila)	18.8	0.3					150	1.7	0.79		raw, edible, Bangladesh	8
Liza parsia	Gold spot mullet (parse)	16.1	14.3					66	1.3	0.84		raw, edible, Bangladesh	8
Eleutheronema tetradactylum	Tailla	20.6	2.2					37	0.6	0.9		raw, edible, Bangladesh	8
Sillaginopsis panijus	Tular dai	19.3	0.6					230	2.1	0.89	20	raw, edible, Bangladesh	8
-	Anchovy	20.35	4.84	1.28	1.637	0.538	0.911	147	3.25	1.72	15	raw, edible, European	1
-	Herring	16.39	9.04	2.04	2.423	0.969	0.689	83	1.12	0.99	32	raw, edible, Pacific	1
-	Mackerel	18.6	13.89	3.26	3.35	0.898	1.401	12	1.63	0.63	50	raw, edible	1
Chano chanos	Milkfish	20.53	6.73	1.67	1.84			51	0.32	0.82	30	raw, edible, Philippines	1
Sardine		24.6	10.5	2.5	2.5	0.6	0.9	275	2	1.9	11	canned in oil, drained solids with bone	1
Salmo salar	Farmed Atlantic salmon	20.1	12.9	2.2	3.6	0.6	0.9	4.7	0.2	0.3	8.5	-	6
Thunnus alalunga	Alabacore tuna	27.3	1.1	0.5	0.4	0.1	0.3	2.9	0.9	0.4	3.5	-	6
	Marine species	**19.74**	**5.53**	**1.92**	**2.25**	**0.62**	**0.85**	**302**	**1.28**	**1.12**	**21**		
OTHER FOODS	**Common(local) name**	**Prot-ein**	**Total lipid (fat)**	**Total satur-ated**	**Total poly-un-saturated**	**EPA**	**DHA**	**Ca**	**Fe**	**Zn**	**Vit A**	**Notes**	**Source**
Beef		14.3	30	11.29	0.696	-	-	24	1.64	3.57	0	raw, 70% lean meat 3% fat	1
Chicken breast		14.7	15.75	3.26	3.34	-	-	19	1.11	0.78	0	breast meat, uncooked	1

Scientific name	Common (local) name	Prot-ein	Total lipid (fat)	Total satur-ated	Total poly-un-saturated	EPA	DHA	Ca	Fe	Zn	Vit A	Notes	Source
Chicken egg		35.6	9.94	3.1	7.555	0.004	0.037	171	3.23	1.11	140	raw, whole	1
Chicken liver		16.9	4.83	1.56	1.306	-	-	8	8.99	2.67	3 292	all classes, raw	1
Cow milk		3.28	3.66	2.28	0.136	-	-	119	0.05	0.37	33	3.7% milk fat	1
Cassava		1.4	0.28	0.28	0.048	-	-	16	0.27	0.34	1	raw	1
Rice		2.69	0.28	0.28	0.323	-	-	10	1.2	0.49	0	white, long-grain, cooked	1
Kidney beans		8.67	0.09	0.09	0.278	-	-	35	2.22	0.86	0	mature, cooked	1
Carrot		0.93	0.17	0.04	0.117	-	-	33	0.3	0.24	835	raw	1
Kale		3.3	0.7	0.7	0.338	-	-	135	1.7	0.44	769	raw	1
Spinach		2.86	0.39	0.39	0.165	-	-	99	2.71	0.53	469	raw	1

Note: Data compiled from Kawarazuka (2010); HLPE (2014); Lymer *et al. (*2016); Bogard *et al. (*2015).

Nutrition information is presented in 100 g for comparison only.

Vitamin A as RAE (Retinol Activity Equivalent).

* Raw, cleaned parts

Sources: 1=USDA (2011); 2=Karapangiotidis, Yakupitiyage and Little (2010); 3=Roos (2001); 4=Roos *et al.* (2007a); 5=Roos *et al.* (2007b); 6= http://nutraqua.com/component/option,com_neocomposition/Itemid,53/lang,en/ ; 7= Lymer *et al*. (2016); 8 = Bogard *et al.* (2015)

ANNEX 5-1: REGIONAL AND COUNTRY DETAIL OF INLAND CAPTURE FISHERIES AND FRESHWATER AQUACULTURE PRODUCTION

AFRICA (Total inland production)

	Landlocked countries	Inland catch tonnes	% Total land-locked	Coastal countries	Inland catch tonnes	% Total coastal	% Total regional inland catch	Freshwater aquaculture	Production tonnes	%	Aquaculture value USD (thousands)
	Africa										
1	* Uganda	424 341	41	*Nigeria	329 026	19	12	*Nigeria	276 738	40	788 311
2	* Malawi	115 565	11	*Tanzania UR	301 954	18	11	Egypt	194 816	28	421 657
3	* Chad	109 004	11	*Congo DR	221 581	13	8	*Uganda	101 659	15	231 865
4	*Mali	90 239	9	Egypt	199 637	12	7	*Ghana	32 438	5	55 931
5	Zambia	77 947	8	*Kenya	158 647	9	6	*Kenya	21 755	3	56 088
6	*the Niger	45 385	4	*Ghana	90 000	5	3	Zambia	17 165	3	57 237
7	*Ethiopia	37 396	4	*Mozambique	80 475	5	3	*Zimbabwe	9 332	1	23 331
8	*Central African Republic	30 800	3	*Cameroon	75 000	4	3	*Malawi	3 819	1	11 387
9	*South Sudan	29 600	3	Congo	36 532	2	1	*Madagascar	3 616	1	12 633
10	*Rwanda	22 571	2	*Senegal	30 725	2	1	*Congo DR	2 890	0	8 666
	Others	44 994	4	*Others*	200 709	12	7	*Others*	19 550	3	61 063
	Total landlocked countries	**1 027 843**	**100**	**Total coastal countries**	**1 724 286**	**100**		**Total FW aquaculture**	**683 778**	**100**	**1 728 167**
	Total catch inland (tonnes)			**2 752 129**							
	AFRICA (total inland production)			**3 435 908**							
	(%) of world's inland production			**7.1**							
	(%) Global inland capture			**28**							
	(%) Global aquaculture			**1.8**							

AMERICAS (Total inland production)

	Landlocked countries	Inland catch tonnes	% Total landlocked	Coastal countries	Inland catch tonnes	% Total coastal	% Total inland catch Americas	Freshwater aquaculture	Tonnes	%	Aquaculture value USD (thousands)
1	**Paraguay**	**17 000**	**71**	**Brazil**	**227 865**	**46**	**44**	**Brazil**	**414 580**	**49**	**996 161**
2	**Bolivia PS**	**6 868**	**29**	**Mexico**	**118 648**	**24**	**23**	**United States of America**	**165 275**	**20**	**432 516**
3				Venezuela BR	37 889	8	7	Colombia	78 416	9	225 475
4				Peru	31 599	6	6	Mexico	39 672	5	76 223
5				Colombia	20 083	4	4	Ecuador	31 749	4	92 812
6				Canada	17 807	4	3	Honduras	24 590	3	68 757
7				Argentina	15 674	3	3	Cuba	23 284	3	23 284

8				USA	9 250	2	2	Costa Rica	22 893	3	112 173
9				Guatemala	2 360	0	0	Guatemala	7 999	1	30 392
10				Uruguay	2 169	0	0	Paraguay	6 552	1	25 288
				Others	9 604	2	2	*Others*	24 147	3	153 464
	Total landlocked countries	**23 868**	**100**	**Total coastal countries**	**492 948**	**100**		**Total FW aquaculture**	**839 157**	**100**	**2 236 545**
	Total catch inland (tonnes)			**516 816**							
	AMERICAS (total inland production)			**2 713 944**							
	(%) of world's inland prod.			**2.8**							
	(%) Global inland capture			**5**							
	(%) Global aquaculture			**2.2**							

ASIA (Total inland production)

	Landlocked countries	Inland catch tonnes	% Total land-locked	Coastal countries	Inland catch tonnes	% Total coastal	% Total inland catch Asia	Freshwater aquaculture	Tonnes	%	Aquacultur e value USD (thousands)
1	**Kazakhstan**	**36 196**	**67**	**China**	**1 647 227**	**26**	**26**	**China**	**24 352 873**	**66**	**34 072 685**
2	***Uzbekistan**	**14 661**	**27**	***India**	**1 209 010**	**19**	**19**	***India**	**4 060 504**	**11**	**7 252 378**
3	*Tajikistan	1 017	2	**Myanmar**	**836 586**	**13**	**13**	Indonesia	2 430 498	7	4 223 667
4	*Afghanistan	1 000	2	***Bangladesh**	**830 316**	**13**	**13**	Viet Nam	2 308 388	6	4 019 025
5	Armenia	347	1	Cambodia	482 450	**8**	**8**	*Bangladesh	1 614 737	4	3 174 694
6	Turkmenistan	314	1	Indonesia	380 789	**6**	**6**	Myanmar	858 472	2	1 258 517
7	Azerbaijan	286	1	Thailand	205 343	**3**	**3**	Thailand	393 981	1	607 555
8	*Kyrgyzstan	92	0	Viet Nam	161 937	**3**	**3**	Philippines	267 317	1	424 492
9				*Pakistan	124 462	**2**	**2**	*Others*	786 963	2	1 759 411
10				Philippines	118 487	**2**	**2**				
				Others	283 069	**5**	**4**				
	Total landlocked countries	**53 912**	**100**	**Total coastal countries**	**6 279 675**	**100**		**Total FW aquaculture**	**37 073 733**	**100**	**56 792 424**
	Total catch inland (tonnes)			**6 333 587**							
	ASIA (total inland production)			**43 407 321**							
	(%) of world's inland production			**89.1**							
	(%) Global inland capture			**64**							
	(%) Global aquaculture			**95.4**							

EUROPE (Total inland production)

	Landlocked countries	Inland catch tonnes	% Total land-locked	Coastal countries	Inland catch tonnes	% Total coastal	% Total inland catch Europe	Freshwater aquaculture	Tonnes	%	Aquaculture value USD (thousands)
1	**Hungary**	**7 466**	**40**	**Russian Federation**	**140 237**	**62**	**57**	**Russian Federation**	**102 158**	**40**	**244 619**
2	**Serbia**	**4 374**	**23**	Finland	20 544	9	8	Poland	22 125	9	64 909
3	**Czechia**	**3 753**	**20**	Poland	18 368	8	7	Ukraine	22 068	9	56 361
4	Slovakia	1 885	10	Germany	16 264	7	7	Czechia	19 568	8	48 089
5	Switzerland	776	4	Ukraine	7 976	4	3	Hungary	15 549	6	36 844
6	Austria	340	2	Sweden	4 818	2	2	Belarus	12 816	5	37 563
7	Macedonia FYR	161	1	Romania	3 279	1	1	Moldova RO	8 973	4	10 315
8	Moldova RO	50	0	Italy	3 110	1	1	Romania	8 690	3	18 211
9	Liechtenstein	-	0	Estonia	2 772	1	1	France	7 920	3	17 553
10				Spain	2 650	1	1	Germany	7 096	3	21 172
				Others	7 710	3	3	Others	26 172	10	83 030
	Total landlocked countries	**18 806**	**100**	**Total coastal countries**	**227 728**	**100**		**Total FW aquaculture**	**253 135**	**100**	**638 666**
	Total catch inland (tonnes)			**246 534**							
	ASIA (Total inland production)			**499 668**							
	(%) of world's Inland production			**1**							
	(%) Global inland capture			**2**							
	(%) Global aquaculture			**0.7**							

OCEANIA (Total inland production)

	Landlocked countries	Inland catch tonnes	% Total land-locked	Coastal countries	Inland catch tonnes	% Total coastal	% Total inland catch Oceania	Freshwater aquaculture	Tonnes	%	Aquaculture value USD (thousands)
1				**Papua New Guinea**	**10 814**	**88**	**88**	**Papua New Guinea**	**1 880**	**63**	**8 306**
2				Australia	1 099	9	9	**Australia**	**803**	**27**	**10 175**
3				New Zealand	325	3	3	Fiji RO	161	5	515
4				Others	94	1	1	Guam	70	2	508
							0	Others	84	3	432
	Total landlocked countries	**-**	**0**	**Total coastal countries**	**12 333**	**100**		**Total FW aquaculture**	**2 998**	**100**	**19 936**
	Total catch inland (tonnes)			**12 333**							
	ASIA (Total inland production)			**15 331**							
	(%) of world's inland production			**0.03**							
	(%) Global inland capture			**0.13**							
	(%) Global aquaculture			**0.01**							

ANNEX 5-2: FRESHWATER MOLLUSCS AND CRUSTACEANS OF THE WORLD

Country (species)	Average 2011–2015			
	Freshwater crustaceans		Freshwater molluscs	
	Tonnes	% of world total	Tonnes	% of world total
China	**329 436**	**76.35**	**271 401**	**76.27**
FW molluscs nei			271 401	76.27
Oriental river prawn	137 676	31.91		
Siberian prawn	137 675	31.91		
Chinese mitten crab	54 085	12.54		
Philippines	**1 582**	**0.37**	**61,701**	**17.34**
FW Freshwater molluscs nei			61,701	17.34
Giant river prawn	1 582	0.37		
Bangladesh	**50 161**	**11.63**		**0.00**
FW crustaceans nei	50 161	11.63		
Indonesia	**16 434**	**3.81**	**1,306**	**0.37**
Giant river prawn	10 870	2.52		
FW prawns shrimps nei	5 165	1.20		
FW molluscs nei			1 306	0.37
FW crustaceans nei	399	0.09		
Japan	**469**	**0.11**	**11 917**	**3.35**
Japanese corbicula			9 030	2.54
FW molluscs nei			2 887	0.81
FW prawns shrimps nei	469	0.11		
Asia top five countries	**404 787**	**93.82**	**351 601**	**98.81**
Rest of Asia	**6 704**	**1.55**	**5 277**	**1.48**
Rest of world	**26 684**	**6.18**	**4 225**	**1.19**
Grand total	**431 471**	**100**	**355 827**	**100**

Notes: 2017 landing prices (per kg) for Chinese freshwater prawns (USD 6.13), Chinese mitten crabs (USD 12.11) and molluscs (USD 5.53) were obtained from local Chinese contacts. Japanese corbicula prices (USD 3.55) were obtained from local Japanese contacts. These were converted back to 2015 prices using the FAO FPI (USD 5.80 [prawn], USD 11.46 [mitten], USD 5.23 [mollusc] and USD3.36 [corbicula]). Given the Chinese dominance of reported inland crustacean and mollusc catches, the estimate employed Chinese prices (with the exception of corbicula) so as to estimate the TUV derived from inland crustacean and mollusc fisheries. Average annual total inland prawn catches over the period 2011 to 2015 are 310 131 tonnes (valued at USD 1.8 billion), crustacean catches are 121 340 tonnes (USD 1.4 billion), corbicula catches are 9 030 tonnes (USD 30 million) and molluscs 346 797 tonnes (USD 1.8 billion). The annual TUV of inland crustacean and mollusc catches is therefore estimated to be worth about USD 5 billion.

Inland culture production of molluscs and crustaceans is almost exclusively shrimp, and is concentrated in the brackish waters of Africa (average production of 2 996 tonnes per annum over the period 2011 to 2015, worth USD 20.3 million) and Asia (average production of 691 568 tonnes worth USD 3.4 billion).

ANNEX 5-3: GLOBAL SAMPLE OF FRESHWATER FISH PRICES

United States of America Period: December 2011 to July 2017									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of Natnl. catch**	**(C) Local price: USD**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Ictalurus furcatus	Blue catfish	Market	Dec. 2011	2 610	28		8.82	8.13	http://www.imperialcatfish.com/
Perca flavescens	American yellow perch	Market	July 2017	814	9		5.99	5.63	http://freshfishhouse.com/caught-wild-categories/yellow-perch/
Sander vitreus	Walleye	Market	July 2017	19	0		3.62	3.43	http://freshfishhouse.com/caught-wild-categories/yellow-perch/
Morone chrysops	White bass	Market	July 2017	299	3		1.81	1.71	http://freshfishhouse.com/caught-wild-categories/yellow-perch/
Ictiobus spp.	Buffalofishes nei	Market	July 2017	1 454	16		1.13	1.07	http://freshfishhouse.com/caught-wild-categories/yellow-perch/
Total	4			4 382	47			3.59	Simple average 2015 price
								5.38	Weighted average 2015 price
Mexico Period: Jan 2015									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: MXN**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Cichlid fish	Tilapias nei	Market	Jan. 2015	69 229	58		2.45	2.45	La Viga Market (net)
Cyprinus carpio	Common carp	Market	Jan. 2015	28 330	24		1.36	1.36	La Viga Market (net)
Total	2			97 559	82			1.91	Simple average 2015 price
								2.13	Weighted average 2015 price
Brazil Period: March 2015 to July 2016									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: BRL**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Prochilodus lineatus	Jaraqui (Prochilods nei)	Market	Mar. 2015	26 697	12	12.00	4.22	4.22	http://g1.globo.com/am/amazonas/noticia/2015/03/confira-precos-de-peixes-em-feiras-e-supermercados-de-manaus.html
Arapaima gigas	Pirarucu (Arapaima)	Market	July 2016	1 180	1	12.75	3.93	3.85	http://g1.globo.com/am/amazonas/noticia/2015/03/confira-precos-de-peixes-em-feiras-e-supermercados-de-manaus.html
Colossoma macropomum	Tambaqui (Cachama)	Market	Mar. 2016	3 957	2	9.59	2.96	2.92	http://g1.globo.com/ro/rondonia/noticia/2016/03/quilo-de-peixe-tambaqui-e-vendido-em-media-por-r-501-em-rondonia.html
Piaractus mesopotamicus	Pacu	Market	Mar. 2015	15 790	7	7.96	2.80	2.80	http://www.correiodoestado.com.br/noticias/precos-do-pintado-e-do-pacu-sao-mais-baratos-do-que-carne-bovina/81548/
Total	4			47 624	21			3.45	Simple average 2015 price
								3.63	Weighted average 2015 price
Peru									

Period: March 2015 to July 2016									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: PEN**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Colossoma macropomum	Gamitana (cachama)	Market	Dec. 2016	198	1	10.00	3.05	2.87	Peruvian Government, DIREPRO: Average fresh fish prices 2016
Prochilodus nigricans	Boquichico (netted prochilod)	Market	Dec. 2016	9 198	29	8.00	2.44	2.30	Peruvian Government, DIREPRO: Average fresh fish prices 2016
Trachinotus goodei	Palometa	Market	Dec. 2016	1 613	5	6.00	1.83	1.72	Peruvian Government, DIREPRO: Average fresh fish prices 2016
Pseudorinelepis genibarbis	Carachama	Market	Dec. 2016	277	1	6.00	1.83	1.72	Peruvian Government, DIREPRO: Average fresh fish prices 2016
Total	4			11 287	36			2.15	Simple average 2015 price
								2.21	Weighted average 2015 price
China **Period: January 2013 to July 2017**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: CNY**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Carassius carassius	Crucian carp	Market	July 2017		N/A	17.62	2.60	2.46	http://english.agri.gov.cn/service/pi/201707/t20170720_292450.htm
Cyprinus carpio	Common carp	Market	July 2017		N/A	11.43	1.69	1.60	http://english.agri.gov.cn/service/pi/201707/t20170720_292450.htm
Hypophthalmichthys molitrix	Silver carp	Market	July 2017		N/A		0.89	0.84	https://www.alibaba.com/product-detail/Frozen-silver-carp-Asian-carp-fresh_60252347363.html
Total	3			0				1.63	Simple average 2015 price
								N/A	Weighted average 2015 price
Myanmar **Period: September 2013**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: MMK**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Channa harcourtbutleri	Snake head	Market	Sep. 2013		N/A	4,650	4.82	4.44	http://www.commerce.gov.mm/en/article/market-price
Chitala ornata	Featherback	Market	Sep. 2013		N/A	3,750	3.89	3.58	http://www.commerce.gov.mm/en/article/market-price
Cirrhinus mrigala	Mrigal	Market	Sep. 2013		N/A	3,600	3.73	3.44	http://www.commerce.gov.mm/en/article/market-price
Catla catla	Catla	Market	Sep. 2013		N/A	2,350	2.44	2.25	http://www.commerce.gov.mm/en/article/market-price
Labeo rohita	Rohu	Market	Sep. 2013		N/A	2,200	2.28	2.10	http://www.commerce.gov.mm/en/article/market-price
Total	5			0				3.16	Simple average 2015 price
								N/A	Weighted average 2015 price

Bangladesh Period: October 2012 to July 2017									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: BDT**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Labeo rohita	Rohu	Market	July 2017		N/A	250	3.10	2.93	http://freshfishbd.com/fresh-water-fish
Catla catla	Catla	Market	Oct. 2012		N/A		2.18	2.18	http://www.academia.edu/4929172/Fresh_Fish_Marketing_Sta
Total	2			0				2.56	Simple average 2015 price
								N/A	Weighted average 2015 price

Cambodia Period: 2012 to 2013									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: KHR**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Trichopodus spp, Trichogaster spp,	Trey kawnthor, Trey romeos	Market	2012-13		N/A	6 828	1.71	1.68	Fisheries valuation project in Cambodia database
Mystus spp (6 species)	Trey kanchos	Market	2012-13		N/A	6 861	1.72	1.69	Fisheries valuation project in Cambodia database
Hypsibarbus spp (5 species); Barbonymus gonionotus	Trey chhpin	Market	2012-13		N/A	3 560	0.89	0.88	Fisheries valuation project in Cambodia database
Puntioplites falcifer, P. proctozysron	Trey chrakaing	Market	2012-13		N/A	5 689	1.43	1.40	Fisheries valuation project in Cambodia database
Henicorhynchus spp (2 species)	Trey riel	Market	2012-13		N/A	5 425	1.36	1.33	Fisheries valuation project in Cambodia database
Wallago attu	Trey sanday	Market	2012-13		N/A	6 407	1.61	1.58	Fisheries valuation project in Cambodia database
Hemibagrus spilopterus	Trey chlang	Market	2012-13		N/A	7 500	1.88	1.84	Fisheries valuation project in Cambodia database
Clarias spp (3 species)	Trey andaing	Market	2012-13		N/A	6 000	1.51	1.48	Fisheries valuation project in Cambodia database
Thynnichthys thynnoides	Trey linh	Market	2012-13		N/A	8 750	2.20	2.15	Fisheries valuation project in Cambodia database
Labeio chrysophekadion	Trey kaek	Market	2012-13		N/A	7 769	1.95	1.91	Fisheries valuation project in Cambodia database
Total	10			0				1.59	Simple average 2015 price
								N/A	Weighted average 2015 price

Viet Nam Period: January 2011 to April 2017									
Taxonomic name	**Species / local name**	**Nature of Price**	**Date of Price**	**(A) Catch per species**	**(B) % of Natnl. Catch**	**(C) Local Price: VND**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Channa micropeltes	Snakehead fish	Market	Jan. 2011		N/A		2.83	2.72	http://www.tandfonline.com/doi/abs/10.1080/13657305.2014.855956
Pangasius bocourti	Tra fish/Basa catfish	Whole-sale	Apr. 2017		N/A		1.20	1.14	http://vietnamnews.vn/economy/374266/soaring-tra-fish-prices-entice-mekong-farmers.html#W8RbJMjDQhJsj0pt.97
Total	2			0				1.93	Simple average 2015 price
								N/A	Weighted average 2015 price

Pakistan Period: March 2012 to December 2016									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: PKR**	**(D) USD / kg**	**2015 price (USD/ kg)**	**Source of information**
Neolissochilus	Mahseer	Market	Dec. 2016		N/A	240	2.29	2.15	https://www.dawn.com/news/1304132
Labeo rohita	Rohu	Market	Dec. 2016		N/A	320	3.05	2.87	https://www.dawn.com/news/1304132
Total	2			0				2.51	Simple average 2015 price
								N/A	Weighted average 2015 price
India Period: August 2017									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: INR**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Catla catla	Catla Indian carp	Market	Aug. 2017	509 614	42	298	4.67	4.42	http://fishappy.in/product.php
Labeo rohita	Rohu	Market	Aug. 2017		N/A	240	3.76	3.56	http://fishappy.in/product.php
Etroplus suratensis	Green chromide	Market	Aug. 2017		N/A	200	3.14	2.97	http://fishappy.in/product.php
Total	3			509 614	42			3.65	Simple average 2015 price
								N/A	Weighted average 2015 price
Thailand Period: July 2017									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: THB**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Channa striata	Striped snakehead	Market	July 2017	19 300	8	129	3.88	3.67	http://udon-news.com/en/main/consumer-prices-in-thailand
Oreochromis niloticus	Nile tilapia	Market	July 2017	25 953	11	59	1.77	1.68	http://udon-news.com/en/main/consumer-prices-in-thailand
Clarias batrachus	Walking catfish	Market	July 2017	10 332	5	59	1.77	1.68	http://udon-news.com/en/main/consumer-prices-in-thailand
Total	3			55 585	24			2.34	Simple average 2015 price
								2.37	Weighted average 2015 price
Indonesia Period: July 2017									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: IDR**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Siluriformes	Catfish	Market	July 2017	19 683	5	74 600	5.60	5.30	http://wpi.kkp.go.id/info_harga_ikan/
Trichopodus pectoralis	Snakeskin gourami	Market	July 2017	23 015	6	42 138	3.16	2.99	http://wpi.kkp.go.id/info_harga_ikan/
Chanos chanos	Milkfish	Market	July 2017		N/A	24 600	1.85	1.75	http://wpi.kkp.go.id/info_harga_ikan/
Total	3			42 698	11			3.35	Simple average 2015 price

								N/A	Weighted average 2015 price
Philippines **Period: December 2015**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: PHP**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Gobiopterus lacustris	"Dulong" (tiny goby)	1st landing	Sep. 2017		N/A	87.50	1.70	1.61	Selected wild-caught freshwater fishes in Laguna de Bay, Philippines
Macrobrachium idella	Freshwater shrimp "Hipon"	1st landing	Sep. 2017		N/A	122.50	2.38	2.25	Selected wild-caught freshwater fishes in Laguna de Bay, Philippines
Arius manillensis	Manila catfish "Kanduli"	1st landing	Sep. 2017		N/A	26.25	0.51	0.48	Selected wild-caught freshwater fishes in Laguna de Bay, Philippines
Leiopotherapon plumbeus	Silver perch "ayungin"	1st landing	Sep. 2017		N/A	262.50	5.10	4.83	Selected wild-caught freshwater fishes in Laguna de Bay, Philippines
Glossogobius giuris	White goby "Biya"	1st landing	Sep. 2017		N/A	250.00	4.86	4.60	Selected wild-caught freshwater fishes in Laguna de Bay, Philippines
Anguilla marmorata	Giant eel "palos"	1st landing	Sep. 2017		N/A	87.50	1.70	1.61	Selected wild-caught freshwater fishes in Laguna de Bay, Philippines
Ophiocephalus striatus	Mudfish	Market	Dec. 2015		N/A	148.17	2.98	2.98	http://www.bfar.da.gov.ph/files/img/photos/Luzon.1.4.15.pdf
Pomadasys argenteus	Breams (bakoko)	Market	Dec. 2015		N/A	144.87	2.91	2.91	http://www.bfar.da.gov.ph/files/img/photos/Luzon.1.4.15.pdf
Chanos chanos	Milkfish	Market	Dec. 2015		N/A	129.52	2.60	2.60	http://www.bfar.da.gov.ph/files/img/photos/Luzon.1.4.15.pdf
Total	9			0				2.65	Simple average 2015 price
								N/A	Weighted average 2015 price
Sri Lanka **Period: Dec 2015**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: LKR**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Channa spp.	Murrel (lula)	Dock price	Sep. 2017		N/A	200	1.30	1.23	Prices from local fishermen and fish sellers of two local dockyards (Beruwala and Hambantota) Sri Lanka
Anguilla bicolor	Level-finned eel (anda)	Dock price	Sep. 2017		N/A	175	1.14	1.08	Prices from local fishermen and fish sellers of two local dockyards (Beruwala and Hambantota) Sri Lanka
Puntius chola	Swamp barb (kotha Pethiya)	Dock price	Sep. 2017		N/A	175	1.14	1.08	Prices from local fishermen and fish sellers of two local dockyards (Beruwala and Hambantota) Sri Lanka
Etroplus suratensis	Green chromide (korali)	Dock price	Sep. 2017		N/A	350	2.28	2.16	Prices from local fishermen and fish sellers of two local dockyards (Beruwala and Hambantota) Sri Lanka
Glossogobius giuris	Bar-eyed goby (waligowa)	Dock price	Sep. 2017		N/A	150	0.98	0.93	Prices from local fishermen and fish sellers of two local dockyards (Beruwala and Hambantota) Sri Lanka
-	thetalam	Dock price	Sep. 2017		N/A	200	1.30	1.23	Prices from local fishermen and fish sellers of two local dockyards (Beruwala and Hambantota) Sri Lanka
Total	18			0				1.45	Simple average 2015 price
								N/A	Weighted average 2015 price

Lao PDR **Period: Dec 2017**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: LAK**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
44 species	Average current price	1st sale-landing	Dec. 2017	39 738	17	32,523	3.92	3.71	*Catch & Culture*, 21(3) Average price calculated from 44 current fish prices reported across Champassak and Xieng Khouang
Total	1			39 738	17			3.71	Simple average 2015 price
								3.71	Weighted average 2015 price
Australia **Period: January 2017**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: AUD**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Macquaria ambigua	Golden perch	market proxy: ex farm	Jan-2017		N/A	17.50	13.67	12.95	http://nswaqua.com.au/fish-species/golden-perch-macquaria-ambigua/
Bidyanus bidyanus	Silver perch	market proxy: ex farm	Jan. 2017		N/A	11.50	8.99	8.51	http://nswaqua.com.au/fish-species/golden-perch-macquaria-ambigua/
Total	2			0				10.73	Simple average 2015 price
								N/A	Weighted average 2015 price
Papua New Guinea **Period: January 2012 to August 2015**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: PGK**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
-	-	-	Aug. 2015	-	N/A	7.00	2.52	2.52	Gillett (2016) *Fisheries in the economies of Pacific Island countries and territories* (2nd Edition) SPC. ISBN: 978-982-00-1009-3
-	-	-	Jan. 2012	6 654	3	4.40	2.09	2.01	https://www.researchgate.net/publication/301770071_Fish_species_sold_in_the_Kikori_market_Papua_New_Guinea_with_special_reference_to_the_Nurseryfish_Kurtus_gulliveri_Perciformes_Kurtidae
Total	0			6 654	3			2.27	Simple average 2015 price
								N/A	Weighted average 2015 price
Russian Federation **Period: Aug 2017**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: RUB**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Sander lucioperca	Pike-perch	Whole-sale	Aug. 2017	4 520	2	218.18	3.64	3.44	http://moskva.all.biz/en/som-bream-perch-vobla-sazan-itd-g6249996#.WZL_9PqGPIV

Abramis brama	Freshwater bream	Whole-sale	Aug. 2017	22 594	10	70.00	1.17	1.10	http://moskva.all.biz/en/som-bream-perch-vobla-sazan-itd-g6249996#.WZL_9PqGPIV
Esox Lucius	Northern pike	Whole-sale	Aug. 2017	11 421	5	60.00	1.00	0.95	http://moskva.all.biz/en/som-bream-perch-vobla-sazan-itd-g6249996#.WZL_9PqGPIV
	Rudd	Whole-sale	Aug. 2017	6 702	3	30.50	0.51	0.48	http://moskva.all.biz/en/som-bream-perch-vobla-sazan-itd-g6249996#.WZL_9PqGPIV
Total	4			45 237	20			1.49	Simple average 2015 price
								1.21	Weighted average 2015 price
Finland **Period: December 2015**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local Price: EUR**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Sander lucioperca	Pike-perch	1st sale-landing	Dec. 2015	3 090	1	5.69	6.05	6.05	http://www.eumofa.eu/ad-hoc-queries3
Esox Lucius	Northern pike	1st sale-landing	Dec. 2015	5 838	3	1.58	1.68	1.68	http://www.eumofa.eu/ad-hoc-queries3
-	Other FW fish	1st sale-landing	Dec. 2015	2 009	1	0.98	1.04	1.04	http://www.eumofa.eu/ad-hoc-queries3
Total	3			10 937	5			2.92	Simple average 2015 price
								2.80	Weighted average 2015 price
Germany **Period: December 2015**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local Price: EUR**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Sander lucioperca	Pike-perch	1st sale-landing	Dec. 2015	126	0	5.19	5.52	5.52	http://www.eumofa.eu/ad-hoc-queries3
Esox Lucius	Northern pike	1st sale-landing	Dec. 2015	224	0	1.76	1.87	1.87	http://www.eumofa.eu/ad-hoc-queries3
-	Other FW fish	1st sale-landing	Dec. 2015	14 086	6	0.78	0.83	0.83	http://www.eumofa.eu/ad-hoc-queries3
Cyprinus carpio	Common carp	1st sale-landing	Dec. 2015	72	0	0.55	0.58	0.58	http://www.eumofa.eu/ad-hoc-queries3
Total	4			14 507	6			2.20	Simple average 2015 price
								0.88	Weighted average 2015 price
Poland **Period: December 2015**									
Taxonomic name	**Species / local name**	**Nature of price**	**Date of price**	**(A) Catch per species**	**(B) % of natnl. catch**	**(C) Local price: PLN**	**(D) USD / kg**	**2015 price** (USD/ kg)	**Source of information**
Sander lucioperca	Pike-perch	1st sale-landing	Dec. 2015	134	-	4.22	4.49	4.49	http://www.eumofa.eu/ad-hoc-queries3

Silurus glanis	Freshwater catfish (wels)	1st sale-landing	Dec. 2015	10	-	4.09	4.35	4.35	http://www.eumofa.eu/ad-hoc-queries3
Esox Lucius	Northern pike	1st sale-landing	Dec. 2015	293	-	1.91	2.03	2.03	http://www.eumofa.eu/ad-hoc-queries3
Cyprinus carpio	Common carp	1st sale-landing	Dec. 2015	34	-	0.72	0.77	0.77	http://www.eumofa.eu/ad-hoc-queries3
Total	4			471	-			2.91	Simple average 2015 price
								2.69	Weighted average 2015 price

ANNEX 6: SUPPLEMENTARY DATA FOR CHAPTER 6 - INLAND FISHERY EMPLOYMENT

Country	Reported to FAO	Year report to FAO	Inland fishers	Post-harvest	Inland fishers + post-harvest	References
Russian Federation	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Myanmar	1 576 500	2015	1 576 500		1 576 500	FAO
Thailand		2013	3 131 355		3 131 355	World Bank, 2012
Viet Nam		2003	2 834 238		2 834 238	World Bank, 2012
India	6 255 247	2013	1 106 199	4 424 796	5 530 995	World Bank, 2012
Lao PDR		2010	1 052 000		1 052 000	Estimate based on Lao PDR Agriculture Census report of 2 members per household
Bangladesh	534 000	2015	1 003 500		1 003 500	World Bank, 2012
China	6 344 593	2006	748 000	475 000	1 223 000	World Bank , 2012 (2006 data)
Nigeria	713 036	2014	324 000	1 350 000	1 674 000	2005 figure World Bank, 2012
Cambodia	578 468	2011	496 091	921 853	1 417 944	World Bank, 2012 (2006 data)
Indonesia	529 800	2015	555 000	382 000	937 000	World Bank, 2012 (not dated)
Nepal	462 067	2015	462 067		462 067	FAO
Tanzania UR	147 479	2015	211 330	234 651	445 981	DeGraaf and Garibaldi, 2014
Chad	435 000	2015	435 000		435 000	FAO
Congo DR	436 592	2014	163 827	198 247	362 074	DeGraaf and Garibaldi, 2014
Brazil	316 000	2012	316 000		316 000	FAO
Philippines	120 000	2012	226 195		226 195	2005 figure World Bank, 2012
Pakistan	211 609	2015	211 609		211 609	FAO
Benin	31 031	2015	124 768	78 513	203 281	DeGraaf and Garibaldi, 2014
Cameroon	177 145	2014	177 145		177 145	FAO
Ghana	175 209	2012	72 391	41 378	113 769	2006 figure World Bank, 2012
Malawi	152 727	2015	149 698	15 296	164 994	DeGraaf and Garibaldi, 2014
Mali	147 863	2015	147 863		147 863	FAO
the Sudan	128 847	2012	128 847		128 847	FAO
Uganda	116 213	2015	116 213		116 213	FAO
Kenya	48 396	2014	48 579	39 074	87 653	DeGraaf and Garibaldi, 2014
Mozambique	69 369	2013	83 174	23 824	106 998	DeGraaf and Garibaldi, 2014
Central African Republic	82 203	2012	82 203		82 203	FAO
Egypt	75 517	2014	69 517	6 000	75 517	DeGraaf and Garibaldi, 2014
Zambia	73 252	2015	73 252		73 252	FAO
Mexico	72 125	2015	72 125		72 125	FAO
Korea DPR	64 395	2012	64 395		64 395	FAO
the Congo	40 848	2012	40 848	19 634	60 482	DeGraaf and Garibaldi, 2014
the Niger	60 000	2014	60 000		60 000	FAO
Sri Lanka	37 227	2015	37 227		37 227	FAO
Burkina Faso	20 180	2015	30 759	2 983	33 742	DeGraaf and Garibaldi, 2014
Peru	32 250	2014	32 250		32 250	FAO
Sierra Leone	27 254	2012	27 254		27 254	FAO
Guinea	15 363	2012	15 362	11 524	26 886	DeGraaf and Garibaldi, 2014
Ethiopia	44 990	2015	1 026	21 520	22 546	DeGraaf and Garibaldi, 2014
Côte d'Ivoire			6 480	14 991	21 471	DeGraaf and Garibaldi, 2014
Zimbabwe	20 441	2012	20 441		20 441	FAO
Angola	19 468	2012	19 468		19 468	FAO
Gabon	19 468	2012	19 468		19 468	FAO
Paraguay	18 915	2014	18 915		18 915	FAO
Madagascar	45 333	2015	17 325	816	18 141	DeGraaf and Garibaldi, 2014
Japan	17 036	2007	17 036		17 036	FAO
Senegal	53 101	2015	15 986	8 723	24 709	DeGraaf and Garibaldi 2014; (39 962 World Bank, 2012)
Venezuela BR	15 982	2015	15 982		15 982	FAO
South Sudan			13 000	50 000	63 000	Linton and Mungule, 2012
Togo	3 700	2015	8 600	3 500	12 100	DeGraaf and Garibaldi, 2014
Colombia	11 793	2014	11 793		11 793	FAO
El Salvador	10 299	2008	10 299		10 299	FAO
Iran (Islamic Rep. of)	8 877	2014	8 877		8 877	FAO
Macedonia FYR	8 594	2015	8 594		8 594	FAO
Burundi	7 880	2012	5 236	1 678	6 914	FAO
Taiwan POC	7 622	2015	7 622		7 622	FAO
Bolivia PS	7 423	2015	7 423		7 423	FAO
Kazakhstan	7 225	2010	7 225		7 225	FAO
Argentina	7 207	2015	7 207		7 207	FAO

Country	Reported to FAO	Year report to FAO	Inland fishers	Post-harvest	Inland fishers + post-harvest	References
Ukraine			7 000		7 000	FAO Country Profile, 2004
Gambia	1 422	2015	6 249	488	6 737	DeGraaf and Garibaldi, 2014
Guatemala	6 200	2012	6 200		6 200	FAO
Panama	5 750	2015	5 750		5 750	FAO
Rwanda	7 497	2014	5 499	0	5 499	DeGraaf and Garibaldi, 2014
Namibia	5 451	2012	5 451		5 451	FAO
Canada	5 000	2012	5 000		5 000	FAO
Turkey	4 471	2015	4 471		4 471	FAO
Nicaragua	4 200	2014	4 200		4 200	FAO
Honduras	3 910	2014	3 910		3 910	FAO
Syrian Arab Republic	3 658	2010	3 658		3 658	FAO
Uzbekistan	3 606	2009	3 606		3 606	FAO
Korea RO	3 292	2010	3 292		3 292	FAO
Botswana	3 280	2010	3 280		3 280	FAO
Romania	3 182	2015	3 182		3 182	FAO
Morocco	3 000	2015	3 000		3 000	FAO
Ireland	2 976	2014	2 976		2 976	FAO
Dominican Republic	2 505	2012	2 505		2 505	FAO
Ecuador	2 458	2015	2 458		2 458	FAO
Turkmenistan			2 200		2 200	1996 Wikipedia
Albania	2 000	2015	2 000		2 000	FAO
Equatorial Guinea	1 947	2012	1 947		1 947	FAO
Poland	1 850	2015	1 850		1 850	FAO
South Africa	1 752	2012	1 752		1 752	FAO
Bulgaria	1 500	2011	1 500		1 500	FAO
Liberia	1 460	2012	1 460		1 460	FAO
Iraq	1 400	2015	1 400		1 400	FAO
Kyrgyzstan	1 300	2015	1 300		1 300	FAO
Suriname	1 182	2007	1 182		1 182	FAO
The Kingdom of Eswatini	1 179	2014	1 179		1 179	FAO
Guyana	1 125	2014	1 125		1 125	FAO
Germany	900	2011	900		900	Centenera, 2014
Lebanon	725	2006	725		725	FAO
Estonia	497	2015	497		497	FAO
Serbia and Montenegro	407	2015	407		407	FAO
Finland	405	2015	405		405	FAO
Somalia	390	2012	390		390	FAO
Jordan	357	2014	357		357	FAO
Serbia	352	2014	352		352	FAO
Lithuania	300	2006	300		300	FAO
Guinea-Bissau	292	2012	292		292	FAO
Switzerland	274	2015	274		274	FAO
Azerbaijan	250	2012	250		250	FAO
Tunisia	233	2015	233		233	FAO
Armenia	226	2015	226		226	FAO
Hungary	220	2014	220		220	FAO
French Polynesia	200	2014	200		200	FAO
Israel	192	2011	192		192	FAO
Lesotho	183	2014	183		183	FAO
Austria	180	2015	180		180	FAO
Belarus	178	2015	178		178	FAO
Sweden	175	2015	175		175	FAO
New Zealand	142	2015	142		142	FAO
Montenegro	123	2010	123		123	FAO
Latvia	109	2015	109		109	FAO
Bhutan	92	2013	92		92	FAO
Croatia	43	2015	43		43	FAO
TOTALS	**20 739 157**		**16 862 811**	**8 326 489**	**25 189 300**	

ANNEX 7: SUPPLEMENTAL MATERIAL FOR SECTION 10.3

Annex 7-1: Replacement food production to replace kilocalories of protein from inland fisheries (million tonnes).

Replacement foods / Region	Farmed Carp	Farmed Tilapia	Farmed Rainbow trout	Farmed Pacu	Farmed Pangasius catfish	Beef	Pork	Chicken	Rice (paddy)	Wheat	Maize
Global	6.93 (160)	6.78 (193)	8.76 (1 563)	7.20 (4 651)	11.78 (723)	7.12 (10.8)	3.72 (3.2)	11.72 (10.9)	9.97 (1.3)	17.98 (2.4)	15.07 (1.4)
Northern Europe	0.03 (646)		0.03 (111)			0.03 (5.5)	0.01 (0.7)	0.05 (6.8)		0.07 (0.5)	0.06 (135)
Eastern Europe	0.04 (50.0)					0.04 (2.7)	0.02 (0.5)	0.07 (1.5)		1.00 (0.2)	0.83 (0.2)
North America			0.04 (168)			0.03 (0.3)	0.02 (0.2)	0.05 (0.3)		0.07 (0.1)	0.06 (0.2)
South America	0.22 (19 390)	0.21 (69.6)		0.23 (147)		0.23 (1.5)	0.12 (2.1)	0.37 (1.8)	0.31 (1.4)	0.57 (1.9)	0.48 (0.4)
African Great Lakes	0.64 (40 732)	0.62 (732)				0.65 (56.9)	0.34 (102)	1.07 (362)		1.65 (382)	1.38 (15.4)
West Africa	0.34	0.33 (447)				0.35 (53.1)	0.18 (48.4)	0.58 (117)	0.49 (3.7)		0.75 (4.2)
Southern Africa		0.14 (890)				0.14 (8.9)	0.07 (13.9)	0.23 (12.3)			0.30 (1.4)
African Sahel	0.19	0.18 (6 325)				0.19 (28.5)	0.1 (171)	0.31 (151)		0.40 (7.7)	0.23 (22.4)
Congo River Basin	0.18	0.18 (5 711)				0.19 (164)	0.10 (216)	0.31 (1 125)	0.26 (82.4)	0.48 (5 805)	0.39 (30.1)
Southern Asia	1.57 (5 811)	1.53 (9 026)			2.66	1.61 (84.3)	0.84 (246)	2.64 (55.8)	2.25 (1.3)		
South- East Asia	1.46 (249)	1.43 (77.9)			2.49 (154)	1.51 (89.0)	0.79 (9.9)	2.48 (28.0)	2.11 (1.1)		
Central Asia	0.05 (798)		0.07 (730)			0.06 (3.0)	0.03 (15.4)	0.09 (25.3)		0.14 (0.5)	0.12 (4.2)
China	1.37 (41)	1.34 (43)				1.42 (21.6)	0.74 (1.4)	2.33 (18.1)	1.98 (1.0)		
Russian Federation	0.17 (297)		0.22 (891)			0.18 (10.7)	0.09 (3.2)	0.29 (7.8)		0.45 (0.8)	0.37 (3.3)
Oceania	0.01 (2 421)	0.01 (594)				0.01 (0.4)	0.006 (1.2)	0.02 (1.5)			

Note: Percentage values indicate the proportion of replacement food production to current food production globally/ regionally. No percentage value indicate regions where this food source is not currently produced.

Annex 7-2 : Water demand for replacement of kilocalories from inland fisheries (km^3) globally and for specified regions.

Replacement food / Region	Farmed Carp	Farmed Tilapia	Farmed Salmon	Farmed Pacu	Farmed Pangasuis catfish	Beef	Pork	Chicken	Rice (paddy)	Wheat	Maize
Global	38.9 (1.4)	36.5 (1.3)	25.3 (0.9)	44.4 (1.6)	135.7 (4.9)	197.6 (7.2)	40.1 (1.5)	91.3 (3.3)	40.0 (1.4)	59.1 (2.1)	33.1 (1.2)
Northern Europe	0.15 (11.5)		0.1 (7.5)			0.78 (58.2)	0.16 (11.8)	0.36 (26.9)	0.16 (11.8)	0.23 (17.4)	0.13 (9.8)
Eastern Europe	0.22 (2.5)					1.10 (12.7)	0.22 (2.6)	0.51 (2.9)		0.33 (3.8)	0.18 (2.2)
North America	0.16 (0.1)	0.15 (0.1)	0.10 (0.1)			0.82 (0.5)	0.17 (0.1)	0.38 (0.2)	0.17 (0.1)	0.24 (0.2)	0.14 (0.1)
South America	1.23 (0.8)	1.15 (0.8)		1.40 (0.9)		6.24 (4.1)	1.27 (0.8)	2.89 (1.9)	1.26 (0.8)	1.87 (1.2)	1.04 (0.7)
African Great Lakes	3.57 (43.2)	3.36 (40.5)				18.15 (219.1)	3.69 44.5)	8.39 (101.2)		5.43 (65.5)	3.04 (36.7)
West Africa	1.93 (23.7)	1.81 (22.3)				9.79 (120.5)	1.98 (24.5)	4.52 (55.7)		2.93 (36.1)	1.64 (20.2)
African Sahel		0.98 (9.6)				5.3 (52.2)	1.1 (10.6)	2.45 (24.0)		1.1 (15.6)	0.89 (8.8)
Southern Africa		0.73 (4.5)				3.96 (24.3)	0.80 4.9)	1.83 (11.2)			0.66 (4.1)
Congo River Basin	1.03 (884.8)	0.99 (830.8)				5.24 (4 491.9)	1.06 (912.6)	2.42 (2 072.8)		1.56 (1 343.9)	0.88 (753.6)
Southern Asia	8.79 (1.0)	8.26 (0.9)			30.67 (3.4)	44.64 (4.9)	9.01 (1.0)	20.63 (2.3)	9.04 (1.0)		
South- East Asia	8.23 (2.5)	7.73 (2.3)			28.75 (8.8)	41.81 (12.8)	8.49 (2.6)	19.32 (5.9)	8.46 (2.6)		
Central Asia	0.31 (0.2)					1.56 (1.1)	0.32 (0.2)	0.72 (0.6)		0.46 (0.3)	0.26 (0.2)
China	7.74 (2.0)	7.27 (1.9)				39.30 (10.0)	7.98 (2.1)	18.16 (4.6)	7.96 (2.1)		
Russian Federation	0.97 (7.3)		0.63 (4.8)			4.91 (37.2)	1.00 (7.6)	2.27 (17.2)		1.47 (11.1)	0.82 (6.2)
Oceania	0.06 (0.4)	0.06 (0.4)				0.31 (1.9)	0.06 (0.4)	0.14 (0.9)			

Note: Percentage values indicate the proportion of water demand to total regional/ global agricultural water use (%).

Annex 7-3: Land requirements for replacement of kilocalories from inland fisheries (1000 km^2) globally and for specified regions.

Replacement foods / Region	Farmed Carp	Farmed Tilapia	Farmed Pacu	Farmed Pangasuis catfish	Beef	Pork	Chicken	Rice (paddy)	Wheat	Maize
Global	1 684 (36.9)	3 206 (70.1)	3 888 (85.0)	4 167 (91.1)	3 403 (10.4)	1 106 (3.4)	705 (2.15)	818 (1.7)	1 071 (2.2)	1 522 (3.1)
Northern Europe	6.6 (6.2)				13.4 (19.1)	4.3 (6.2)	2.7 (3.9)		4.2 (3.0)	6.0 (4.3)
Eastern Europe	9.35 (17.5)				11.7 (5.7)	6.1 (3.0)	1.4 (0.7)		5.9 (0.6)	8. 5 (0.7)
North America	7.0 (0.4)	13.2 (0.8)			14.1 (0.5)	4.7 (0.2)	2.9 (0.1)		4.4 (0.1)	6.3 (0.1)
South America	53.2 (15.5)	101 (29.6)	123 (35.9)		108 (2.3)	34.9 (0.8)	22.3 (0.5)	25.9 (0.4)	33.9 (0.5)	48.1 (0.8)
African Great Lakes	155 (109)	295 (208)			312.7 (58.6)	101.7 (19.0)	22.5 (4.2)		93.4 (10.8)	140 (15.3)
West Africa	83.4 (149)	159 (283)			169 (23.6)	54.8 (7.7)	12.1 (1.7)		53.0 (3.6)	75.4 (5.1)
African Sahel		85.9 (168)			91.2 (5.7)	29.6 (1.9)	6.6 (0.4)	21.9 (1.1)		40.8 (2.1)
Southern Africa		64.2 (132)			68.14 (1.5)	22.12 (0.8)	4.90 (0.2)			30.47 (1.0)
Congo River Basin	44.5 (50.6)	85.0 (96.2)			90.2 (25.0)	29.3 (8.1)	6.5 (1.8)		28.4 (6.0)	40.4 (8.6)
Southern Asia	381 (105)	724 (199)		942 (509)	769 (416)	250 (135)	159 (86.2)	185 (7.9)		
South- East Asia	356 (222)	678 (422)		882 (549)	720 (427)	234 (139)	149 (88.5)	173 (13.2)		
Central Asia	17.15 (22.5)				21.5 (0.6)	11.2 (0.27)	2.5 (0.06)		10.8 (0.24)	15.5 (0.34)
China	335 (176)	638 (336)			421 (10.7)	220 (5.6)	48.7 (1.3)	163 (3.2)		
Russian Federation	41.8 (5.8)				52.6 (5.7)	27.5 (2.96)	6.1 (0.7)		26.6 (1.3)	37.9 (1.8)
Oceania	2.7 (3.6)	5.0 (6.75)			5.4 (0.1)	1.7 (0.04	0.04 (≤0.01)			

Note: Percentage values indicate the proportion of water demand to total regional/ global inland/ pasture/ agricultural area (%).

Annex 7-4: Additional carbon emissions from replacement of capture fisheries with replacement foods (Global- 1000 000 tonnes; all others 10 000 tonnes).

Replacement foods / Region	Capture fisheries	Farmed Salmon	Farmed Tilapia	Farmed Pangasius catfish	Beef	Pork	Chicken	Rice (paddy)	Wheat	Maize
Global	43.1	30.9 (0.6)	3.3 (<0.1)	80.9 (1.6)	823 (48.9)	4.5 (2.5)	70.9 (122)	9 342 (1 375)	3 468 (819)	6 013 (1 420)
Northern Europe	16.9	12.1 (0.1)			324 (9.9)	1.8 (0.3)	27.9 (48.6)		1 364 (138)	2 364 (239)
Eastern Europe	23.9				457 (10.7)	2.5 (0.2)	39.3 (21.3)		1 925 (45.6)	3 337 (79.0)
North America	17.8	12.8 (<0.1)	1.4 (<0.1)		340 (2.2)	1.8 (<0.1)	29.3 (4.5)		1 432 (13.7)	2 483 (23.9)
South America	136.3		10.4 (<0.1)		2 602 (4.9)	14.1 (1.0)	244 (28.8)		10 959 (391)	19 002 (679)
African Great Lakes	396.1		30.2 (0.3)		7 564 (156)	41.1 (19.5)	651 (1 721)		31 856 (>50 000)	55 238 (>50 000)
West Africa	2176		16.3 (<0.1)		4 078 (62.3)	22.1 (6.2)	351 (253)		17 175 (2 794)	29 781 (4 845)
African Sahel	156		8.8 (<0.1)		2 207 (52.1)	12.0 (13.9)	190 (361)		9 293 (3 467)	16 114 (6 012)
Southern Africa	86.3		6.6 (13.5)		1 649 (80.1)	8.9 (17.9)	142 (194)			12 039 (3 694)
Congo River Basin	114		8.7 (0.2)		2 183 (372.3)	11.9 (17.8)	188 (1 415)		9 191 (27 046)	15 938 (46 897)
Southern Asia	974		74.3 (<0.1)	1829 (2.0)	18 603 (145.9)	101 (53.2)	1 601 (230)	21 1071 (1 463)		
South- East Asia	913		69.6 (0.2)	1 713 (3.8)	17 423 (255)	84.6 (6.5)	1 500 (142)	197 687 (816)		
Central Asia	34.0	24.4 (0.4)			649 (32.5)	3.52 (28.1)	55.9 (265)		2 734 (628)	4 741 (1 089)
China	858		65.4 (0.1)		16 375 (102)	88.9 (1.6)	1 410 (171)	185 797 (1 280)		
Russian Federation	107	76.8 (0.8)			2 047 (84.1)	11.1 (3.0)	176 (169)		8 619 (659)	14 945 (1 141)
Oceania	6.8		0.5 (0.003)		129 (1.9)	0.7 (0.3)	11.4 (27.8)			

Note: Percentage values for livestock and crops indicate the proportion of carbon emissions to total/ regional emissions per food source.

ISBN 978-92-5-130793-9 ISSN 2070-6065

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CA0388EN/1/07.18