Water, food security and human dignity

– a nutrition perspective

Swedish FAO Committee
Publication series 10
ISSN: 1652-9316

Production: Ministry of Enterprise and Innovation
Swedish FAO Committee
May 2015

Suggested citation: Lundqvist, J., Grönwall, J. and Jägerskog, A. (2015). Water, food security and human dignity – a nutrition perspective. Ministry of Enterprise and Innovation, Swedish FAO Committee, Stockholm.

Printed by: Elanders Sverige AB, July 2015

Article no: N2015.29 **revised edition**

Additional copies can be ordered from the Ministry of Enterprise and Innovation via www.regeringen.se
or by telephone: +46 (0)8-405 1410

Foreword

This is the tenth volume in the Swedish FAO Committee's series of discussion papers. The purpose of the publications is to spread knowledge about and raise interest in issues of global cooperation, in particular the work of the Food and Agriculture Organization (FAO), the UN's specialized agency for agriculture, forestry, fisheries and food. FAO's main tasks are to contribute to eradicating food insecurity and global hunger, and to work for sustainable use of natural resources and reduced poverty in rural areas.

This discussion paper examines the importance of water in ensuring food security. The Government prioritises FAO-related activities because FAO plays a crucial role in global food security and the resource management activities within its mandate are essential. When competition for natural resources increases, the need for sustainable management of these resources also increases. This very much applies to water. The estimated population growth of 2 billion people by 2050 means that if our consumption patterns do not change, food production must increase. The growing demand for water-intensive foodstuffs is also increasing competition. Because agriculture accounts for the majority of freshwater resource withdrawals, more efficient use of water in agricultural production is a necessity.

One serious problem addressed in the paper is the increased importance of groundwater as a strategic resource as a result of the heavy exploitation of surface water. Another serious problem is that while according to FAO some 800 million people in the world are undernourished, well over 2 billion are now overweight and obese. Encouraging healthy diets would, however, make it necessary to use water and other resources more effectively. The paper also examines the challenge of reducing the food waste that leads to a large proportion of the water used in food production not being utilised effectively and as intended. The human right to adequate food and access to water is also examined. At the same time, the paper stresses the private sector's crucial role in managing water and food systems, in the form of innovations, technologies and financing, and the links to a public water policy.

But how can competition for water be resolved to allow us to manage global food security? The paper outlines a number of important and promising initiatives and concrete measures. One example is the fact that the trade in food – and thereby in water – plays an important role in spreading access to water to areas with a deficit. Another is the production of salt-tolerant crops, which could enable food to be produced in areas of saltwater intrusion, and a third example is work on desalination of seawater for use

in irrigation. In the Middle East, imports of food – 'virtual water' – have decreased tensions over water. Australia has trialled a solar-powered method using seawater to cool crops during the day and warm them at night.

The Committee on World Food Security (CFS), the most inclusive forum for global-level discussions on global food security, has written a report on this theme to act as a basis for discussions in the CFS in October 2015. This paper should therefore also be seen as a contribution by the Swedish FAO Committee to the Government's positions in those discussions.

This paper, which was commissioned by the Swedish FAO Committee, was produced by Jan Lundqvist (chapters 1, 2, 3, 6, and 7) and Jenny Grönwall (chapter 4 and boxes 1, 7 and 9) at the Stockholm International Water Institute and Anders Jägerskog (chapter 5) at the Embassy of Sweden in Jordan. The authors are responsible for its content, and the Committee has not taken a position on the views expressed. The views presented by Mr Jägerskog do not necessarily reflect the views of the Swedish International Development Cooperation Agency or the Swedish Government. I hope that you will find the paper interesting, and that it provides a valuable insight into ways forward to find solutions to the global challenge of making the world's limited water resources go around, thereby ensuring food security.

Elisabeth Backteman
Chair, Swedish FAO Committee

Contents

Acknowledgements	***7***
Summary	***9***
Way forward – to a desirable future	**12**
1. Human needs and wants, food systems and water	***17***
Demand side dynamics and water predicaments	17
Game-changing circumstances	18
2. Water resources: mega trends and need for partnerships	***20***
Blue and green water, rates of exploitation and use	20
Groundwater dependence is booming	23
Natural and man-made water scarcity	24
Scarcity due to population increase	24
Seasonal scarcity and uncertainty is amplified by climate change	25
Land use affects water flows	25
Economic context affects quantity and quality	26
Subsidized, demand driven scarcity	26
Role of good governance and need for constructive partnerships	27
3. Water for food supply - water for sustainable diets	***31***
Our daily food supply – trends and water implications	31
An extra daily tonne of water and yet another half a tonne?	31
Nutrition challenge at par with climate change for global development?	34
Typologies for food security and nutrition	34
Reliability, validity and terminology	37
4. Human rights, water rights and access	***38***
Background: the human rights to food and water	38
Water for food production purposes	41
Practical aspects of realisation	42
Private actors and human rights	43
The right to adequate and nutritious food	44
Water, land rights and food security	46

5. Trade in food is also trade in water ***50***

The limits to trade in agricultural produce – perceived or real? 52

The surge in land acquisitions – a surge in water acquisition 52

The Middle East as a case in point
– water cooperation possible in spite of all challenges 54

6. Fresh water thinking: opportunities and new combinations ***60***

The nexus: water and energy 60

Synergies and trade-offs in the nexus 61

Intensified production, resilience and sustainable diets 67

New opportunities and potential for combinations 68

Fish better than chips 70

7. Savings and most worthwhile use of water and food ***74***

Role of consumers in alliances for water and food security 74

Alternative scenarios about food security to inform policy 74

Reduced losses and increased variety for mutual benefits 76

Water stewardship, better nutrition and less waste
– towards a future that is not what it used to be 78

References ***80***

Acknowledgements

A large number of colleagues have provided inputs and comments to drafts of the report. First, we like to thank colleagues who have prepared the texts for the boxes and sections of the report: Donald Wilhite, Roberto Lenton, Thomas L. Friedman, Jenny Fredby, Moa Cortobius, Olcay Unver, JeanMarc Faures, Olivier Dubois, Lucie Pluschke, Andrew Noble, Kyungmee Kim, Junguo Liu, Nicolas Brozovic and David Lymer. We are indebted to Ralf Klingbeil, Piero Conforti, Jippe Hogeveen, Alexandra Clark, Anna-Karin Modin-Edman, Amy VanderZanden, Claes Halvorsson and Anders Berntell for help with data and information and Britt Louise Andersson for preparing the Figures. Comments to drafts of the report have been provided by Victoria Engstrand-Neacsu, Torgny Holmgren, Håkan Tropp, Sofia Widforss, Phillia Restiani, David Molden, Mats Åberg, Ola Möller, Mats Eriksson and A. Rajagopal. Finally, we are grateful for continuous support and interest in the issues discussed in the report by the editorial committee of the Swedish FAO Committee, Christina Furustam, Jakob Lundberg and Arvid Uggla as well as the Secretary of the FAO Committee, Helena Sivard Askvik.

Summary

Distressed water resources and human dignity at play

Water is a pillar of human well-being and environmental stability. Without water and access to it, there is no food security and no human dignity. The same amount of water is available on planet earth today as in the past but global warming makes water availability more uncertain and water-related risks are on the top of decision-making agendas (WEF, 2015). Yet, the demand and expectations for more water, more food and more of everything are soaring.

Water availability varies tremendously between countries, local areas and over time as a consequence of hydrological and natural circumstances. Access to water is a socio-economic and political challenge. Demographic trends, food preferences and consumer habits are strong drivers behind the expansion of agriculture and the current water predicaments. Food systems contribute significantly to global warming, which modifies rainfall patterns and evapo-transpiration rates. Farmers experience more drastically than other groups the "inconvenient truth" of droughts, floods and uncertainties – Society's New Normal (Box 2) – which threatens their livelihoods, current food supplies and those of our children.

Rapid urbanization, expansion of industry and service sectors, and changed dietary preferences boost the demand for water and food. Obviously, 'there is no such thing as a post-agricultural society' (Weiskel, 1988), nor should there be a post-fisheries society.

Agriculture accounts for about 70 per cent of water allocations worldwide. The consumptive use of water[1] has resulted in a situation where an estimated 1.4 billion people live in river basins that are closed or closing. If environmental flow requirements are respected, there is insufficient water in these basins for additional irrigation or other uses. A temporal and gradual desiccation of rivers and a lowering of groundwater tables are a reality in parts of the world.

Main challenges and opportunities

- *Water and food for the impoverished- human dignity, socioeconomic progress:* Globally, more than enough of food is produced to feed the entire population. But shortcomings in the distribution system and socioeconomic and cultural circumstances mean that the bottom billion

[1] Consumptive use of water refers to the fact that a large part of water used in agriculture returns to atmosphere as evaporation and transpiration. In the open landscape in hot climate regions, the rate of return flow is significant. As a comparison, water use in industry is generally non-consumptive. In principle, water in manufacturing may be re-used within the premises.

(Collier, 2007) lack access to food and basic services – safe household water, sanitation and energy. In a speech at the first World Food Conference at the Food and Agriculture Organization of the United Nations (FAO), Rome, 5 November 1974, Henry Kissinger, then US Secretary of State remarked '...within a decade no child will go to bed hungry,...' [2]. Millions of children still go to bed hungry and malnutrition is severely affecting their lives, their abilities to be assets in development, and their future [3] .

- *Human rights to household water, sanitation and food:* Widely endorsed, these principles need to be translated into concrete actions. Alarming information on the double burden of malnutrition has been published recently. About 800 million people are undernourished versus well over 2,000 million – aged 20 and above – who are overweight and obese (IFPRI, 2014). Similarly, the links between deficiencies in household water, sanitation and hygiene, and food and nutrition security need to be addressed (Box 3).

- *Renewed partnerships between public and private sectors and civil society:* The private sector, which also includes farmers and fishermen, plays major roles in water management and food systems, in terms of e.g., innovation, technical know-how and finance. The importance and potential of combining public water and food policies and concrete governance is manifested through initiatives and agreements involving the UN system, national and local governments and private actors in water management and in the production, processing and marketing of food.

- *Trade must be a key ally in water and food security:* With the uneven availability of water, trade in food – which is also trade in water – is essential. It is not only trade in food that is important. To use available water productively, farmers need access to proper inputs at reasonable prices. Strategies for water, food production and security must build on political initiatives and institutional arrangements for trade and contacts across borders and between sectors and are particularly important in water stressed contexts (Box 5).

- *Water and the food system:* Increasing wealth is associated with enhanced

[2] http://www.fordlibrarymuseum.gov/library/document/dosb/1851.pdf#page=3, page 829
[3] www.who.int.nutrition/challenges/en/; Ng et al. (2014); IFPRI (2014)

demand for meat, dairy products and other high quality food that is generally water and energy intensive. Another challenge is the high rates of losses and waste (Chapter 7). All things considered, between one-third and one-half of the food produced globally and the associated water and energy consumption are questionably used (FAO, 2011a; CFS-HLPE, 2014b; Lundqvist et al., 2015).

- *Water resources, the environment and nutrition:* Production, demand and intake of food must be related to water resources availability and environmental sustainability. Planetary boundaries, climate uncertainties and consumer needs and wants contribute to a game-changing situation: the era of easy and cheap food production is over. Better nutrition, combination of agriculture and fisheries, sustainable intensification, new crops and new water, support to women in food production and trade, and reduction of losses and waste constitute objectives and opportunities that need further attention (chapters 3, 6 and 7).

- *Water and energy linkages:* While about 80 to 90 per cent of consumptive water use occurs in connection with food production, about 20 per cent of the total energy used in food systems is associated with production. Distribution, processing, preparation and refrigeration in households consume the remaining 80 per cent of energy (FAO, 2011c; Boxes 6 and 7).

Way forward – to a desirable future

Alliances for action

A vision and the design of a process for implementation and monitoring of policies for water, food security and nutrition are needed (Box 6). Partnerships are essential. 'Strong alliances for action are much more effective than silver bullets' (IFPRI, 2014, p. 2). Governance of water resources and food systems must involve public policy and private sector in interaction with civil society and consumers. Generally, food production by farmers and fishermen, distribution, processing and marketing belong to private sector sphere. Activities in this sphere must be guided by and coordinated with the public-policy, including the human dignity-related aspects, e.g., arrangements that ensure access to water and food for basic human needs.

Effective partnerships should include the application of scientific understanding, collection and use of best possible data and information for policy formulation and execution and monitoring of programs.

Align effective governance of water for food supply…

On the supply side, water stewardship[4] hinges on technical competence, modern inputs and coordinated activities in irrigation and rain-fed systems and fisheries. Unprecedented droughts need negotiated adaptation approaches where farmers, governments and other relevant actors cooperate (Box 2). In the battery of important governance tasks, chapter 6 highlights the urgency to manage land, water and ecosystems for enhanced resilience, to tap the synergies of 'the water–energy–land nexus' and explore the potential of new crops and how to combine agriculture and fisheries. Effective governance of water in agriculture has to target water and energy efficiency and productivity enhancement for improved rural incomes and better livelihoods to define the business case for behavior change at the farmer level.

… with a strategy inducing sound food habits among nine billion consumers…

There is a dynamic demand for more and better food and a need to address food wastage and the role of consumers. A resolution passed by the European

[4]The Alliance for Water Stewardship promotes responsible use of freshwater that is socially and economically beneficial as well as environmentally sustainable http://www.allianceforwaterstewardship.org/

Parliament (January 2012) to halve food waste within the European Union by 2025 should be followed up in terms of targeted commitments by national and local governments and by individual actors, e.g. the education sector. Access to improved nutrition rather than more calories must be one of the guiding principles in food policies and consumer education programmes. Support is needed to research programmes that could analyse how sound food habits can best be promoted. Similarly, the implication of a transition to improved nutrition with regard to water resources and environmental implications need to be analysed.

… through partnerships between corporate and public sectors and civil society

Major food companies have taken initiatives for water stewardship and have committed themselves to water saving programmes with targets and time lines coupled with social and environmental commitments[5]. Two aspects need further effort. First, companies in the front-line of water stewardship and committed to Corporate Social Responsibility and Creating Shared Value principles, in partnership with government agencies and financial institutions, should be a lever for constructive change among small firms. There are millions of small firms, and although entrepreneurial skills may be high many of them have limited resources and capacity for innovations and water stewardship. Similarly, Pubic Private Partnerships for Integrated Agricultural Development offer opportunities for co-financing efficiency-related interventions[6]. Second, food companies should together with public sector guide consumers about the need to reduce losses and waste, for instance, in education while catering for nutrition (chapters 3 and 7).

Invest in transport, storage, market access and trade

A number of administrative and physical barriers need to be removed to promote trade in food but also trade in the inputs for food production. Farmers in poor regions, e.g., in Africa have problems accessing improved seeds and other inputs for water efficient production along with difficulties in modernizing and diversifying their agriculture (e.g., World Bank, 2012).

[5] The CEO Water Mandate, http://ceowatermandate.org/files/Ceo_water_mandate.pdf, is a contribution to the UN Global Compact: https://www.unglobalcompact.org/. For an example of how water commitments are linked to other commitments, e.g., nutrition, rural development, environmental sustainability and human rights, see: http://www.nestle.com/asset-library/documents/library/documents/corporate_social_responsibility/nestle-in-society-summary-report-2014-en.pdf. In Sweden, Sida initiated and coordinates a network involving companies and think tanks "Swedish Leadership for Sustainable Development" where CSR principles are adhered to: http://www.sida.se/Svenska/Samarbetsparter/Naringsliv/Samverkan-med-naringslivet/Swedish-Leadership-for-Sustainable-Development/Declaration

[6] See e.g., http://www.waterscarcitysolutions.org/assets/WRG-Managing-Water-Scarcity-Catalogue.pdf.

Similarly, the lack of storage, transport and market logistics makes it difficult to reach beyond local markets to sell the produce. As a consequence, an efficient and effective use of water and other resources and associated improvement in livelihoods is not possible and both farmers and consumers lose. Coordinated efforts by public and private sectors, including financial institutions need to be implemented to enable farmers and local communities to be active partners in development at various geographical scales and for innovations in food production and water management.

Walk the talk about the human right to food

The human right to 'adequate' food can be realized in many ways and state governments are entitled to determine how. There is no obligation to provide water for agricultural use by enabling access to irrigation or provision of freshwater. The efforts must, however, involve scrutinising the nutritional quality of readily available and affordable food and its links with non-communicable diseases, and questioning those agricultural policies that make some types of food more available than others. For instance, agricultural subsidies targeting production of certain types of sugar form part of an unsustainable global food system that contributes to poor diets and misallocates water resources. Business corporations are increasingly expected to take a human rights approach and respect present and future generations – and to reduce their water footprints.

Align policies for the sustainable intensification of agriculture and healthy diets

Box 8 details a new paradigm for agriculture and water use: how to enhance resilience at field, watershed and regional scales. Support to national and international research and development consortia to formulate and test the new paradigm, including the exploration of the opportunities to introduce or scale up production in areas where the conventional approaches yield low returns, is essential. Targets and time lines for the adoption and gradual implementation of concrete details of these principles need to be formulated by governments and relevant national and international agencies.

Some guiding principles for the new paradigm are:

- Very low or zero expansion of agriculture into natural ecosystems
- Zero loss of biodiversity

- Drastically reduce the excessive use of nitrogen and phosphorus rich nutrients and recycle nutrient flows

- Improve water productivity in agriculture and fisheries.

These principles must be aligned with policies for nutritious and healthy diets.

Effective water use requires coordination with energy planning

Coordination mechanisms are necessary to capitalize on potential synergies in the use of water, energy and land and to reduce negative externalities and trade-offs. Urbanization and expansion of industry and service sectors imply a new mix in the demand and competition for water and energy. Still, crop production, livestock, fisheries and forestry continue to need large areas with fertile soils, significant volumes of water and energy. National and local governments in partnership with relevant organizations and institutions, including relevant user groups should coordinate the use of water, energy and land through suitable institutional arrangements. Effective co-governance of these resources presumes inclusion of environmental concerns and also socioeconomic objectives, e.g., generation of jobs and income. Governance of such complex systems requires a combination of flexibility, vision and strong alliances and it must be based on evidence and tested for realistic and desirable scenarios (Box 6).

Evidence based strategy – reliability, validity and terminology

Data and information are essential in policy and governance of water for food security and nutrition as well as in other contexts, for instance, in the formulation of the sustainable development goals (SDGs), targets and indicators. Monitoring and predictions of progress or detection of shortcomings are not possible without baselines and continuous updates and improvements in methodology for the gathering, compilation and dissemination of data and information. Similarly, an evidence based development strategy requires data and information that are context specific.

Research organizations and interdisciplinary teams should be given support to formulate scenarios of the water and other implications of sustainable diets (FAO, 2010b). For results to be valid and useful in policy and governance, statistical information must be interpreted in a context, e.g., the double burden of malnutrition and mounting water predicaments. Similarly, research on ways to reduce inefficiencies in food systems and how to save water and other resources by a reduction of losses and waste are needed to guide food policy. Presentation of new knowledge must be in a form that

is digestible to governments and other main actors in the food systems including the consumers.

Finally, it is crucial to promote a proper terminology regarding the components and dynamics in food systems. For instance, the difference between food consumption and food intake needs to be clarified (chapter 3).

1. Human needs and wants, food systems and water

Demand side dynamics and water predicaments

Demographic and socioeconomic changes have resulted in an augmented demand for a range of goods and services, including water and food. While the majority have experienced improved livelihoods, poverty continues to be a reality for the bottom billion (Collier, 2007).

The shift to more water-intensive diets (e.g., more of animal products) is noticeable among the better-off. The high quality food that is common among the rich involves a consumptive water use of 4–5 m3/capita/day. A lean diet containing few animal products requires about 1–1.5 m3 water to produce. On average, it takes one litre of water to produce one calorie of food, with relatively much more water for animal food as compared to cereals and other vegetal food items (Lundqvist et al., 2007, p. 73; cf. Table 1). However, variation in water implications between food items and differences in contexts are significant. Some meat and dairy products are produced by animals that graze in areas where crop cultivation is not an option and where irrigation is not used – in e.g., Mongolia, southern Africa and parts of Europe. Other animal food, however, comes from animals fed on fodder that is produced with the help of irrigation.

On-going transformations in food systems are linked to urbanization and changes in mind-sets and life styles. Age-old universal attitudes to food are eroded as illustrated by the high losses and the discarding and waste of food produced. As discussed in chaper 7, there are reasons to revive these attitudes as a part of water stewardship efforts.

In spite of laudable improvements, an estimated 805 million people are undernourished (FAO et al., 2014). To a large extent, this group overlap with the about 1 billion people who are forced to eke out a living on USD 1.25 per person/day. For Sub-Saharan Africa, close to half of the population are in that category[7].

Food security for a burgeoning world population presumes high performance in terms of resource use and low environmental impacts. An estimated additional 2 billion people will need to be fed in about a generation. Most of these will be living in areas with limited water and other resources and where poverty is rampant. It is hard to see how pleges of

[7] http://data.worldbank.org/topic/poverty#boxes-box-topic_cust_sec

food and nutrition security can be realized without a further exploitation of resources *in situ* and globally. But new perspectives and fresh thinking will be necessary as discussed in chapters 3, 6 and 7.

While about 11 per cent of global population are categorized as undernourished, some 38 per cent of the world's population (aged 20 and above) constitute the other part of the double burden of malnutrition (Schrimpton and Rokx, 2012). More than 2 billion people aged 20 and above are now overweight or obese (IFPRI, 2014; Ng et al., 2014). An estimated 45-50 per cent of the world's population are thus affected by various forms of malnutrition and the prevalence of malnutrition is highest among children. Modifications in food and agricultural policies to counter these trends are urgent (Hawkesworth et al., 2010; ODI, 2014). Food and agricultural policies, in turn, must be related to water and environmental implications as discussed in the following chapters.

For hundreds of millions of people, fish is a very important part of the diet and an integral component of livelihoods and water husbandry even far inland (see Chapter 6).

Overeating, conversions of food (grain), losses and wastage of food produced, and a poor uptake by the body of the food eaten (Box 3) imply that about half the food produced is not used as intended. The figures indicate truly staggering challenges, but also opportunities, for a more worthwhile use of limited water resources.

Game-changing circumstances

As eloquently noted by Paul Valéry (1937), "Le problème avec notre époque est que le futur n'est plus ce qu'il était." ("The problem with our era is that the future is no longer what it used to be"). Three generations later, this statement remains valid. Changes in society and nature and their consequences have always been hard to predict. But with the current dynamic turbulence, unprecedented opportunities are mixed with significant challanges. In the Anthropocene era, the human capacity to modify the Earth's geo-bio-physical and atmospheric systems is at par with geological forces with significant implications with regards to planetary boundaries and society (Rockström et al., 2009). This report highlights another driver in the transformation of our planet and livelihoods; the rapid changes in socioeconomic terms and associoated changes in attitudes, which have direct and indirect repercussions on water, resource exploitation and the environment.

Signs of the good and the bad can be seen in many combinations at scales from the global to the community and even household level. In short: the world is getting richer and fatter while poverty lingers and water is becoming

more uncertain with unprecedented droughts and devastating floods. Yet, a number of initiatives for positive change are taken. Other opportunities need a further push.

The hazards of climate change, which signal a new kind of uncertainty, which is very much manifested in water change, have been thoroughly analysed. IPCC (2014) summarized the findings on the threats of global warming presented in over 30,000 articles and reports by some 850 scientists. Water risks are rated as the number one threat (WEF, 2015).

Mounting risks and growing competition for water and other resources suggest, among other things, that the era of easy and cheap food production is over. A number of how, what, what if, and who questions are key in the design of effective governanve for water, food and nutrition security: how much more and what kind of food is needed and how and by whom can the food be produced and best be distributed, accessed and enjoyed in a fair and sound manner.

Tunisia. Watershed of the Mejerds River dam showing vast soil erosion on all sides.
© FAO/Florita Botts

2. Water resources: mega trends and need for partnerships

Blue and green water, rates of exploitation and use

Oceans cover about 70 per cent of the Earth. For agricultural production it is mainly freshwater that is of interest although a small fraction of this comes from desalinization (Box 1). According to estimates by Falkenmark and Rockström (2004), the annually renewable water in rivers and lakes is about one per cent of average annual rainfall over continents. As a comparison, groundwater resources are about two hundred fifty times larger. However, slow recharge means that ground water is a stock resource while a continuous flux and variation in flow characterize surface water resources. Some two-thirds of the planet's freshwater are frozen in ice and snow caps.

In terms of volume, soil moisture is about twice the amount as in rivers (ibid.). It is vital for crops and other biomass and ecological services. It is composed of that fraction of the rainfall (and/or irrigation water) that infiltrates through the surface. It forms the unsaturated zone, whereas groundwater is the saturated zone. Soil moisture is often referred to as green water, alluding to the fact that it makes the landscape green. In analogy with this, the water in rivers and lakes is referred to as blue water, the colour used on maps. Blue water includes ground water.

Box 1. Salty water turned sweet

Desalination of seawater and brackish groundwater for horticultural and agricultural irrigation is gaining in appeal as high-efficiency energy recovery devices and improved membrane technology decrease energy consumption. Stringent quality standards apply for the boron and chloride contents of desalinated water for agricultural uses. The resulting energy-intense post-treatment makes irrigation water more costly to produce than potable water. The development of an integrated forward and reverse osmosis process currently holds the greatest promise for optimisation; it is also a more sustainable application requiring less treatment chemicals (Shaffer et al. 2012). The development of membrane technology is also significant for the treatment of sewage and wastewater for reuse in agriculture. Given that wastewater has a lower salt content than seawater, such a strategy is more viable (K.M. Persson, personal comment).

(Semi-) arid Spain and Israel have the longest experience in using desalinated water for the irrigation of fruit, vegetables and cereals. In Spain, where the produce mainly

is for export, there is a greater willingness to pay for the water. The latest statistics (2008) show that more than 22 per cent of the desalination capacity in Spain (including the Canary Islands) is used for agricultural irrigation. Recently, to replace small, private desalination plants, the government built large capacity plants in Almeria and Murcia on the southeast coast. Israel has not only become essentially self-sufficient in food, it also produces for the export market. Both countries use a host of energy- and water-saving methods, including greenhouses, drip-irrigation and solar photovoltaic.

The local environmental impacts of seawater desalination – entrainment and impingement of marine organisms, and elevated salinity of seawater brine effluents – remain a focus for public criticism. However, in a review article for Science, researchers found that there are several feasible technical solutions to mitigate the problems. In addition, they pointed to a lack of useful data to assess the potential adverse impacts from desalination plant effluents on marine ecological systems (Elimelech and Phillip 2011).

Tomorrow's nexus solution may be witnessed in the South Australia desert, in the large-scale commercial 'Sun drop' facilities developed from the original 'Seawater Greenhouse' method. A solar powered desalination process is linked through a system that first uses the seawater to humidify and cool the greenhouse during the day through evaporative cooling, and generates heat at night. Vegetables are grown in a high-tech, computerised hydroponic environment, without soil. The technology is now set to be further scaled-up in Australia and replicated in Middle Eastern countries to address regional food security, with subsidies and investments secured in part from local governments. In Australia only, 15 million kg of vegetables are produced yearly.

Viet Nam. A worker in a salt flat near the coast on central Viet Nam. © FAO/P. Johnson.

Groundwater dependence is booming

The importance of groundwater as a strategic resource has grown. A major reason is that surface water is heavily exploited. About 1.4 billion people live in closed basins (Smakhtin, 2008) where additional allocations of water should not be expected. In addition, droughts and changes in rainfall pattern make the availability of surface water more uncertain (Box 2). Conversely, access to cheap pumping technology, lack of enforceable regulation and, in some places, subsidized energy (cf. Box 7) are important drivers in the contemporary exploitation of ground water. On average, groundwater is the source for a third of the world's irrigation water with 70 per cent of this being abstracted in Asia (Shah, 2014).

In the developing world, there is a striking difference between the contemporary boom in water exploitation and previous water development. Earlier works were driven by state entrepreneurs, largely financed from public budgets and generally large scale, with magnificent land-marks that continue to attract attention. Today, while the number of pumps installed can be counted in the millions, they are typically small scale and can be moved readily from one well and one site to another. Although there are no physical land-marks, they are significant in their imprint on water.

Arrangements for lifting and diverting water are observed in all parts of the world. In India alone, the number of private wells was estimated at close to 20 million (Mukherji et al., 2013). Recent studies confirm that the situation looks quite different in different parts of the country; groundwater table is falling in some States and seems to be rising in other[8]. In Africa, irrigation development has been much slower. Slightly less than 5 per cent of the cultivated area is irrigated (Namara et al., 2014). So far, most of the water withdrawn is through simple technologies and often by hand (de Fraiture and Giordano, 2013). A thriving development of small private irrigation systems is facilitated through access to cheap Chinese-made motorized pumps (de Fraiture and Giordano, 2013). Already, the acreage cultivated through different kinds of informal arrangements is larger than the command area of official irrigation schemes (ibid.). For Sub-Saharan Africa, it has been estimated that the amount of water available as groundwater may be 20 times more than that available in the lakes and rivers (MacDonald et al., 2012).

The search for water goes deeper and deeper. In India, it is estimated that water is lifted from aquifers around 300 m below ground. The main constraint

[8] http://www.indiawaterportal.org/articles/groundwater-status-should-we-be-worried

is the energy supply (Box 7), as well as the value of crops being irrigated. In parts of California where there are extensive vineyards, water may, in some cases, be pumped from depths of more than 600 m, and there is long-term depletion of aquifers (Konikow, 2013). Here the return from cultivating grapes and other high-value perennial crops is very high. Indeed, returns from agriculture can be so high that agricultural production can compete with the demand for land for new housing subdivisions (Lohse et al., 2008).

Naturally, policy makers encounter difficulties related to controlling a very large number of dispersed well-owners, many of whom have few viable livelihood alternatives (Doczi et al., 2014; Shen, 2014). The proliferation of small, privately managed schemes generates economic growth and human well-being alongside improved local and global food security. The positive effects dominate when the number of water users is limited. The impacts on natural processes and the environmental consequences of a very large number of users abstracting water are of concern in poor as well as in rich societies. In California and elsewhere, lowering groundwater tables reduce the outflows to streams with adverse consequences for activities that rely on stream flow (Newburn et al., 2011; Kuwayama and Brozovic, 2013). While several complicating factors from an increasing dependence on groundwater are known, there are also 'unknown unknowns' that research and monitoring need to shed light on[9].

Natural and man-made water scarcity

Scarcity due to population increase

A common approach to describe water scarcity refers to the ratio between the availability of renewable water in a country and its population size[10]. When the annual available amount of renewable water per capita is below 1,700 m3, the country is described as water stressed. A 'red line' of water scarcity is 1,000 m3, implying severe challenges for domestic production of food and for socioeconomic development in general. Countries in the Middle East and North Africa (MENA) region have to cope with a water reality far below the 1,000 m3/person/year (see Chapter 5). The global average is about 6,000 m3 and for Sweden the figure is about 18,000 m3 showing that we are well above water scarcity problems. However, other countries with significant volumes of freshwater on a national basis face severe water problems. In Brazil, for

[9] The UK is currently channelling large sums to research on the potential of groundwater for the poor in Sub-Saharan Africa, and likewise to studies into the future of climate change in the region. See further at http://upgro.org/ and http://www.nerc.ac.uk/research/funded/programmes/fcfa/.

[10] See World Bank: http://data.worldbank.org/indicator//ER.H2O.INTR.PC; AQUASTAT: http://www.fao.org/nr/water/aquastat/main/index.stm

instance, the average per capita water availability is about 27,000 m3/year, but there are desert areas in the northeast and, currently, the Sao Paulo and Rio area, with a population of about 30 million, is severely affected by drought and pollution reduces usability of water that is available (Kelman, 2015).

In these kinds of calculations of water availability, estimates of evapotranspiration are subtracted from precipitation. Hence, commonly used figures on availability do not show the total water resource in a society. Food production in rain-fed systems, forestry and other functions in the landscape have benefitted directly from rainfall while availability refers to 'the extra water' i.e., after the subtraction of evapotranspiration from precipitation. Additional information on water resources is thus necessary.

Seasonal scarcity and uncertainty is amplified by climate change

Water resources are derived from the continuous circulation of water in the hydrological cycle; from the rain and liquid water in streams, lakes and aquifers, from soil moisture in the root zone and the return flow of vapor back to the atmosphere. With global warming, the flow of water back to the atmosphere will be faster. Similarly, the volume of vapor in the atmosphere increases with higher temperature as does the likelihood of heavy downpours.

In the Himalayan region the total annual amount of precipitation has varied little over the last 40 years but rainfall events have become more intense (Eriksson et al., 2009). Unexpected downpours during the monsoon period cause multiple problems and are hard to cushion. Generally, the start and length of the cultivation seasons have become harder to predict with more rains and run-off during the off-season and less water when most needed. Changes in temperature also affect preconditions for different kinds of crops. Since this is a heavily populated region, the challenges are correspondingly big (ibid.).

Global warming also adds new demands, such as for cooling purposes. During recent warm and dry summers a number of thermoelectric power plants in Europe and the southeastern United States have been forced to reduce production due to water scarcity (van Vliet et al., 2012).

Land use affects water flows

The type of vegetation, tilling practices and organic matter content in the soil affect infiltration and water holding capacity and water flows. Changes in land use over large areas can have significant effects on water fluxes as experienced in many parts of the world and particularly in areas with a strong seasonal rainfall pattern. Cherapunji, northeast India, is famous

for its world record precipitation – up to 9,000 mm in a single month and an annual average of some 11,000 mm. The wettest place on Earth is now periodically parched land with wells that run dry. Rainfall is concentrated in the monsoon period from June to September. Degradation of vegetation has removed the 'breaks' that nature provided against torrential water flows. The water from the heavy downpours now washes down the slopes. People in the area face periods of scarcity for part of the year while an abundance of water is a threat during other parts of the year and for downstream areas.

Economic context affects quantity and quality

A distinction should be made between the availability of water and access, and the quality and usability of the water. For poor countries, investments in infrastructure for storage, regulation and conveyance and for clean technologies in the production and treatment of waste water are limited. These kinds of predicaments are often referred to as economic water scarcity (e.g. CAWMA, 2007) and have been associated with quantity. It is also relevant to recognize the lack of economic and technical capacity to counter quality degradation, which impedes safe use. Although these challenges are most common in and around major cities, the degradation of water in these parts of a country often means water that used to be for agriculture may now be diverted to booming urban centres. This is, for instance, the case in the Sao Paulo and Rio area. Unprecedented and on-going drought contributes to the competition for water resources in a wider geographical area (Kelman, 2015).

Subsidized, demand driven scarcity

Heavy investments have been made in storage, canals and other physical infrastructure for agriculture, often facilitated and stimulated through generous subsidies. No doubt, subsidies to water development and allocations to irrigation have had a positive effect on rural livelihoods and contributed to a laudable increase in food supply as discussed in chapter 3.

While subsidies for water development and provision have had positive socio-economic effects they have also reduced incentives for judicious use. Current policies are often rooted in situations arising decades ago when the water situation was different. For instance, the Law of the Colorado River, which gives details of the allocations to seven basin states, was signed in 1922, which happened to be a wet year (The Economist 2014). Some farmers in California pay about 15 per cent of the capital cost of the federal system whereas other farmers pay large amounts. Water is brought from the

Colorado River via a sophisticated conveyance system to grow thirsty crops with low economic values.

For groundwater, subsidies and perverse prices on energy for lifting water create significant challenges (see Box 7).

Role of good governance and need for constructive partnerships

Water and food security issues typically involve interests and actors from public and private sectors, including farmers and also civil society. Society's new normal, as described in Box 2, illustrates that independent actions and planning in silos is less and less feasible. For instance, farmers have been used to cope with normal variation in precipitation but now face challenges that go beyond 'normal practice'.

Government interventions will continue to be necessary but with constraints on public budgets, a large part of investments must come from private actors. Private actors, including farmers posses relevant technical skills and have a direct interest and modus operandi in promoting and implementing cost-effective innovations. Budgets for research and development are significant within big corporations.

Debates about the appropriate role of business in water policy and management are emerging. It is important to note that corporate initiatives often go beyond specific sector engagements. For instance, Nestlé and PepsiCo programmes aim at holistic programmes including agricultural water use and household water supply and sanitation. Concrete initiatives in this regard are initiated by the 2030 Water Resources Group. Efforts to change the "political economy" for water reform in a number of countries are made through convening a wide range of actors and providing guidance that is digestible for politicians and business leaders. In a catalogue of some forty cases from agricultural and industrial sectors and municipalities (2030 WRG, 2013), it is shown that private sector participation facilitates, among other things, capacity building and technology promotion and that substantial water saving are possible. With proper reforms and monitoring these programmes can continue to function.

Adaptation to less water is necessary although it is often a painful process. During a ten year period, ending in 2009, the inflow into the Murray-Darling Basin was about half the historic average (Kirby et al., 2014). Acute shortfalls in river flow resulted in natural cuts in the water available for irrigation. Very tough negotiations between representatives of the irrigation community and those concerned about the basin's ecosystems and estuary resulted in a permanent cut in irrigation water allocations by 20 per cent.

The irrigation communities have adapted to the new situation with "...crop mix changes, water trade, substituting purchased feed for irrigated pasture in dairy production, irrigation efficiency improvements and irrigated crop yield improvements." (ibid). Pittock and Connell (2010) noted with regard to the prolonged drought in the Murray-Darling Basin that a scarcity crisis provides an effective impetus for institutional reform, but to overcome the legacy of the past is a 'very formidable challenge' (pp. 573/574).

Ethiopia. Due to drought, cattle resort to eating cactus. © FAO/M. Bleich

Box 2. Disastrous drought: society's new normal

Donald Wilhite, School of Natural Resources, University of Nebraska-Lincoln, and Roberto Lenton, Robert B. Daugherty Water for Food Institute at the University of Nebraska

The extreme droughts capturing the headlines in California, Sao Paulo and elsewhere have given this natural disaster the publicity it deserves. Droughts are everywhere and expected to become more frequent and severe for many locations in the future as a result of climate change (Cook et al., 2015). Currently, farmers in the US, Africa, Australia, India and China, as well as large regions of Russia and Eastern Europe, struggle with a deficiency of precipitation, combined with dwindling water reservoir levels. Severe and prolonged droughts underline how inadequate current policies are in dealing with today's harsh reality.

Nations need to think strategically about drought. We urgently need a new approach to manage this threat—one that shifts away from treating drought as an isolated, event-like crisis to one that emphasizes preparedness, risk reduction and water conservation year round.

Most countries treat droughts as uncommon and tragically underestimate their social and economic consequences. In fact, these routine natural hazards cost the world more economically and in human lives than hurricanes, earthquakes and floods combined.

Droughts in the US in 2011 and 2012 alone cost the government and taxpayers an estimated USD 60 billion to USD100 billion (Weiss et al., 2013). In the Horn of Africa 50,000 to 100,000 people died during that region's drought in 2011 and hundreds of thousands remain at risk for malnutrition. More than 13 million people still struggle with loss of livelihoods and other consequences.

While most nations experience droughts, what capture the headlines these days are their frequency, intensity and duration. At the same time, climate change projections suggest many regions will become even drier and hotter.

As crops wither and livestock weaken, local and global food markets are disrupted. Food prices go up and vulnerable populations face greater malnutrition and starvation. Beyond agriculture, drinking water becomes scarce, rivers and lakes dry up — and fishing industries with them — and conflicts erupt as people fight over limited water resources.

Today, international aid organizations and nations respond to drought only after

it is underway and its impacts acutely felt. Then, money and resources flow in as loans and food to aid communities and farmers. While relief is necessary to help communities survive in the short term, it fails to reduce long-term risks.

Our ability to predict drought months in advance is limited. Establishing drought policies focused on risk reduction would give countries an opportunity to develop a framework to build resilience and use resources more effectively. Increased resiliency is not only achievable, but also less costly than a piecemeal approach in response to crises.

Australia recently revised a 1992 national drought policy. Mexico and Brazil are developing new policies and other countries are re-evaluating their reactive approaches to drought.

On an international scale, the FAO, UN-Water, Global Water Partnership and the World Meteorological Organization, among others, have formed alliances to develop policy and management guidelines and are offering training workshops to assist nations to develop risk-based drought policies (Wilhite et al., 2014).

Droughts in far-off lands usually fail to galvanize public reaction. But it is time to educate the public and policymakers about drought's global reach and of our individual and collective responsibilities to conserve water for current and future generations. Droughts provide opportunities to change the way that long-standing problems are addressed and to establish wiser water management policies and practices. The urgency with which nations must act to tackle this challenge cannot be overstated.

3. Water for food supply – water for sustainable diets

Our daily food supply – trends and water implications

How to feed the world healthily and to do it in a resource effective and environmentally sound manner is a mega challenge in an era of rapid demographic change, lingering poverty, economic and nutrition transitions (Hawkesworth et al., 2010; ODI, 2014). The increase in the supply of food over the last 50 years has proved Malthus' predictions wrong. In 1961, global average supply was 2,194 kcal/person/day (338 and 1,856; animal and vegetal kcal); 50 years later it had increased to 2,868 kcal/person/day (507 and 2,362; animal and vegetal calories)[11] . Global increase in average daily per capita food supply was thus about 30 per cent and the proportion of animal to vegetal calories increased from about 18 to 21 per cent. The supply of protein and fat also increased significantly. The supply of food is expected to reach 3,050 kcal/person/day in 2050 (Alexandratos and Bruinsma, 2012). More and more people can enjoy more than one meal a day.

Improvements in food supply and changes in its composition are associated with an increased consumptive use of water. Proper management is vital for best use of water but, generally, increasing biomass, including the edible and non-edible parts, is associated with increasing consumptive water use. Variations between temperate and hot climate regions, between crop varieties and climatic circumstances are significant. With these precautionary remarks, estimates have been made of the volume of water consumptively used to produce the food supplied in 1961 and 2011 and projections for 2050 (Table 1).

An extra daily tonne of water and yet another half a tonne?

The figures in Table 1 refer to food supply, i.e., after losses in the first segments of the supply chain and after conversion of grain for feed (currently about 36 per cent of total grain production). Since water is consumed also by the food that is lost, the volume of water used in the field for production is higher than indicated in Table 1. The calculations suggest that the average volume of water that is consumptively used to produce the food supplied for a person for one day is currently in the order of 3.2 tonnes and that it increased by an estimated 1 tonne between 1961 to 2011. If projections

[11] Source: Food Balance Sheets, FAO: http://faostat.fao.org/site/368/DesktopDefault.aspx?PageID=368).

of increases in food supply will materialize, an additional half a tonne of consumptive water use for daily food supply per person may occur between 2011 and 2050. To arrive at total global consumptive use of water, the estimates in Table 1 need to be multiplied by figures on population size in 1961, 2011 and projections for 2050.

What is the added value to society from the extra tonne of water between 1961 to 2011? How will an augmented supply of food and an estimated extra half a tonne of water for food benefit the nine billion people in 2050 and what are the implications for other water requirements?

Table 1. Average global food supply in kcal/person/day and estimates of the associated consumptive water use.

Sources: food supply in 1961 and 2011: Food Balance Sheets (see foot note 11); for food supply in 2050: Alexandratos and Bruinsma (2012). Estimates of the consumptive water use are based on Hoekstra (2012, 5): figure on water footprint per vegetal kcal (from cereals) is 0.51 liter. For animal kcalories an average of 4 liters/kcal has been used. Details can be found in Hoekstra (ibid.): for bovine meat (10,19), sheep or goat meat (4.25), pig meat (2.15), chicken meat (3,0), eggs (2.29) and milk (1.82). Two estimates are made for 2050: a) presumes the same relative distribution between vegetal and animal calories as in 2011, b) presumes a relative increase of 3% in animal food between 2011 – 2050, corresponding to the same relative increase as between 1961 to 2011 (see text above).

	Food supply: kcal/person/day	Vegetal kcal person/day	Animal kcal/ person/day	Consumptive water use: liters/person/day
1961	2,194	1,856	338	1,856 x 0.5 + 338 x 4 = 2,280
2011	2,868	2,362	507	2,362 x 0.5 + 507 x 4 = 3,209
2050a)	3,050	2,410	640	2,410 x 0.5 + 640 x 4 = 3,760
2050b)	3,050	2,318	732	2,318 x 0.5 + 732 x 4 = 4,087

In search for an answer to the question above, it should be recognized that the overall food supply in the world already gives a wide margin for global food security. An average daily per capita intake requirement is in the order of 2,200 kcal (e.g., Hawkesworth et al., 2010). It is interesting to note that the actual intake of food in some cases seems to be below the recommended level, even in rich countries (ibid.; Smil, 2000). Needless to say, vartiations are significant and the collection of reliable information on food intake is extremely difficult, i.e., even serious studies may not mirror the true situation and how it varies.

A gradual reduction in the global prevalence of undernourishment is a laudable result of increased food supply (Figure 1). For some countries, like

Ghana, relatively few people suffer from undernourishment today. Even if some 800 million are still undernourished, increases in food supply have obviously contributed to a reduction in undernourishment.

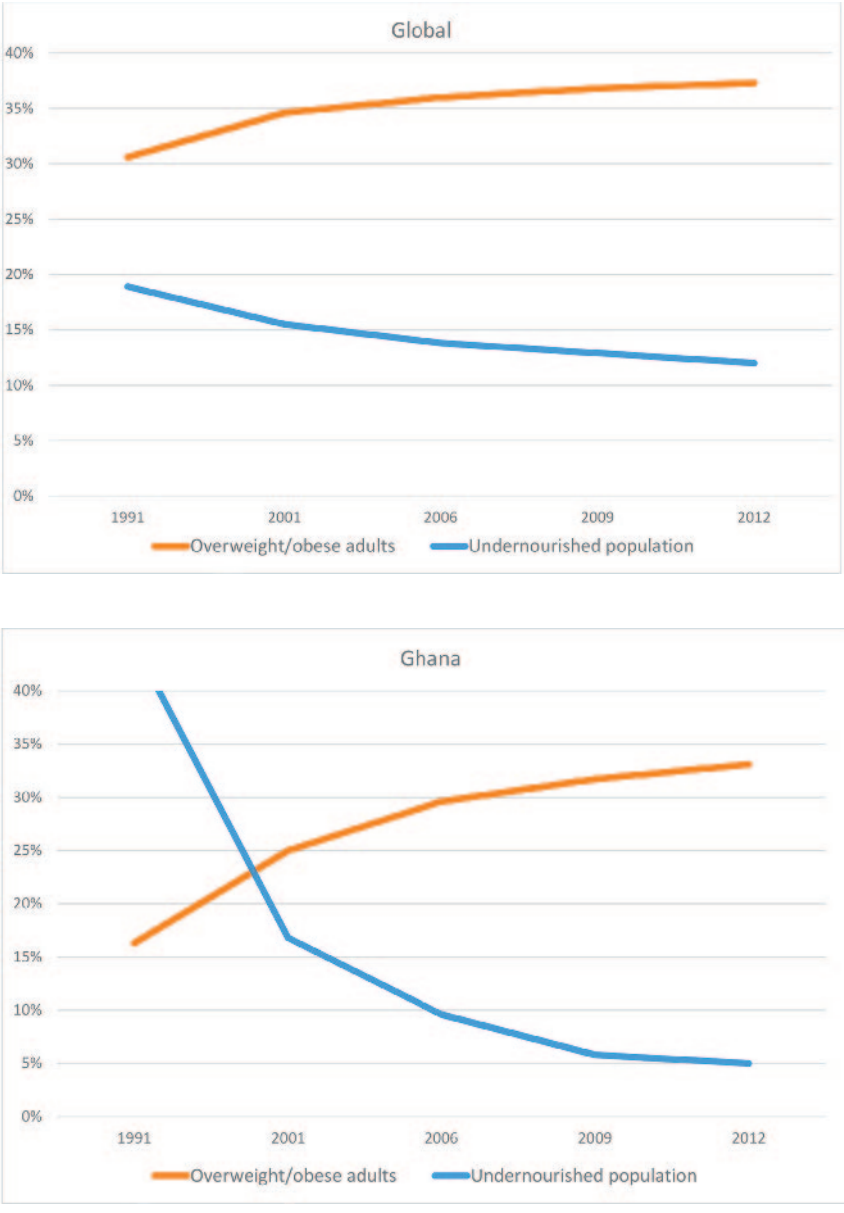


Figure 1. Trends in the prevalence of undernourishment and being overweight and obese globally and for Ghana, 1980-2013. Sources: For undernourishment: FAO et al., (2013a); for overweight and obesity: IHME, (2012; last modification of entry, Aug 6, 2014).

Nutrition challenge at par with climate change for global development?

However, Figure 1 also demonstrates that another kind of food insecurity is developing rapidly. In an amazingly short time, the nutrition situation has escalated in a negative direction. According to the Global Nutrition Report (IFPRI, 2014), between 2 and 3 billion people are malnourished in some form (undernutrition, being overweight and obese, or with some sort of micronutrient deficiency, ibid. p. 2)[12]. The report argues that the nutritional crisis is '...at par with climate change as one of the highest stake global development challenges.'

Between 1980 and 2013, the number of individuals affected by overweight or obesity increased from 857 million to 2.1 billion (Ng et al., 2014, p. 770), which means that the number of people affected by these types of malnourishment is about 2.5 times the number of people who are affected by undernourishment. This crisis is evolving faster in developing countries than in rich ones.

Will another half a tonne of water for increased food supply till 2050 modify the trends shown in Figure 1? Scenarios and 'what if' questions are urgent to guide food and agricultural policies and design strategies that could improve food security and nutrition in a context of water predicaments (see further chapters 6 and 7).

Typologies for food security and nutrition

The most common definition of food security dates back to the World Food Summit in 1996:

> "Food security, at the individual, household, national, regional and global level is achieved when all people, at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." (FAO, 1996).

This definition has been amended at several occassions and a recent interpretation of the definition is summarized in four dimensions: availability, access, stability and utilization (FAO et al., 2014, p. 13). (cf. the discussion about Human right to adequate food in Chapter 4.)

Availability, access and stability have guided efforts to improve food security for a long time whereas utilization elaborates on the nutrition dimension in two regards:

- Composition of the diet
- Absorption of the energy and nutrients by the body (Box 3).

[12] For visualization: http://www.healthdata.org/data-visualization/overweight-and-obesity-viz

Kenya. Martin Owino removes a new banana sucker for planting, using conservation agriculture technique to facilitate water retention.This new way of planting mixed with terracing allows farmers to save excess rainwater that would otherwise wash away top soil and flood the entire area. © FAO/Christena Dowsett.

Colleagues from medical profession provide guidelines of the components of a healthy diet and intake requirements (e.g. Hawkesworth et al., 2010). Given the worrysome trends in nutrition, on the one hand, and water and environmental implications of expanding food systems, on the other, it is urgent to align policies in these two spheres. Incentives and regulations for land and water use need to promote an orientation in production and supply that is benign for humans, water and the environment in line with the idea of sustainable diets (FAO, 2010b).

Nutrition strategies need to include aspects related to food intake and the ability of the body to absorb the nutrients in the food as discussed in Box 3.

Box 3. Food Security and Nutrition – impact of sanitation and hygiene

Jenny Fredby, Head of Policy and Programmes, WaterAid Sweden

> The dominant and traditional discourse on food security and nutrition has focused on agriculture/food production and, in principle, on access. Based on solid research, arguments now are being made to expand the thinking around nutrition from availability and access to also recognizing the significance of absorption; at

what happens inside the body after the food has been eaten, as well as at when human excreta itself becomes a risk to nutrition and the environment when not safely managed.

The body's ability to properly absorb nutrients is affected by diarrhoea, soil transmitted helminth infections or parasitic intestinal worm infections and environmental enteropathy (characterised by increased gut permeability and nutrition malabsorption), all caused by inadequate sanitation, insufficient hygiene and unsafe water (Checkley et al., 2008, Lima et al., 2000). The World Health Organisation estimates that 50 percent of malnutrition is associated with repeated diarrhoea or intestinal worm infections resulting from poor water, sanitation and hygiene (WHO, 2008).

The need to pay more attention to absorption in food security strategies has been raised by Swaminathan, who outlined a conceptual model of what he saw as the pillars of food security, the three As; Availability, Access and Absorption (Keynote address, Third South Asian Sanitation Conference, 2008). Availability and access are about getting food to the body, areas which are well understood and cover food systems, distribution/delivery and rights of people, while absorption is about the uptake of energy and nutrients in the body.

Availability – the amount of food that is produced and made available in society

Accessibility – the possibilities for people to buy or procure the food available in the market and through other channels

Absorption – much of the food eaten is not properly absorbed, due to for example diarrhoea and damages to the wall of the gut caused by bacterial infections and parasites

Thinking around absorption has been further developed by Chambers and Medeazza (2014) who argue for the need to reframe and further broaden the thinking on undernutrition. They are calling for more attention on the role of faecally-transmitted infections and their effects and are proposing a model of five As. In their thinking, Availability, Access and Absorption are followed by two more As; Antibodies and Allopathogens, concerning the multiplicity of faecally-transmitted infections and their effects (ibid.). For a most worthwhile use of the food produced and improved nutrition security, all the five As and the connections between them must be recognized.

The role of water, sanitation and hygiene as critical determinants of nutrition and the importance of addressing nutrition across a wider range of sectors have been more acknowledged recently (c.f. IFPRI, 2014) and a growing evidence base is being developed on the theme (Dangour et al., 2013; Fischer Walker et al., 2013).

Reliability, validity and terminology

Making comparisons between different years on undernourishment and other forms of food insecurity is difficult. For instance, in the annual State of Food Insecurity Reports, SOFI Reports, (e.g. FAO et al., 2014) seemingly there are inconsistencies in the data sets as compared to corresponding data in SOFI reports published in another year. These differences result from a revision of the methodology for data compilation and how basic data are collected within the member countries. It is important to be aware of these mofifications and to recognize that these difficulties are beyond the control of the compilation agency.

In analyses of food insecurity, attention is focused primarily on food supply and its calorific contents. Attention to food intake and indicators on nutrition and the prevalence of being overweight and obese are less often noted. In FAO et al., (2014) it is argued that the Millennium Development Goal (MDG) hunger target is within reach – a positive. However, if the prevalence of undernourishment is combined with other trends in the double burden of malnutrition, a more complex picture of food security and nutrition emerges, as illustrated in Figure 1. Both trends have implications for food and agricultural policies.

Finally, it is relevant to note that key concepts are not used in a coherent manner. 'Food consumption' is one of the most commonly used terms in daily language and to describe what is happening with the food on the demand side:

> "The terms 'demand' and 'consumption' are used interchangeably. Unless otherwise specified, both terms comprise all forms of use, i.e. food, feed, seed and industrial use as well as losses and waste." (Alexandratos and Bruinsma, 2012, p. 3).

Two quite different aspects are involved. Food consumption is an economic concept and refers to final use of food (and other agricultural commodities) as illustrated in the quote above. From a nutrition and medical point of view, food intake or ingestion is the valid term. From a resource pint of view, it is important to recognize that all food produced has consumed water, occupied land, contributed to environmental problems whereas it is only the fraction of food produced that is eaten that is relevant from a health perspective. Since a large fraction of the food produced is lost or wasted, it makes sense to distinguish between data on food consumption and data on food intake. A more diligent use of the two concepts is important when formulating food policies and to understand the significance of waste (cf. Chapter 6).

4. Human rights, water rights and access

Under international law, human rights call for action at many levels by states, business and other actors. Addressing societal development from a rights-based approach involves a state that is guided by core values, acts on behalf of all citizens, invests in welfare, and provides a foundation for everyone to reach their full potential. It builds on international cooperation, active civil society and non-governmental organisations (NGOs), and implicates an agri–food sector that respects the rights of others.

Micronutrient deficiencies and inequity in access to food have been known for some time and must be dealt with on several scales. Human rights set the framework for societies to strive towards dignity and function as moral imperatives. The rights to water and food are framed such that they do not entitle every person to water for her/his own food production. Nor does human rights law oblige the state to ensure food self-sufficiency on a national basis provided an adequate supply is available in the market, also for vulnerable groups.

There is no obligation to provide water for agricultural use by enabling access to irrigation or provision of freshwater. The right to food can be realized in other ways and state governments are entitled to determine how. State governments should, nonetheless, always pay respect to indigenous people and other vulnerable groups and give priority to food production over industrial water demands.

Food production and preparation both require access to water. Further guidance is needed on how to interpret the interconnection between the human rights to food and water and how to prioritise water allocations between different sectors. The agri–food business and corporate world are expected to respect, and in some cases support or help fulfil, human rights. This is increasingly important today regarding the nutritional quality of the food that is produced and marketed, and the allocations of scarce water resources that enable these activities.

Background: the human rights to food and water

The right to adequate food was first recognised in the 1948 UN Declaration of Human Rights. In the 1966 UN International Covenant on Economic, Social and Cultural Rights (ICESCR), it was acknowledged that everyone has a right to an "... adequate standard of living for himself and his family, including adequate food, clothing, and housing, and to the continuous improvement of living conditions" (Art 11). This is underpinned by a

fundamental right to freedom from hunger and malnutrition.

In 2010, two UN Resolutions recognised the right to safe and clean drinking water and sanitation as essential for the full enjoyment of life and all other human rights (acknowledged by Sweden March 2011). The content of the right to food is set out in General Comment 12 (GC12) of 1999 and that to water in General Comment 15 (GC15) of 2002. General Comments are non-binding, but authoritative and widely accepted interpretations from the Committee on Economic, Social and Cultural Rights (CESCR), serving to clarify substance and obligations.

In GC12 it says that every state is obliged to ensure access to the minimum essential food which is sufficient, nutritionally adequate and safe. Food should also be available and accessible. Among other things this means the following:

- 'Availability' of food in a quantity and quality sufficient to satisfy the dietary needs of individuals. This refers to either the possibility to feed oneself directly from productive land or other natural resources, or have the means to obtain (purchase) food through well-functioning distribution, processing and market systems that can move food from the site of production to where it is needed in accordance with demand.

- 'Economic accessibility' implies that the financial costs to acquire food for an adequate and acceptable diet should not threaten or compromise the attainment and satisfaction of other basic needs – socially vulnerable groups, such as landless persons and other particularly impoverished segments of the population, may therefore need special attention.

- 'Adequacy' is intrinsically linked to sustainability and food security. It implies that food must be accessible and available for both present and future generations.

Two things deserve to be noted. First, this Comment nowhere mentions water. It only directs the state to proactively strengthen people's access to "... resources and means to ensure their livelihood, including food security" (GC12, para. 15), and to take care to ensure "... the most sustainable management and use of natural and other resources" (GC12, para. 25).

Second, the FAO launched its key concept food security in 1974, then defined in terms of supply, availability and price stability. The definition has been revised and expanded many times to reflect changes in official thinking. The wording decided at the World Food Summit in 1996 (see Chapter 3) gained wide acceptance. More recently, the ethical and human rights dimensions of food security have come into focus (FAO, 2006b).

Tanzania. Women and young girls harvesting water from a dried up stream.
© FAO/Simon Maina.

Today the FAO definition of food security goes further than GC12 in terms of encapsulating the general importance of water. This is seen in the Voluntary Guidelines, adopted by the UN Committee on World Food Security in 2004 to support the realisation of the human right to food. These mention that water resources are "fundamental for life and health" (FAO, 2004, para. 8C). However, like the GC12 the Guidelines do not lay down a concrete connection between water and food and do not treat the subject of trade-offs, competition and priorities between different sectors. Where they are silent on how to balance interconnected water resources needs and demands between different uses, users and sectors, they should be made explicit.

Water for food production purposes

The human right to safe drinking water covers personal and domestic uses for cooking and washing and personal and household hygiene. GC15 declares that priority in the allocation of water "must" be given for those purposes (para. 6). It follows from the given definition that water for agriculture falls outside the scope of the right to water and, correspondingly, outside what states have an obligation to respect, protect and fulfil.

GC15 calls attention to how water is irreplaceable in many areas and sectors and that it is required to realize other rights than that to water for domestic, personal uses. Examples of such are the right to health and the right to earn a living by work. With respect to the right to food the Comment "... notes the importance of ensuring sustainable access to water resources for agriculture" (para. 7).

The Comment also states that priority in water allocation should be given to the water resources required to prevent starvation (para 6). Furthermore, people may not be deprived of its own means of subsistence and, hence, states should ensure that there is adequate access to water for subsistence farming. Indigenous peoples' livelihoods and customary land and water rights should be respected (para. 6, 7). The latter is a negative duty to refrain from undue interference with traditional practices and the right to self-determination.

The formulations in paragraphs 6 and 7 remind state governments and other users that there are a range of different interests involved when planning and managing water, especially when competing demands and limited resources need to be balanced. As such, GC15 does not create binding obligations for states.

The steps to be taken to realize the rights to food and drinking water entail a number of choices and trade-offs. Primarily, it is the responsibility of state actors to embark on reform and re-allocation, where necessary, between different end-users. Decisions on priorities are key in water management and governance.

A number of nations have recognised food as a human right in their Constitutions, statutory law or other legal frameworks; many have issued (non-binding) policies on water allocation. The latter normally give preference to domestic purposes to realize the right to drinking water, putting agricultural needs second, then industrial demands, including power generation. In practice, though, urban activities often trump over the needs of rural areas, as political power and economic interests are usually concentrated in the former.

Only a few nations prioritize water for ecosystem requirements in their policies, such as South Africa, while most others fail to provide specifically for sustainability in water allocation. As discussed in Chapter 2, the agricultural sector is presently associated with almost 70 per cent of the total available freshwater resources withdrawals, on a global average. Industrial uses amount to just under 20 per cent and the rest goes to so-called municipal users (FAO, 2012b). Arguably, a large portion of the water withdrawn for agriculture goes to purposes that are in fact not foodstuffs at all, such as cut flowers, cotton and biofuels.

Practical aspects of realisation

States have a broad margin of discretion to determine the most appropriate ways and means of realizing the right to food. This depends largely on people's existing means of accessing food, and its availability. Notably, these elements may be ensured in two ways. Either individuals have the possibility to feed themselves directly from productive land, water or other natural sources, which the state must respect and protect. Alternatively, individuals have the necessary means to procure food via distribution and market channels, which the state may need to facilitate.

Land rights and access to water are often closely interconnected. To protect the interests of subsistence farmers, disadvantaged and marginalised farmers, including women farmers, and indigenous peoples, GC15 reminds of that land (tenure) reform may be necessary. Likewise, the land and water rights of such groups must be taken into account before authorities grant licences to private actors whose operations risk interfering with indigenous people's traditional ways of living. The groups mentioned – particularly women farmers – seldom have formal access to irrigation techniques (see Box 4). Better (and gender-sensitive) advice on small-scale and rainfed practices, soil moisture monitoring and drought-tolerant crops, is a way forward considering increasing climate uncertainties.

There is a common misconception that the right to food entitles people to be fed. On the matter of affordability and 'economic accessibility' the former Special Rapporteur for food has clarified that this means that everyone has

an income or other means to realize their access to the food available in the market. The income can come from own use of productive resources, wage labour or trade or transfer programmes. States are required to facilitate an enabling environment in which people can use their own, full potential to produce or procure adequate food for themselves and their families, but individuals are primarily expected to meet their own needs. Only as an exception – such as because of armed conflict or natural disaster – is there an obligation on states to directly provide food.

State governments and agencies acting on their behalf need to proactively engage in activities intended to strengthen people's access to and use of resources and means to secure their livelihood. This responsibility includes ensuring that there are available, accessible and functional markets.

Private actors and human rights

The opportunity cost of producing food domestically where water is scarce motivates trade in food (see Chapter 5). This requires food import options to be secured instead, from places where water is available and accessible in a sustainable manner.

States have a duty to ensure that commercial enterprises and other third parties do not violate human rights. Business enterprises are expected to comply with the three core principles of the UN Human Rights Council:

- The state duty to protect against human rights abuses by third parties
- The corporate responsibility to respect human rights
- The need for access to effective remedies at both state and company levels.

More detail is given in the 'Guiding Principles on Business and Human Rights' (OHCHR, 2011). These seek to foster business operations that are based on due diligence to avoid harm, and encourage companies to reflect on their impacts on 'affected stakeholders.' For instance, the Swiss company Nestlé pledged in 2015 to pilot a new reporting framework based on the Guiding Principles, as part of its 'Creating Shared Value' approach to human rights.

The Guiding Principles are relevant to transnational food corporations and national governments that have developed relations with markets outside their own borders. The majority of the resulting deals, which tend to cover water rights as well as land acquisition, have been made in Sub-Saharan Africa by the Gulf countries and Chinese and Indian interests. Solid regulation and good governance are crucial to ensure sustainability and human rights as elements of global food security and sustainable food

systems. Without these there may be serious implications for local access to water and food production possibilities.

The Guiding Principles also advice that companies need a human rights perspective in their thinking on water resources; they should focus on water-related risks to people rather than water-related risks to the business. For instance, a large agricultural company or mining operation can draw large quantities of water from an aquifer, affecting individual and community water availability from shallow wells – and hence the local food security. Likewise, industrial processes and agricultural practices can have significant water quality implications.

In 2003, the Special Rapporteur on the right to food noted the increasing control of transnational corporations over food production and water resources and argued that such private actors are bound to take responsibility and bear obligations to promote and secure human rights. Further guidance on corporate water stewardship and human rights was provided in 2015 (UN Global Compact CEO Water Mandate et al., 2015).

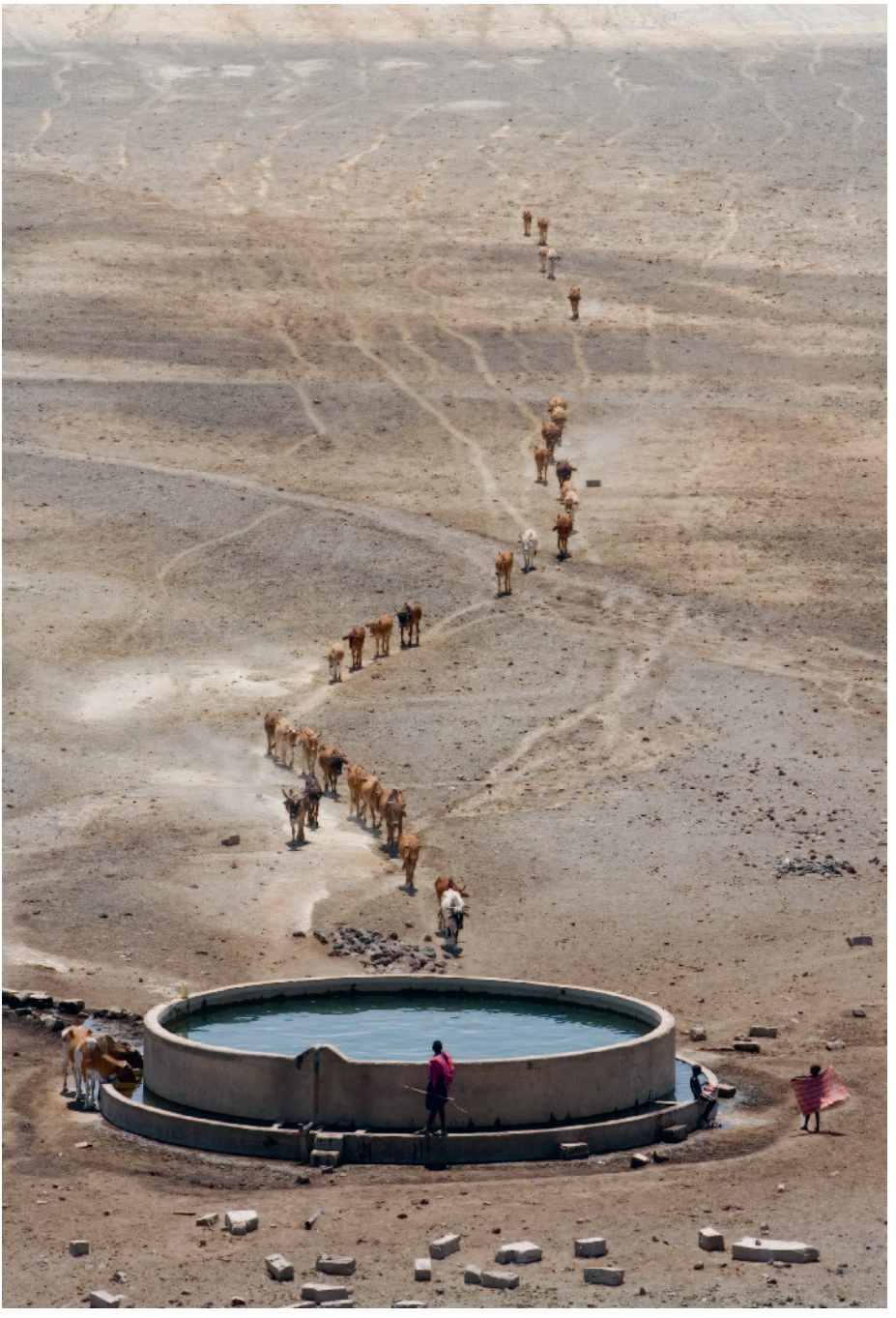
The right to adequate and nutritious food

The interdependence between food production and water resources is beyond doubt. In 2003, the Special Rapporteur on the right to food expressed that his mandate included water as a fundamental element of nourishment. The 1966 ICESCR obliges states to develop or reform agrarian systems and disseminate knowledge about nutrition to achieve the most efficient use of natural resources. The GC12's interpretation of food 'availability' and 'adequacy' refers to quantity, quality and sustainability.

Further clarifications of the implications for agricultural policies and the regulation and reshaping of food systems have also been made (Special Rapporteur on the right to food, 2011). An adequate diet is one providing all the nutritional elements an individual requires. States have a duty to protect this, making sure that changes in the availability of and accessibility to food supplies do not negatively affect dietary composition and intake, and supporting dietary diversity and healthy eating patterns. Agri–food companies, too, must respect the right to adequate food for present and future generations.

Experts agree that food systems must ensure that everyone has access to 'sustainable diets,' defined as "... diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations" (FAO, 2010b).

The efforts to realize the right to adequate food should involve scrutiny of the nutritional quality in readily available and affordable food and its links with non-communicable diseases. People should question those agricultural



Kenya. An aerial view of pastoralist and herds of livestock gathering at a water well in a dry portion of Lake Magadi. © FAO/Giulio Napolitano.

policies that make some types of food more available than others; policies that encourage the production of grains, rich in carbohydrates, but relatively poor in micronutrients, at the expense of the production of and access to fruits and vegetables (Special Rapporteur, 2011). Consequently, agricultural subsidies – for instance those targeting production of sugar beets and cane in the EU, the USA, and India among others – form parts of an unsustainable global food system that contributes to poor diets and misallocates water resources.

It should be sound policy to prioritize subsistence farming over cash-crop producers, many of which are mono-cultures. Similarly, subsidies and pro-poor policies should be critically evaluated. Winkler (2015) argues that water allocation requirements for food production should be assessed at three levels:

- As attributed to sheer survival
- To meet core obligations and the minimum standard in terms of a varied diet that ensures health
- For full realization of the right to food.

'Full realization' would include individual dietary preferences such as for dairy and meat. It is worth noting that in guidelines suggested in 2014, the Swedish National Food Agency (Livsmedelsverket) advises on reducing meat intake for improved health as well as environmental reasons.

Water, land rights and food security

The rights to water and food involve extraterritorial obligations requiring international cooperation (GC15 para. 30-36). When deciding on water allocation policies, states must refrain from actions that interfere with the enjoyment of the right to drinking water or the right to adequate food in other countries, and "have to respect the enjoyment of the right to food in other countries" (para 31). The obligation encompasses taking corrective actions when problems are reported, and extends to any activities undertaken within their own jurisdiction, including third party activities.

Each country has the freedom to regulate the use of water resources within its territory, save for the limits formulated by the international community. For instance, the 1997 UN Convention on Non-Navigational Uses of International Watercourses builds on the fundamental obligation not to cause significant harm to others, such as through water pollution. In addition, the International Freshwater Treaties Database lists more than 400 transboundary water agreements that have been developed for various purposes in river basins that cross political boundaries, giving scope for

negotiations and diplomacy regarding water use on a case-by-case basis.

However, to realize the right to food universally for coming generations, societies must plan for their own and shared water resources in efficient, sustainable and equitable ways. Windfuhr (2013) argues that the principles of integrated water resources management (IWRM) should be developed and implemented to avoid and mitigate conflicts that can be predicted, and aligned with decisions on land and water use. To this end, the global and independent Land Matrix (www.landmatrix.org) would be a useful monitoring tool to promote transparency and accountability in decisions over land acquisitions and investment.

However, IWRM and other soft law principles will be insufficient as long as water allocation remains insensitive to regulatory realities. Spatial planning by necessity builds on legally binding water rights (such as permits, licences, and concessions, and/or customary rights in land and water), that are in need of reform in many countries. For instance, large parts of the USA either acknowledge landowners' riparian water rights, or allocate water based on 'prior appropriation' (first in time to lay a claim becomes first in right to a water source).

Prior appropriation is presently much discussed in California where a 100 year old Act entitles the most senior water rights to take precedence over more junior ones. Both need to be curtailed from diverting water from rivers and streams during severe drought, scarcity and competition. Not all irrigators are involved in producing nutritious food. From society's point of view and in the interest of a wider group of stakeholders, this type of water rights regime should be reformed to promote a more equitable and sustainable access to water for food.

Application for a licence and the granting process ideally involves consideration by the concerned public, competing interests, of climate variability and the health of the ecosystem at large. In practice, however, legal compliance and good governance will often seem unattainable. Not least with respect to land acquisition contracts, the decisions are seldom characterized by principles of transparency, accountability, participation and integrity, or duly based on strategic environmental impact assessments.

Most legal systems build on institutions that include a public administration or its equivalent, which grants licences to individuals or groups upon application. Statutory law and the individual licence define who can use a certain quantity of water and under what conditions, or alter (impact on) the quality or characteristics of a water course or adjacent land in the catchment. The licence is generally limited in time and place and is withdrawable under certain circumstances. Some places allow licences to be traded on a market. Australia embarked on a major reform to decouple water access entitlements and allocation rights from land ownership in 2004. The

government spent the equivalent of about USD 2 billion to purchase private water rights to increase river flows. Legislators elsewhere should study this example of a proven way forward.

Box 4. Acknowledging women's role in water and food security

Moa Cortobius, SIWI

Traditionally domestic water management falls under women's responsibility. However, women also participate in water management for agriculture. Yet, women often face multiple constraints to equal participation and influence in water-related projects and governance, as well as in gaining access to water for irrigated agriculture. It is widely recognized that women's empowerment is important as a means of reducing poverty and food insecurity, particularly in poor rural areas. The 1992 Dublin Statement on IWRM listed the role of women in one of its four principles. Women's secure access to water and land was also widely perceived as central in the efforts to achieve the MDGs, in particular Goal 1 (IFAD, 2007). Yet, it has proven hard to change male-biased policies and practices in ways that are consistent, coherent and persisting.

Increasing women's contribution to food production and food security is challenged by their lack of access to the key agricultural resources – land, water, labour, economic resources (such as credits) and infrastructure. Today rural women produce the majority of global food, especially home production, yet they own between 10 and 20 percent of the land. This is mainly a consequence of discriminatory statutory and/or customary laws preventing women from inheriting or owning land. Since water rights largely depend on land titles, women have much less access to water for irrigation and rely on rainfed agriculture. Consequently, women are harder hit by climatic change than men; when precipitation becomes more irregular it has a strong negative effect on their possibilities to maintain continuous food production (CEDAW, 2013).

Urban and rural women's needs, control and access to resources and services vary greatly. By and large rural women are disadvantaged in comparison to rural men and urban men and women. Rural women have also benefitted less from the progress towards the MDGs (UN Inter-Agency Task Force on Rural Women, 2012; CEDAW, 2013). Age, ethnicity, cast/religion, class and abilities are examples of other characteristics that affect women's needs, control and access to resources and services (Kabeer, 2010). Globally, indigenous peoples have their human rights – including that of access to safe water for consumption and for maintaining livelihoods – violated to a much larger extent than other groups (de Albuquerque, 2011; IWGIA and Tebtebba, 2014). Indigenous peoples are overrepresented among

the world's poor, constituting approximately 5 percent of the global population but 15 percent of the global poor (IFAD, 2009). They also tend to suffer to a larger extent from multiple dimensions of poverty, such as under-nutrition, higher child mortality, overall poorer health and shorter life expectancy (Eversole, 2005).

Indigenous women in particular face multiple structural barriers when it comes to leading healthy and dignified lives. Nonetheless, indigenous women frequently hold traditional knowledge related to agricultural practices and the use and storage of traditional seed types and crops. Since their production generally is focused on home farming they tend to preserve local varieties, which often are more resistant to plagues, seasonal variations and climate changes than cash crops. Women also tend to focus their production on multipurpose crops; improving the household's overall access to food and other resources for own consumption and local markets (WWF et al., 2005).

Even if women's contribution to food production and security is substantial it is often not considered in programmes directed towards the agricultural sector. Frequently, capacity building and direct investments target the heads of households, which generally is the man. Yet, as the World Bank showed in a study in Kenya, the head of a household is not always the primary farmer. Many times women manage the farm while the men migrate to access paid work elsewhere. Therefore, when investments are directed to heads of households they run a great risk of not benefitting the person responsible for the food production and, therefore, not have the intended impact (Torkelsson, 2012).

The lack of reliable gender-disaggregated data is one of the challenges that have prevented the role of women in food security from being acknowledged. Without disaggregated data, the status, situation and contributions of women in informal employment and agriculture remain invisible and undervalued (ILO, 2014; CEDAW, 2013).

5. Trade in food is also trade in water

Although most food produced in the world is demanded in the countries where it is produced, exports and import increase rapidly. Countries depend on a functioning global food trade system. While this increasing interdependence has moved countries and regions closer it has also induced a level of uncertainty. Trade enables countries that are water stressed to achieve a certain degree of food security. This is also something that has been addressed as a strategic priority from a geopolitical perspective. The stability of the MENA region is connected to a reliable import of foodstuffs. The water that has been traded in the shape of food – virtual water – since the 1970s has decreased tensions over water (Allan, 1998).

When Egypt imports 1 kg wheat it means that Egypt has imported 1,000 L of water (www.waterfootprint.org). When Jordan imports 1 kg of rice from South Asia, it has added between 2,500 and 4,000 L of water to its water budget. Trade implies a massive resource transfer not only of water, but also energy and other inputs in food production. For countries that lack both energy and water the ability to access these resources through the import of food is very important. For water short countries that are poor also in economic and strategic terms, the predicaments remain (cf. Gaza in Figure 2).

As Hausman and Patrick (2013) note, there will always, and increasingly so, be a need for trade in food since water is unevenly distributed on the planet. To make matters worse, it is often in the water short areas that population growth is most significant. About 90 per cent of the population growth during the next 40 years is expected to occur in Asia and Africa where the per capita water availability is a fraction of that in many other regions (ibid.).

Trade in food is, however, not a panacea for all regions. Physical restrictions and administrative/political barriers cause considerable problems. 'Barriers' refer to the trade of food and other commodities that are produced. It also refers to trade and access to inputs for the efficient production. For instance, farmers in Africa have difficulties accessing the best seeds and the price of fertilizer is often quite high (World Bank, 2012). Outdated regulations and lack of coordination between small countries concerning imports and deficiencies in transport and storage are well-known barriers to trade. On top of these barriers, social and cultural norms add to the poor performance of food systems and, indirectly, water use. In Africa, most of the traders in food are women while border officials are men who routinely ask for bribes and cause other kinds of harassment. As a result of the combination of physical, administrative and social barriers, only about 5 per cent of Africa's import of cereals comes from other African countries

although the potential for regional trade is much bigger (ibid.).

Growing markets for food present opportunities for export and import. However, the social 'fabric' in many of the food importing countries does not lend itself easily to the import of food, while the opportunity to increase local and regional production is circumscribed.

Many of the countries lacking water, and sometimes land and energy resources, for sufficient domestic food production also have a high proportion of their labour forces in agriculture. Thus the social stability in this category of countries is dependent on a continuation of their employment in the agricultural sector.

Even if some of the workforce can be moved into other sectors within the national economy, many food and water deficit countries simply lack diversified economies (Allan, 2011). Such a lack of diversification relates to education, the institutional arrangements, openness to innovation, private sector development and social mobility. These aspects are culturally embedded in a society and take a long time to change. In industrialized countries the move from mainly agrarian to economic diversification took decades.

The inability to increase regional and local production of food is something that is not easily admitted publicly by politicians. In the MENA region as well as in parts of Asia and Africa, food self-sufficiency is often highlighted as an ambition in the rhetoric of politicians while in reality their countries are already heavily dependent on food imports (Jägerskog, 2003). As shown by Larson (2013), the cost of increased food self-sufficiency is very high and would easily double the demand for water in the MENA region,

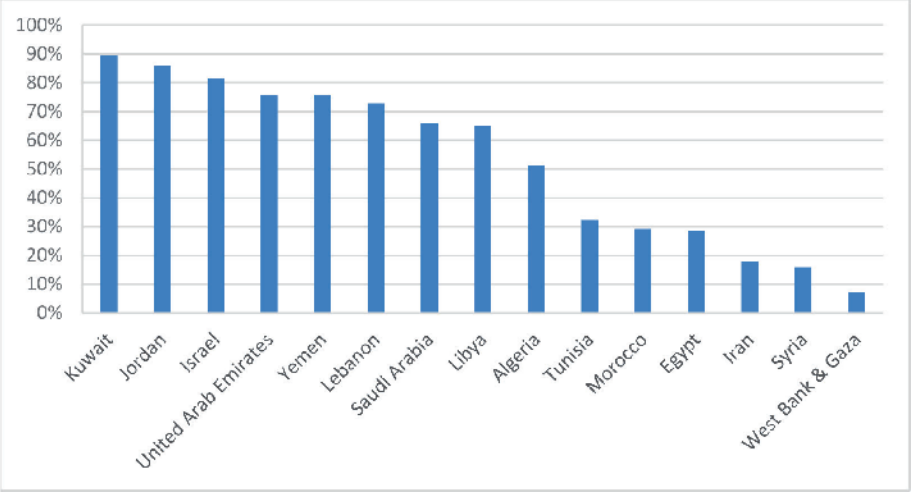


Figure 2. Ratio of water imported to total water for national use (per cent) 1996-2005. (Figure based on Mekonnen and Hoekstra, 2011).

something that is highly unrealistic. Nevertheless, this shows how political food and water are in certain parts of the world.

The limits to trade in agricultural produce – perceived or real?

Despite the largely positive effects of increased globalization of the food market and efforts to integrate regional markets for food there are challenges. Trust and predictability need to be vested in the markets. If states do not trust the regional and international markets, increased focus on food self-sufficiency is likely. Thus, in the current state of increasing global and regional instability, conflict and insecurity, the dependence is increasingly questioned. Countries simply want to have more control and not face the risk of being affected by sudden export restrictions in other countries, increased trade barriers or sudden fluctuations in the prices of food.

The surge in land acquisitions – a surge in water acquisition

Investments in foreign land have been undertaken by private investors seeking profits, state-owned companies and sovereign wealth funds. The motivation for China, India and the Gulf countries has been to increase food security for themselves. In the Gulf region the states have been highly dependent on food imports (cf. Figure 2). The food price crisis of 2008-2009 and the export restrictions in food producing countries, exposed the vulnerability of the strategy for food security in many countries (Evans, 2009). In the aftermath of this food price crisis an increase in land investment abroad was noted (Jägerskog et al., 2012; Jägerskog and Kim, 2015). These land acquisitions ('land grabs') have to a large degree occurred in Africa, but have happened in parts of Asia and Latin America as well. While they are by no means a new event, the motivation behind them and the extent and speed with which the deals are happening is new. Global markets for food trade are not seen as trustworthy and conflicts and instability threaten to disrupt ordinary trade.

For China, which needs to feed an increasing population with a limited amount of arable land, water management challenges relating to quantity as well as quality are paralleled by an increase in demand for more water-intensive foodstuff. This is presenting a new range of challenges (Liu et al., 2013). While China has managed to significantly reform its agriculture and increase output during the last decades, in 2004 it became a net importer of food. Lack of arable land, water shortages and changing diets (more meat and dairy based) are all causing China to look increasingly outward for its food security.

It is clear that the countries investing abroad in land for the production

of food regard this a *risk mitigating* strategy. A higher degree of control can thus be achieved over your own food security than a stronger reliance on the global food market. At the same time companies see the same situation as a business opportunity (Jägerskog and Kim, 2015).

Jordan. Construction of a dry wall to protect cultivated land from water erosion.
© FAO/Roberto Faidutti.

The Middle East as a case in point – water cooperation possible in spite of all challenges

It was widely believed that shortages of water for food production – notably in the MENA region – would be a major source of conflict and even cause wars between countries (Starr, 1991; Bulloch and Darwish, 1993)[13]. This conclusion assumed that unless a country had enough water to produce the food it needed the state would look into options – including war – for increasing its water availability. This assertion is underscored by bellicose statements from rulers in the Middle East region (Jägerskog, 2003).

Although food self-sufficiency is unrealistic in many parts of the world, it still forms part of the discourse in the MENA region. Allan (2011) pointed to the fact that while Egypt had "run out of water for food self-sufficiency" no major conflict can be associated with water scarcity. When analysing the trade of Egypt and the whole MENA region it was evident that since the 1970s the imports of food grain, wheat and other key crops had gone up significantly (Figure 4) with potential geopolitical and strategic implications. Primarily Egyptian imports had been coming from the US, but Russia is also a major source of food for Egypt and the region, something which was painfully noted during the food price crisis in 2008 when Russia decided on export barriers.

Since 1994 Israel and Jordan have had a peace agreement in which water is a central part and between Israel and Palestine water is addressed in the Oslo Declaration of Principles (Jägerskog, 2003). However, between Israel and Palestine the cooperation is not one characterized by equality and a fair sharing of the water resources, but is rather dominated by Israel (Selby, 2013). Given that trade in virtual water has reduced tensions over water resources, it is apparent that the power asymmetries that exist are affecting the quality of the cooperation. Zeitoun and Warner (2006) note that the hegemons in a basin seek to reserve as much of the water as possible for themselves, which leads to inequitable outcomes. In most basins, the issue is rather how conflict and cooperation are happening at the same time (Zeitoun and Mirumachi, 2008). At the sub-national level conflicts over water can become more violent with, for example, pastoralists clashing over limited amounts of water.

[13] For an overview of this discussion see Jägerskog et al., 2014.

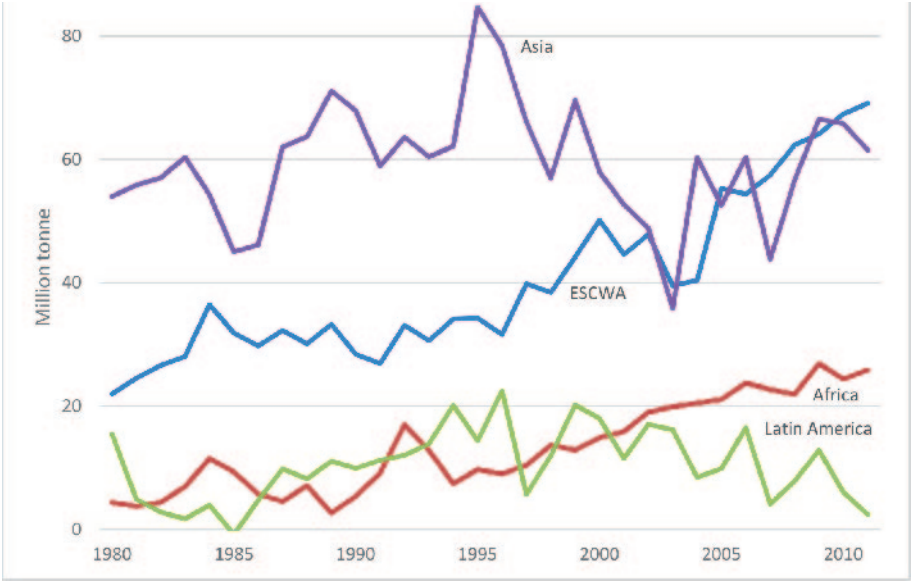


Figure 3. Cereal trade (million tonne) globally and in the western Asia region, ESCWA, 1980-2011. Source: Klingbeil and Byiringiro (2013).

It is clear that the import of food/virtual water to the MENA region has served as an ameliorating factor and has helped the region to avoid conflicts over water. There are still political conflicts over water, but they seldom become violent.

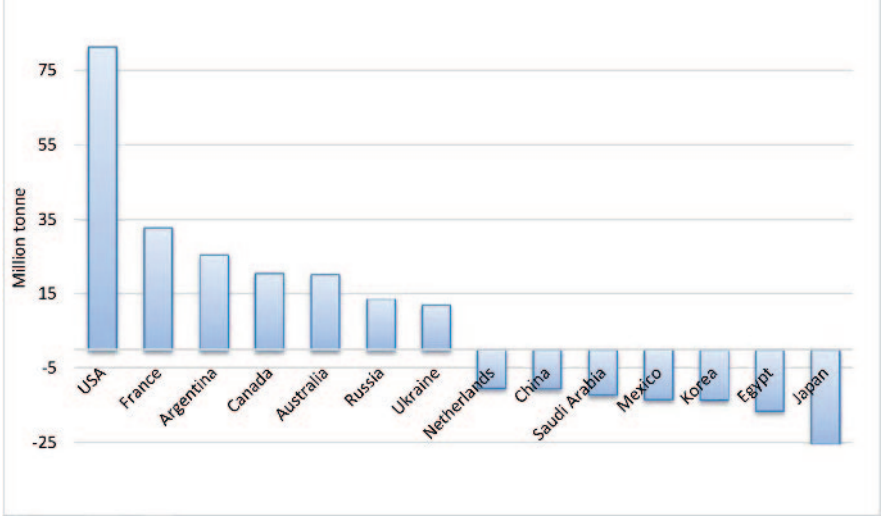


Figure 4. Net cereal trades (million tonne) by country, 2010. Source: Klingbeil and Byiringiro (2013).

Even with the import of food into the region, many countries maintain unsustainable use and management of their water resources. In Palestine –the Gaza Strip, particularly – far too much water is pumped from the groundwater aquifer in relation to the rate of replenishment. This leads to a severe degradation in quality as a result of salt water intrusion in the aquifer. In Libya, Saudi Arabia and partly in Jordan fossil groundwater is pumped for use in agriculture and other sectors (cf. Chapter 2).

While cooperation over water is possible it is also noted by seasoned commentators of the MENA region that the environment is making important inroads into the strategic thinking in the region. Friedman (2013) notes that while many conflicts in the MENA region still follow along sectarian lines the geopolitical implications of the poor management of nature. As put in Box 5 below: "They have no choice: too many people, too little oil, too little soil".

Box 5. Mother Nature and the Middle Class

Thomas L. Friedman, New York Times[14]

> If you fell asleep 30 years ago, woke up last week and quickly scanned the headlines in Iran and Egypt you could be excused for saying, "I didn't miss a thing." The military and the Muslim Brotherhood are still slugging it out along the Nile, and Iranian pragmatists and ideologues are still locked in a duel for control of their Islamic Revolution.
>
> So go back to sleep? Not so fast. I can guarantee that the next 30 years will not be the same old, same old. Two huge new forces have muscled their way into the center of both Egyptian and Iranian politics, and they will bust open their old tired duopolies.
>
> The first newcomer is Mother Nature. Do not mess with Mother Nature. Iran's population in 1979 when the Islamic Revolution occurred was 37 million; today it's 75 million. Egypt's was 40 million; today it's 85 million. The stresses from more people, climate change and decades of environmental abuse in both countries can no longer be ignored or bought off.
>
> On July 9, Iran's former agriculture minister, Issa Kalantari, an adviser to Iran's new president, Hassan Rouhani, spoke to this reality in the Ghanoon newspaper: "Our main problem that threatens us, that is more dangerous than Israel, America or political fighting, is the issue of living in Iran," said Kalantari. "It is that the Iranian

[14] Reprinted with kind permission from the New York Times.

plateau is becoming uninhabitable.... Groundwater has decreased and a negative water balance is widespread, and no one is thinking about this."

He continued: "I am deeply worried about the future generations.... If this situation is not reformed, in 30 years Iran will be a ghost town. Even if there is precipitation in the desert, there will be no yield, because the area for groundwater will be dried and water will remain at ground level and evaporate." Kalantari added: "All the bodies of natural water in Iran are drying up: Lake Urumieh, Bakhtegan, Tashak, Parishan and others." Kalantari concluded that the "deserts in Iran are spreading, and I am warning you that South Alborz and East Zagros will be uninhabitable and people will have to migrate. But where? Easily I can say that of the 75 million people in Iran, 45 million will have uncertain circumstances.... If we start this very day to address this, it will take 12 to 15 years to balance."

In Egypt, soil compaction and rising sea levels have already led to saltwater intrusion in the Nile Delta; overfishing and overdevelopment are threatening the Red Sea ecosystem, and unregulated and unsustainable agricultural practices in poorer districts, plus more extreme temperatures, are contributing to erosion and desertification. The World Bank estimates that environmental degradation is costing Egypt 5 percent of gross domestic product annually.

But just as Mother Nature is demanding better governance from above in both countries, an emergent and empowered middle class, which first reared its head with the 2009 green revolution in Iran and the 2011 Tahrir revolution in Egypt, is doing so from below. A government that just provides "order" alone in either country simply won't cut it anymore. Order, drift and decay were tolerable when populations were smaller, the environment not so degraded, the climate less volatile, and citizens less technologically empowered and connected.

Both countries today need "order-plus" — an order that enables dynamism and resilience, and that can be built only on the rule of law, innovation, political and religious pluralism, and greater freedoms. It requires political and economic institutions that are inclusive and "sustainable," in both senses of that word. Neither country can afford the old line that Hosni Mubarak used for so many years when addressing American leaders: "After me comes the flood, so you'd better put up with my stale, plodding but stable leadership, otherwise you'll get the Muslim Brotherhood."

That is so 1970s. As Karim Sadjadpour, an Iran expert at the Carnegie Endowment, puts it: In the Middle East today "it's no longer 'After me, the flood' — Après moi, le déluge — but 'After me, the drought.' " Syria's revolution came on the heels of the worst drought in its modern history, to which the government failed to respond.

Iran's Islamic leadership seems to realize that it cannot keep asking its people to put up with crushing economic sanctions to preserve a nuclear weapons option. Mother Nature and Iran's emergent middle classes require much better governance, integrated with the world. That's why Iran is seeking a nuclear deal now with Washington.

And that's why two of the most interesting leaders to watch today are President Rouhani of Iran and Egypt's new military strongman, Gen. Abdul Fattah el-Sisi. Both men rose up in the old order, but both men were brought into the top leadership by the will of their emergent middle classes and newly empowered citizens, and neither man will be able to maintain order without reforming the systems that produced them — making them more sustainable and inclusive. They have no choice: too many people, too little oil, too little soil.

And pay attention: What Mother Nature and these newly empowered citizens have in common is that they can both set off a wave — a tsunami — that can overwhelm their systems at any moment, and you'll never see it coming.

Ethiopia. Community members renovating a hand dug well. FAO-EU Project – Immediate support to agro-pastoral communities as a drought mitigation response.
©FAO/Giulio Napolitano

6. Fresh water thinking: opportunities and new combinations

The nexus: water and energy

Most food is produced in the open landscape where huge volumes of water return to the atmosphere through transpiration and evaporation. Compared to production, the amounts of water used in connection with transport, storage and processing and also the amounts of water used for cooking and food preparation by the consumers are insignificant.

Figure 5 shows how the use of water and energy in food systems differ. About 20 per cent of the total energy consumed in food systems applies to the production of crops, livestock and fisheries (FAO, 2011c). In contrast to water, most of the energy use occurs after the farm gate, with a relatively large part being used by consumers. It is interesting and relevant to note that the commodities produced by agriculture may contain several times more energy as comparted to the input of energy in production[15]. The FAO study

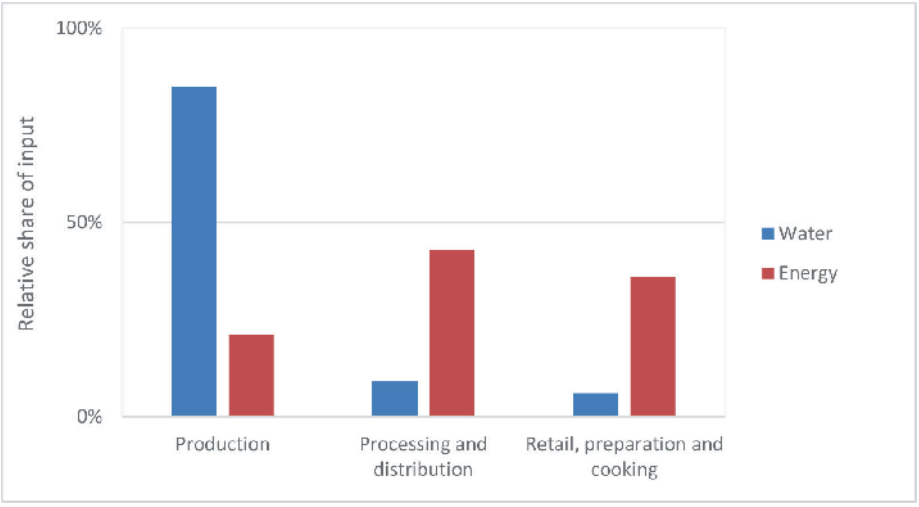


Figure 5. Schematic presentation of water and energy inputs in the main segments of the food supply chain. Bars illustrating energy consumption are based on FAO (2011c) while figures on consumptive water use, the blue bars, are readily available in literature.

[15] For Sweden, it is e.g., estimated that the food produced contains about nine times more energy as compared to the input of energy in production (personal communication, Serina Ahlgren and Annika Åhnberg).

(ibid.) estimates energy consumption 'from field to fork' at around 32 per cent of the total global end-use of energy. The energy use pattern is about the same for high and low gross domestic product countries.

These estimates imply that the energy used for food production is around 6 to 7 per cent of total global energy use while the consumptive use of water in food production is significantly much higher. Efforts to improve energy use efficiency in food production may thus have limited effects on total energy use in food systems whereas efforts to improve water use in production could make a lot of difference (Lundqvist et al., 2015; 2030 WRG, 2015).

Synergies and trade-offs in the nexus

The discussion above illustrates the links between water and energy. As elaborated in Box 6, development and use of water and energy in food production and in other sectors involves both synergies and trade-offs.

Box 6. Wrapping our heads around complexity: the water–energy–food nexus at FAO

Olcay Ünver, Jean-Marc Faurès, Olivier Dubois and Lucie Pluschke, FAO

In agriculture, the water–energy–food nexus is particularly important. Land and water are needed for crop production, for livestock and fisheries, for forestry, and, in the case of water, along the entire agro-food supply chain, food preparation and for the production and transport of energy (FAO, 2011b). Additionally, energy is required to produce, transport, distribute, store and prepare food as well as to extract, pump, lift, collect, transport and treat water (FAO, 2011c). Cities, industries and other users claim increasingly more water, energy and land resources.

Agriculture is only one sector of many that uses natural resources and even here there are different, sometimes competing, claims. This can result in trade-offs and increased competition for resources, but may also provide opportunities to rethink current practices, policies and governance arrangements and to identify synergetic uses across sectors.

This topic was addressed during the 24th session of the Committee on Agriculture, FAO's main technical advisory committee, when FAO's programme on 'Water Governance for Agriculture and Food Security' was approved, specifically mentioning the water–energy–food nexus. Backed by member states, FAO has since developed its own conceptual approach to the water–energy–food nexus (Figure 6). The approach distinguishes between the resource base and the different goals and interests that are to be achieved with the same, but limited resources. It is about

understanding and managing these different resource user goals and interests, while maintaining the integrity of ecosystems. For that, FAO has identified three areas of work through which it can contribute. These are by providing evidence, by developing scenarios and by designing and appraising response options.

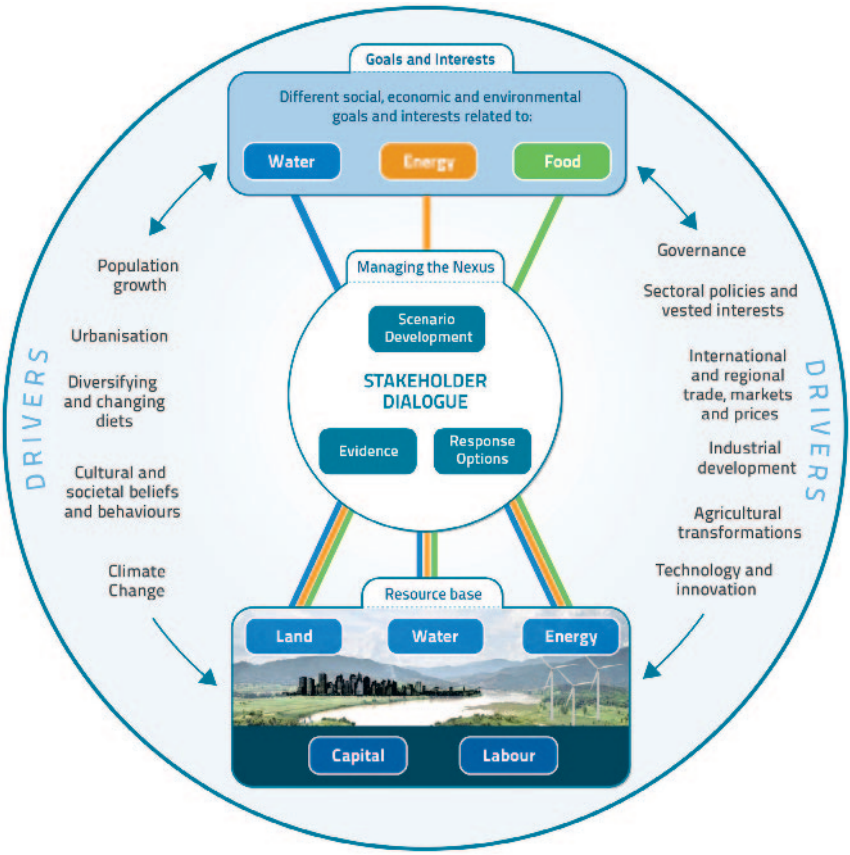


Figure 6. A conceptual diagram of the FAO approach to the water–energy–food nexus

Evidence is needed to inform and substantiate discussions on future scenarios and responses. Scenarios provide ways to explore the potential impacts of different responses. None of this can be done in isolation, but only in dialogue with stakeholders.

1) **Evidence.** Reliable, relevant and timely data and analysis of key issues is needed. FAO works to provide data, tools and methods to analyse the current state and use of natural resources, trends and variability. As part of this, FAO has developed a nexus assessment methodology which allows:

- Assessment of context
- Assessment of the nexus performance of interventions
- Comparison of interventions in terms of their performance.

FAO also seeks to better understand the implications of drivers for demand structures and resource use. What are the impacts of urbanization processes on land use and ownership, and how do these affect water–energy–food security?

2) **Scenario development.** Scenarios can be useful to explore strategic questions, to review policies and investment decisions, and to create common ground and improved understanding of the interrelations between water, energy and food.

In Central Asia, FAO is working with the riparian countries of the Syr Darya Basin to develop a shared vision for its development (FAO, 2012a). During the Soviet era, upstream dams were collecting water in the winter to be released for irrigation during the summer months. In exchange, downstream countries were supplying energy upstream. After the disintegration of the Soviet Union, the riparian countries started to pursue their own national strategies for the use of the water resources of the river, mainly for hydropower production and irrigation. Energy-rich countries started selling their oil and gas in international markets at prices that the energy-poor countries could not afford. Unable to buy energy regionally, the energy-poor countries upstream started to release water in the winter to produce hydropower when it was most needed. This resulted in flooding downstream in the winter and water shortages in the summer. During the scenario exercise, country participants sat together to discuss how their different goals and interests could be achieved, taking into account resource constraints in the river basin. The scenario-thinking approach helped them move away from narrow problem definition to an open and highly participatory debate about the complex structure of the water–energy–agriculture nexus in Central Asia.

3) **Response options.** FAO can play an important role in planning, implementing and evaluating response options. These options include policies, investment decisions, regulations and incentives, capacity development and training, and technical interventions.

- What are the implications of policies and planning across sectors? If a decision is made at the national level to increase the share of bioenergy in Ghana, what implications does this have for water, land and energy? How do electricity subsidies for solar irrigation in Karnataka, India contribute to groundwater depletion and what can be done about it?

- What sorts of investments are needed to support the synergetic use of resources across sectors? Good example of this are investments in multiple-use water supply systems that support different user needs, improving people's access to and effective use of water resources.

- How can we effectively manage demand, so that fewer resources are wasted? Many valid sector approaches exist for the development of sustainable food and agriculture and there is a great need to find solutions within sectors by improving water use efficiency. At the same time, we need a shared vision and effective mechanisms to deal with cross-sector issues.

Many examples show that there is an increasing competition for limited amounts of energy and water as a result of demographic and socioeconomc trends. One case refers the challenges to use parts of limited supply of energy for lifting groundwater in India (Box 7).

Box 7. Energy and groundwater in India[16]

In India, the water–energy–food policy framework is a perfect storm of non-integrated components. Since colonial times, landowners have not needed a licence to pump groundwater, and some draw water from depths exceeding 300 m in hard rock, low-yielding areas. Groundwater for irrigation, high-yielding seed varieties and

India. Andra Pradesh Farmer Managed Groundwater Systems Project.
© FAO/Noah Seelam.

[16] This box draws from Grönwall (2014).

chemical fertilizers were the keys to the country's Green Revolution and resulting self-sufficiency in food grains. Since then, groundwater irrigation has lifted millions of people out of poverty. Ever-cheaper and more powerful submersible pumps have enabled small-scale farmers to cultivate cash crops, and intensify their output regardless of season and monsoon rain predictability.

The links between groundwater, energy and food were firmly established in the 1960s when electricity to the agricultural sector was subsidized as part of a rural electrification programme. Irrigation pumping is often free, or charged for at a low, flat rate per unit. Today, at least half of India's irrigation pumps – about 20 million – rely on electricity. The cheap access to groundwater has been of vital importance especially for small and marginal farmers, as large landholders are more often connected to surface water irrigation schemes. Subsidies for diesel were phased out over about two years and finally removed in October 2014.

However, electricity subsidies contribute significantly to unsustainably increasing power consumption, resulting in load shedding that disrupts household life and production and requiring costly maintenance. There is also a clear connection between free or cheap energy and a drastically lowered groundwater table in many parts of the country. Furthermore, the build-up in subsidies is contributing to India's fiscal deficit. For decades pressure has increased to abolish/reform the system while ensuring that poor and marginalised farmers still benefit from better-targeted assistance.

The Indian Planning Commission has recently emphasized the need to restrict electricity access for competitive pumping between tubewell owners, while other rural users need to be served at an increasing rate. Incentives and disincentives must be applied in a coherent manner, unconventional solutions tried and uncomfortable decisions made. Amendments to the favourable water rights (permit) system and/or electricity tariffs policy are perpetually unpopular in the eyes of elected and aspiring politicians in need of votes from the very large farmers' community. In addition, the transaction costs of controlling compliance among tens of millions of dispersed and uncooperative farmers – and potentially corrupt meter reading staff – are seen as prohibitive.

Rationing of the rural electricity supply, to effectively restrict irrigation pumping, has been tried unsuccessfully in several places. It encourages irrigators to circumvent the regulations at all cost while impacting negatively on rural life in all other respects. In order to reverse the negative trends, several Indian states have attempted to design programmes for rural electricity segregation whereby separate feeders provide power to agricultural and non-agricultural consumers.

The most interesting example is the Jyotigram scheme in Gujarat, western India. Besides coming to grips with electricity load management, the Jyotigram was planned to reduce groundwater extraction. Over a ten year period, the scheme's measures were fine-tuned. They involved extensive education of the power distribution companies' staff to instil a sense of accountability, and installation of advanced technical components to hinder tampering with cables. It became necessary to deploy 500 retired army men to restrain farmers who were not inclined to conform to the new rules.

Through Jyotigram, Gujarat State managed to curb energy transmission and distribution losses and flatten peak demand for electricity. However, the results are inconclusive as the areas under irrigation seemed to decline for two very different reasons. Some farmers chose to convert to alternative, non-agricultural income generating activities when radically improved access to electricity in the villages so allowed. Others were adversely affected when the power rationing meant decreased access to groundwater using electrified tubewells. Many moved away from cereal crops to high-value crops, like Bt cotton, tobacco, orchard and commercial crops, and dairy products, to maximise the economic value per drop of water. Moreover, farmers have found new ways around the rationing. Technical and economic advances have made it possible to install more powerful pumps in ever-deeper wells.

For a long time, legislation on groundwater conservation had been regarded as impractical to implement among such a large number of dispersed well-owners, and the law-makers in Gujarat chose instead to strengthen the energy legislation and attach forceful means of coercion. With the advanced technologies devised by the implementing agencies, and many farmers' ways of out-smarting those, the end result may be a zero-sum game. However, if replication elsewhere of Gujarat's recipe for intelligent rationing is attempted, the outcome may be that more farmers opt for or feel forced to choose other income activities. If more farmers simultaneously convert to non-cereal crops, like tobacco and cotton, the end result may be an unintended blow to food security.

Jyotigram is the best starting point for learning about nexus issues in India, but the programme needs tweaking and complimentary measures may be applicable elsewhere in the country. Gujarat's experience contains an important reminder that political will to effect change is insufficient when it is not combined with skills in judging and balancing the outcomes of policy decisions in a complex reality marked by resource deficits, unpredictability and power struggles. The state has witnessed projects for the encouragement of drip-irrigation, checkdams, percolation tanks and recharge wells to arrest the negative groundwater development.

Intensified production, resilience and sustainable diets

Feeding a world population that is still growing and where more people enjoy higher disposable income while about a billion people are still poor requires a combination of approaches. An intensification in production is necessary, as is a new direction for agriculture as elaborated in Box 8.

Box 8. Sustainable agricultural intensification

Andrew Noble, CGIAR Program on Water, Land and Ecosystems, IWMI

The Comprehensive Assessment of Water Use in Agriculture (CAWMA, 2007) cogently argued that a business-as-usual approach to water use in agriculture is no longer tenable. Not if we are to feed a world population of 9 billion by 2050, which most likely will reach 11 billion by 2100 (Gerland et al., 2014). Others have expressed concerns regarding the loss of arable land from land degradation including salinization, decline of soil structure and erosion, biodiversity decline and urbanization (Nelleman et al., 2009). There is agreement that a global food revolution based on a new paradigm for agricultural development is urgently required. Without this shift, we are unlikely to feed humanity and live within boundaries that define the safe operating space with respect to the planet's biophysical processes (Rockström and Karlberg 2010). Agriculture is at the heart of this challenge, both as the world's single largest driver of global environmental change (Tilman et al., 2001; Foley et al., 2005; Godfray and Garnett, 2014) and as its first victim (IPCC 2014).

There is growing consensus that it is no longer enough to enhance agricultural productivity alone; environmental impacts from agriculture must be reduced or addressed (Conway 1997; Godfray and Garnett 2014). There is a growing body of evidence suggesting that even this is not enough. Instead it is now necessary to add two additional dimensions to agricultural development:

- To manage land, water and ecosystems in ways that enhance resilience at field, watershed and regional scales to deal with more frequent multiple shocks

- To secure its long-term viability by ensuring that agricultural impacts on Earth system processes are minimized, to avoid disrupting the Earth system.

It has been argued that a shift to sustainable agricultural intensification (SAI) will in part respond to the challenges of food security, but there is no consensus on what constitutes SAI (Conway and Waage, 2010; Godfray et al., 2010, Rockström and Karlberg, 2010; Tilman et al., 2011; Pretty et al., 2012; Garnett et al., 2013; Godfray

and Garnett, 2014). The emerging view is that SAI is built around the principle whereby 'yields are increased without adverse environmental impact and without the cultivation of more land' (Royal Society, 2009). However, it may not go far enough in terms of the challenge of building a resilient agricultural system that can contribute to global development within a safe operating space of a stable and resilient Earth system. It is argued that a comprehensive definition of sustainable intensification should be based on the Earth system processes that regulate the resilience of the Earth system, and operate within the planetary boundaries that scientifically provide a high probability of safeguarding stable environmental conditions. A comprehensive set of criteria that constitute the safe operating space were quantified by Rockström et al. (2009) and although these may be subject to adjustments (Rockström and Karlberg, 2010), they form the basis of a framework in which SAI could sit and contribute to.

Adopting these comprehensive criteria for sustainable agriculture, would constitute a basis for defining the key attributes of SAI and meet the twin objectives for people and planet. The 'human goal' now proposed by the UN Secretary General's synthesis report on the SDGs, is to eradicate hunger and poverty by 2030 [which will require a greater than 50 per cent increase in food production]. The global sustainability goal required will be to achieve this within a safe operating space of a stable and resilient Earth system. Together, these integrated goals translate to the necessity for a new double green revolution within very ambitious targets for sustainability that in principle require:

- Very low or zero expansion of agriculture into natural ecosystems
- Zero loss of biodiversity
- Drastic reduction in excessive use of nitrogen and phosphorus
- Major improvements in water productivity and water quality and the safeguarding of environmental water flows.

From these social-ecological criteria, emerges a clear definition of sustainable intensification – adopting practices, along the entire value chain of a global food system that meet rising needs for nutritious and healthy food through sustainable practices, which build resilience and operate within the safe operating space of planetary boundaries.

New opportunities and potential for combinations

With constrained possibilities to produce more from limited water resources,

it is important to explore the potential of 'new crops and new water' (Box 9). A combination of agriculture and inland fisheries is another option of significant relevance for hundreds of millions of people (see "Fish better than chips").

Box 9: New crops, new water: a grand challenge

The UN estimates that at least 1 billion ha of land is currently affected by salinity and the world loses at least 3 ha of arable land every minute as a result of salinization. In agricultural lands affected by high salinity, smallholder farmers realize lower-than-average yields and reduced incomes. In these regions, improving food production and creating new opportunities for earning a livelihood are desperately needed. In Pakistan, 4.2 million ha of land is salt affected. Farmers are frequently forced to use brackish groundwater to water their crops, which reduces overall yields and the quality of crops. The pressure on freshwater resources can be reduced and new livelihood opportunities created by making it possible to use lands and waters with human induced salinity.

Feeding the world in 2050 will be difficult unless the global community finds better ways to grow food with less water and makes more water available for the food value chain. To accelerate innovations that make more water available for food production, the Swedish International Development Agency (Sida), the US Agency for International Development (USAID), and the Ministry of Foreign Affairs of the Kingdom of The Netherlands (MFA-NL) have recently funded 17 game-changing ideas under the program *Securing Water for Food: A Grand Challenge for Development*[17].

Two non-genetically modified, salt-tolerant crops were among the initiatives selected for their high potential for transformative impact: a quinoa variety and a potato variety.

The quinoa variety, which not only grows, but thrives in saline soils, will be introduced in Chile, China, Viet Nam and Egypt. The potato variety, which is four times more salt tolerant than regular potato varieties, will be tested in Pakistan.

By making these high-value grain and potato available to farmers in areas affected by high salinity, there is the potential to reduce fresh water consumption, reduce food scarcity, reclaim unused or underused agricultural lands and create new livelihood opportunities for smallholder farmers affected by salinity.

A second call for proposals under the Securing Water for Food programme consists of the 'Desal Prize'. This prize encourages the creation of small-scale brackish

[17] http://www.securingwaterforfood.org

water desalination systems that can provide potable water for humans and water appropriate for crops in developing countries. The technical specifications require the innovations to be environmentally sustainable, powered solely by renewable energy and be cost efficient, durable and easy to maintain at the household farming level. There is a special interest in solutions that will enable the use of brackish groundwater in rural or remote settings.

Eight semi-finalists were selected to design, build and optimise prototypes embracing state-of-the-art technologies such as hybrid forward osmosis and brine evaporation for testing in Spring 2015 in New Mexico. The research group countries – Brazil, Jordan, India, Israel, Nepal, South Africa and USA – signal the breadth of the growing interest in the topic. Other countries with strong research and development in desalination include Australia, China, the MENA region, Singapore and Spain (see Chapter 1 on Salty water turned sweet).

Fish better than chips[18]

Nutritional food does not come only from the agricultural sector. For communities in Asia and the Pacific in particular, fish is a significant and crucial part of the diet, culture and livelihood. Paddy cultivation and irrigated agriculture often have positive synergies with fish cultivation. These synergies arise when water in irrigation canals and reservoirs is used for fish cultivation during certain times of the year – when the water and area are not used for crop cultivation (Needham and Funge-Smith, 2014). Human dependence on cultivated fish has grown and combinations of agriculture and fish cultivation are found in areas far inland from coastal locations (ibid.). Combinations of fish ponds and the use of water for irrigation represent a better use of water and labour, and enhance food and nutrition security. Additionally, small-scale capture fisheries are widespread in many regions and provide substantial inputs to food security and crucial micronutrients. In contrast to cultivation, capture fisheries are not dependent on the abstraction of water and are often overlooked in water management related fora. However, inland fisheries require water in sufficient quantity and quality, at the right time and with the right flow variations, in rivers, lakes, wetlands and estuaries (Welcomme and Petr 2004). This can lead to trade-offs with other water users. Water development for agriculture has direct and mostly negative consequences for fisheries (see Dugan et al., 2007).

Freshwater fish is a crucial source of protein, especially for the most poor and vulnerable people because it requires much lower investments compared to livestock production. At the beginning of this century, it

[18] This section is based on inputs from Dr. David Lymer, FAO

was estimated that about 1 billion people worldwide relied on capture and aquaculture fisheries as their primary source of animal protein (FAO, 2000). While freshwater capture fisheries have a negligible footprint on land and water, livestock is an important user of these resources. The replacement of freshwater fish protein by livestock protein would be accompanied by environmental costs. To replace the potential loss to capture fisheries from proposed dam construction in the lower Lower Mekong Basin countries with livestock protein would lead to substantial increases in water and land use elsewhere, especially for Cambodia (Orr et al., 2014; Lymer et al., 2015).

Changes in food production patterns have important implications for GHG emissions and carbon, nitrogen and phosphorus cycles. Livestock make a significant contribution to GHG emissions, while functioning aquatic ecosystems might even mitigate these effects. Hence replacing protein production from capture fisheries with that from livestock will increase GHG emissions.

Globally, the yield from inland capture fisheries is estimated at 11.6 million tonne (FAO, 2014b). However this figure is an underestimation of the actual catch. Production from small-scale fisheries, which employ 90 per cent of the people involved in inland capture fisheries, is often not recorded in official catch records. It has been estimated that the actual catch is at least twice as high (Mills et. al., 2011) and hence the contribution to food security and nutrition is much higher than official figures reveal. Additionally, recreational fisheries are seldom recorded in official catch records (Cooke and Cowx, 2004). Sweden's official inland water catch (as reported to FAO) was 1,644 tonne in 2006, whereas the estimated catch from inland water recreational fisheries for the same period was 9,369 tonne.

Using the official, and underestimated, data it is projected that freshwater capture fisheries provide income and nutrition for hundreds of millions of people worldwide (FAO, 2014b). The dependence on functioning freshwater ecosystems and the transfer of energy from mainly primary production to higher trophic levels is crucial. The major existential external threats to freshwater fisheries are environmental changes, degradation and loss of freshwater ecosystems (FAO, 2011d), and loss of access to them. Inland fisheries are especially important in landlocked countries in the developing world, where they can provide an important source of protein. Also countries with significant coastlines, such as. Bangladesh, Cambodia, Kenya, Nigeria and Tanzania, are highly dependent on large inland systems for their fish supply (UNEP, 2010). Africa (23.3 per cent) and Asia (68.4 per cent) accounted for over 91.6 per cent of the reported inland fish catch worldwide in 2012 (FAO, 2014b).

While inland fisheries are a critical food resource, especially in much of the developing world, management of agricultural, water and investment policies

are often at odds in maintaining their long-term sustainability. (See Box 10 concerning the Mekong Basin.) It is important to ensure that governance decisions take into account the contribution inland fisheries make to food security, human well-being and ecosystem productivity by promoting cross-sector and cross-jurisdiction governance approaches.

Box 10. Opportunities to mitigate risks in food security in the Mekong Basin

Kyungmee Kim, Uppsala University and SIWI

> The Mekong Basin has the most intensive and productive freshwater in the world. According to the Mekong River Commission (MRC) Secretariat, total catches and production from Mekong fisheries (including aquaculture) amounted to about 3.9 million tonne in 2008. Of these, about 2 million tonne were from capture fisheries. In the Lower Mekong countries, eating freshwater fish is widely accepted and sometimes preferred in the food culture. Fish is an important source of protein that

Laos. Fishermen ply their trade at sunset in southern Laos on one of the many tributaries of the mighty Mekong River. ©FAO/P.Johnson

accounts for 50 per cent of the total protein supply in Cambodia, 38 per cent in Lao PDR, 16 per cent in Thailand and 12 per cent in Viet Nam; all much higher than the world average of 5 per cent (FAOSTAT, 2003).

The Mekong Basin offers significant opportunities to develop hydropower potential from its mainstream and tributary rivers. The hydropower development project in the Mekong Basin is viewed as one of the primary engines of economic growth for the countries in the Lower Mekong Basin (Öjendal et al., 2002). The hydropower potential from the mainstream Mekong is 31,200 MW per year (Bakker, 1999, p. 214). According to the Strategic Environmental Assessment of the planned mainstream hydropower dams, planned dams impose high risks to the fisheries and agricultural productivity by negatively affecting fish migration, creating disturbances in fish habitats and reducing sediments and nutrients (ICEM, 2010). Researchers, NGOs and civil society actors actively addressed the concerns over the risks imposed to the food security and livelihoods of local communities for the first mainstream hydropower dam in the Lower Mekong Basin (Vrieze, 2011). The scientific evidence and research results have contributed to the enhanced dialogues and awareness raising on the trade-off between hydropower development (energy) and fisheries (food). The MRC Secretariat has contributed to strengthening the knowledge and dialogue around the hydropower decision-making processes, but the intergovernmental process on planned measures, including dams on the mainstream, has been limited to voluntary consultation that has no jurisdiction over national decision-making.

Despite the challenges at the transboundary decision-making level, a number of actors worked on mitigating the risks to food security at national and local levels. Important aspects to improve food security in the Lower Mekong Basin include building local capacity to produce, store and trade food as well as improving community management of natural resources. Rice paddy fisheries from seasonally inundated rice-fields and adjacent canals and ponds constitute a valuable source of food. Promoting sustainable intensification can benefit the production of fish and other aquatic animals by the reduced use of pesticides (Silva et al. 2013). Introducing Community Fish Refuges (CFR)[19] in suitable locations can be an effective measure to enhance fish stocks in the dry season (Joffre et al, 2012). In connection with the CFR, rehabilitating community reservoirs for multiple-use can enhance food production for the local communities.

[19] Community Fish Refuge is a form of stock enhancement or a fish conservation measure that is intended to improve the productivity of rice field fisheries (Joffre et al., 2012).

7. Savings and most worthwhile use of water and food

Role of consumers in alliances for water and food security

As discussed in chapter 2, a number of promising initiatives involving food producers, industry and governments for water savings and improved productivity are witnessed in various parts of the world. Efforts should also involve the consumers since they, indirectly, are major users of water, energy and other resources. Similarly, consumer behaviour has significant environmental implications. Level and trends in food waste among consumers mean that huge quantities of the water and energy are used in vain (FAO, 2011a; Lundqvist et al., 2015; CFS-HLPE, 2014b). A number of efforts are now made by e.g., EU Parliament; national governments and sub-national units and private sector to involve consumers in efforts to reduce losses and waste[20].

Alternative scenarios about food security to inform policy

It has been estimated that between 2005/07 and 2050 food production needs to increase by 60 per cent (Alexandratos and Bruinsma, 2012, p. 3) to meet growing demand. During the same period the expected increase in world population is estimated at 25 to 30 per cent.

It is important to note that the calculation of 60% refers to an increase in demand. One option is to increase production. An alternative option is to improve efficiency in the supply chain – reducing losses and waste. Naturally, the two options can be combined, which seems to be a realistic strategy. Although productivity improvements are conceivable, a sole focus on production means an increasing pressure on water and environmental challenges. Equally important, gains from improvements in water management in production of food will be reduced if waste of food goes on unabated.

Naturally, a reduction in losses and waste involves costs and challenges. But if communities are involved in development initiatives and processes, it is

[20]See e.g., The Milan protocol by Barilla http://www.milanprotocol.com/ and a discussion of the Creating Shared Value concept promoted by a number of companies: Nestlé, Unilever, Wal-Mart, etc.: http://adamant-consult.com/wp-content/uploads/2014/05/11-porter-creating-shared-value-ss-highlights.pdf. For the resolution in the EU Parliament: http://www.europarl.europa.eu/news/en/news-room/content/20120118IPR35648/html/Parliament-calls-for-urgent-measures-to-halve-food-wastage-in-the-EU. Based on initiatives at Expo Milano 2015: "Feeding the Planet, Energy for Life" a resolution will be forwarded to the Commission, Council and Member States. It calls on the Commission to tackle food waste, to designate 2016 as the European Year against Food Waste, and for better water resources management.

sound policy to also include them, in their role as consumers, in a strategy to improve resource use and food supply chain efficiency.

Other things equal, reduced losses and waste mean a saving of water and other inputs of production and economic benefits. In Lundqvist et al. (2015), potential annual gains from a reduction by 50% of the losses and waste of food produced are discussed:

– Potential to save 650 million tonnes of food produced, which can be beneficially used rather than thrown away;
– Potential to reduce supply of irrigation water by 450 km3 (reduction of consumptive water use will be lower since some irrigation water returns to local recipient)
– Potential to reduce energy use by 16 ExaJoules (total global use of primary energy is about 500 ExaJoules, FAO, 2011c);
– Potential for gross monetary savings of $375 billion (net savings will be lower since investments e.g., in transport and storage will be required to reduce losses and waste)

A main practical and policy challenge refers to the fact that losses and waste occur in several segments of the food supply chain (CFS-HLPE, 2014b). Some of the problems require technical solutions and modification in logistic arrangements, i.e., investments, whereas other challenges refer to attitudes and human behaviour. It is, however, essential to note that almost by definition, food production and supply over a certain level will result in a higher incidence of overeating and/or higher waste rates. Hall et al. (2009) showed that "US per capita food waste has progressively increased by approximately 50 per cent since 1974, reaching more than 1400 kcal/person/day or 150 trillion kcal/year. Food waste now accounts for more than one-quarter of total freshwater consumption and about 300 million barrels of oil per year".

When formulating strategy and an effective policy for future water and food security, and nutrition, a few points are relevant:

- There is no easy solution to mobilize the additional volumes of water that will be needed to increase production by 60 per cent. The demand for water from urban sectors is projected to grow more quickly than that for agriculture (GTTWFH, 2014; OECD, 2012). Plans to use water for urban sectors and for hydropower are noticeable in many countries, e.g., in the Mekong (Box 10).

- The focus on production has implied that the opportunities to save water and other scarce resources by making better use of what is produced are overlooked (cf. Box 11). Improving efficiency in the

supply chain can also result in a reduction of negative environmental externalities. It makes sense to develop a strategy that enables farmers and society to use and benefit more of what actually is produced. It is plausible to assume that benefit/cost ratios are promising from reductions of losses and waste, at least initially. With higher ambitions, the costs and difficulties in reducing losses will increase.

- From a resource and environmental point of view, the *era of easy and cheap food production* is over. Game-changing circumstances discussed in this report, e.g., unprecedented droughts and other water predicaments, environmental concerns, stiff inter-sector competition for natural and financial resources, together with strong drivers on the demand side call for new approaches. Food system shortcomings and untapped opportunities need to be considered for better water resources stewardship and human progress.

Reduced losses and increased variety for mutual benefits

For a better understanding of untapped opportunities to use limited volumes of water and other resources to achieve food security and nutrition, a food supply chain perspective is warranted (Figure 7). For farmers and other food producers it is essential to capitalize on the opportunities related to a growing demand in urban centres. For that, they need transport, storage and marketing arrangements. Urbanization and increasing wealth mean a growing demand for a diversified range of food items, including fruits, vegetables, meat and dairy products – food items that are sensitive to degradation.

Last September, the Union Minister in India, Ms H.K Badal, called upon entrepreneurs to invest in food processing in an effort to combat wastage. The Minister argued that around USD 7.2 billion worth of fruits and vegetables are going to waste each year (Whitehead, 2014). These products require better storage, including cold storage. Unfortunately, deficiencies in these regards are common. Available storage in India, for instance, is not suitable for bringing sensitive food items to areas where demand is increasing. About 92 per cent of total storage capacity is suitable for potatoes as compared to around 1 per cent for other food items in high demand – fruit and vegetables (1.07 per cent), fish (0.73 per cent), dairy and milk (0.68 per cent) (Schreiber, 2014). As part of this context, only about 2-3 per cent of perishables are processed in India (Whitehead, 2014).

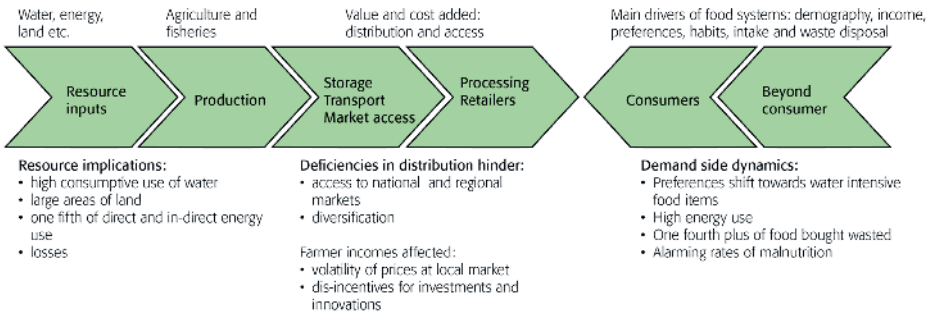


Figure 7. A schematic illustration of the main segments in the food supply chain.

Box 11. Food losses and waste in China and their implication for water and land

Junguo Liu, Beijing Forestry University, Beijing, China

Liu et al. (2013a), in a comprehensive review of the available information concerning China's food losses and waste found that the food loss rate for grains in the entire supply chain was 19.0 ± 5.8 per cent. The single largest amount of food waste – 7.3 ± 4.8 per cent – occurred in the consumer segment. No animal food items are included. The total water footprint related to food losses and waste in China in 2010 was estimated to be 135 ± 60 billion m3 –the water footprint of Canada. Such losses also imply that 26 ± 11 million ha of land were used in vain – the total arable land of Mexico.

The volume of irrigation water used in vain is estimated to 43 billion m3, an amount comparable to the volume of water planned to be diverted from south to north in China. This implies that there is a considerable room for improving the food supply chain system and alleviating water scarcity.

The actors in the supply chain need to have an urgent dialogue on strategies to reduce the high rates of food loss and waste and make a more worthwhile use of scarce natural resources.

Figure 8. Implications of food losses and waste on water and land in China

Source: Liu et al., 2013a

Differences between countries in terms of the relative size of losses and waste described by FAO (2011a) and CSE-HLPE (2014b) imply that a battery of approaches are required. To curb losses, investments in physical infrastructure are necessary. Reducing waste requires policies directed towards consumer attitudes and behaviour. The good news is that reducing consumer waste, which is significant, may not require much investments and such a change would save money for consumers, many of whom complain that food is expensive.

Water stewardship, better nutrition and less waste - towards a future that is not what it used to be

As discussed in chaper 1, game-changing circumstances suggest that the future may look quite different as compared to what we have been accumstomed to think. Documentation of increasing uncertainties and water-related risks highlights challenges. However, as this report has also shown, the capacity and commitments to deal with these challenges are significant. Positive results are demonstrated. In a situation described as Society's New Normal, water savings and better use of available water become vital. Innovations and combinations of e.g., agriculture and fisheries and other production systems, with a potential to yield more of crops and nutrious food per drop of water, are necessary.

Feeding a growing world population with a mix of wealthy and poor

people in a era of mounting water predicaments nevertheless involves multiple challenges. While the need and demand for more food must be recognized, it is relevant to note that an increase in food production and supply - over a certain level - is not synonymous with enhanced food security as illustrated in Figure 1. Evidence is mounting that improved nutrition must be included in food and agricultural policies. Scenarios about how to improve nutrion in an era of water scarcity are urgent.

Production is naturally a pillar in food systems. However, with urbanization and growing significance of consumer preferences and behavior, strategies for effective distribution, access and beneficial use of adequate and nutritious food become vital. Effort to produce more must be combined with efforts to modify the mix of what is produced for sustainable diets. Similarly, a revision of traditional thinking that increases in demand can only be met by a corresponding increase in production is timely.

Increasing efficiency in the food supply chain, i.e., a reduction of losses and waste, increases the possibility to cater for growing demand, *without* a corresponding increase in production. A momentum is building up with promising and new partnerships on the supply side for agri-water-efficiency-related innovations and interventions and water stewardship. A correspondingly brave thinking and concrete initiatives to revive a sound food culture among consumers are warranted. Combining efforts on the supply and demand sides will help to build a future that is desirable.

References

All web pages were retrieved in April 2015.

de Albuquerque, C. Special Rapporteur on the human right to safe drinking water and sanitation. (2011). *Statement to the Permanent Forum on Indigenous Issues.* http://www.un.org/esa/socdev/unpfii/documents/session_10_statement_SR_water.pdf

Alexandratos, N. and Bruinsma, J. (2012). *World agriculture towards 2030/2050: the 2012 revision.* ESA Working paper No. 12-03. FAO. Rome.

Allan, J.A. (1998). Virtual water: a strategic resource. Global solutions to regional deficits. *Groundwater.* 36(4), 545-546.

Allan, J.A. (2011). *Virtual water: tackling the threat to our planet's most precious resource.* London: I.B. Tauris.

Allan, J.D., Abell, R., Hogan, Z., et al. (2005). Overfishing of inland waters. *BioScience*, 55(12), 1041. doi:10.1641/0006-3568(2005)055[1041:OOIW]2.0.CO;2

Bakker, K. (1999). The politics of hydropower: Developing the Mekong. *Political Geography.* 18:209-232.

Bullock, J. and Darwish, A. (1993). *Water Wars: Coming Conflicts in the Middle East.* London: St Dedmundsbury Press.

CAWMA (Comprehensive Assessment of Water Management in Agriculture). (2007). *Water for food, water for life: a comprehensive assessment of water management in agriculture.* London: Earthscan and Colombo, Sri Lanka: International Water Management Institute.

CEDAW (Convention on the Elimination of all Forms of Discrimination Against Women) (2013). *Concept note for the general recommendation on Article 14 of CEDAW*. New York.

CESCR (Committee on Economic, Social and Cultural Rights) (1999). General Comment No. 12: The right to adequate food (Art. 11 of the Covenant). http://www.refworld.org/docid/4538838c11.html.

CESCR (2002). *General Comment No. 15:* The right to water. http://www.unhchr.ch/tbs/doc.nsf/0/a5458d1d1bbd713fc1256cc400389e94/$FILE/G0340229.pdf.

CFS-HLPE (Committee on World Food Security-High Level Panel of Experts on Food Security and Nutrition) (2014a). *Note on critical and emerging issues for food security and nutrition.* 6 August. www.fao.org/cfs/cfs-hlpe.

CFS-HLPE (Committee on World Food Security-High Level Panel of Experts on Food Security and Nutrition) (2014b). *Food losses and waste in the context of sustainable food systems.* Report 8. June. www.fao.org/cfs/cfs-hlpe.

Chambers, R. and Medeazza, G. (2014). *Reframing undernutrition: faecally-transmitted infections and the 5 As*. IDS Working Paper 450. London: Institute of Development Studies.

Checkley, W, Buckley,G., Gilman, R.H. et al. (2008). Multi-country analysis of the effects of diarrhoea on childhood stunting. *International Journal of Epidemiology* 37, 816-830.

Collier, P. (2007). *The bottom billion: why the poorest countries are failing and what can be done about it*. New York, NY, USA: Oxford University Press.

Cooke, S.J. and Cowx, I.G. (2004). The role of recreational fishing in global fish crises. *BioScience* 54, 857-859.

Cook, B.I., Ault, T.R. and Smerdon, J.E. (2015). Unprecedented 21st century drought risk in the American Southwest and Central Plains. *Science Advances 1*(1), e1400082, 12 February.

Conway, G. (1997). *The Doubly Green Revolution: Food for All in the Twenty-First Century.* Ithaca, New York: Comstock Publishing Associates.

Conway, G. and Waage, J. with Delaney, S. (2010). Science and innovation for development. London: UK Collaborative on Development Sciences.

Dangour, A.D., Watson, L., Cumming, O., et al. (2013). Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children. *Cochrane Database of Systematic Reviews* DOI: 10.1002/14651858.CD009382.pub2.

Doczi, J., Calow, R. and d'Alançon, V. (2014). *Growing more with less: China's progress in agricultural water management and reallocation.* London: Overseas Development Institute.

Dugan, P., Sugunan, V.V., Welcomme, R.L., et al. (2007). *Inland fisheries and aquaculture. pp. 459-483. In D. Molden (Ed)*, *Water for Food*, *Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (pp. 459-483). London: Earthscan and Colombo, Sri Lanka: International Water Management Institute.

Elimelech, M. and Phillip, W.A. (2011). The future of seawater desalination: energy, technology, and the environment. *Science*. 333, 712-717.

Eriksson, M., Xu, J., Shrestha, A.B., et al. (2009). *The changing Himalayas – impact of climate change on water resources and livelihoods in the greater Himalayas.* Kathmandu: International Centre for Integrated Mountain Development (ICIMOD).

Evans, A. (2009). *The feeding of the nine billion: global food security for the 21st century.* Chatham House Report. London: Royal Institute of International Affairs.

Eversole, R. (2005). Overview – patterns of indigenous disadvantage worldwide. In: R. McNeish, A. Eversoleand D. Cimadore (eds.) *Indigenous Peoples and Poverty: An International Perspective*. London: CROP International Studies in Poverty Research, Zed Books.

FAO (1996). Rome Declaration on world food security and world food summit plan of action. World Food Summit 96/3. Rome: FAO.

FAO (2000). *The state of world fisheries and aquaculture* 2000. Rome: Fisheries Department, FAO.

FAO (2004). V*oluntary guidelines to support the progressive realization of the right to adequate food in the context of national food security.* Rome: FAO.

FAO (2006a). *Livestock's long shadow.* FAO, Rome.

FAO (2006b). Policy brief on food security. www.fao.org/forestry/13128-0e6f36f27e0091055bec28ebe830f46b3.pdf.

FAO (2010a). *The state of food insecurity in the world. Addressing food insecurity in protracted crisis.* Rome: FAO.

FAO (2010b). International scientific symposium on biodiversity and sustainable diets. 3-5 November 2010, Rome. www.fao.org/ag/humannutrition/29186-021e012ff2db1b0eb6f6228e1d98c806a.pdf.

FAO (2011a). *Global food losses and food waste. Extent, causes and prevention* http://www.fao.org/docrep/014/mb060e/mb060e.pdf

FAO (2011b). *The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk.* Rome: FAO and London: Earthscan.

FAO (2011c). *Energy-smart food for people and climate.* Issue Paper. Rome: FAO.

FAO (2011d). *Review of the state of the world fishery resources: inland fisheries.* Fisheries and Aquaculture Circular No. 942, Rev. 2. Rome: FAO.

FAO (2012a). *Mutually acceptable mechanism on integrated use of water resources in Central Asia. Application of the scenario approach.* Ankara: FAO.

FAO (2012b). Water withdrawal by sector, around 2006. www.fao.org/nr/water/aquastat/globalmaps/AquastatWorldDataEng_20121214_Withdrawal.pdf.

FAO (2013a). *State of food insecurity in the world. Strengthening the enabling environment for food security and nutrition.* Rome: FAO.

FAO (2013b). Food wastage footprint. Impacts on natural resources. Summary report. www.fao.org/docrep/018/i3347e/i3347e.pdf.

FAO (2014a). *The right to food: past commitment, current obligation, further action for the future: a ten-year retrospective on the right to food guidelines.* www.fao.org/3/a-i4145e.pdf.

FAO (2014b). *The state of world fisheries and aquaculture* (SOFIA). Rome: FAO.

FAO (2014c) FishStat plus, http://www.fao.org/fishery/topic/16073/en.

FAO, IFAD and WFP (Food and Agriculture Organization of the United Nations, International Fund for Agricultural Development and World Food Programme) (2014). *State of food insecurity in the world: strengthening the enabling environment for food security and nutrition.* Rome: FAO.

FAO and WHO (Food and Agriculture Organization of the United Nations and World Health Organization) (2014) ICN2 Second international conference on nutrition. 19-21 November, Rome. http://www.fao.org/about/meetings/icn2/documents/en/.

FAOSTAT (2003). Average consumption of animal protein by source of protein in

average between 2000 and 2003. FAO food balance sheets. http://faostat.fao.org/site/368/default.aspx.

Falkenmark, M. and Rockström, J. (2004). *Balancing Water for Humans and Nature. The New Approach in Ecohydrology.* Earthscan. London

Fischer Walker, C., Rudan, I., Liu, L., et al. (2013) Global burden of childhood pneumonia and diarrhoea. *The Lancet* 381(9875), 1405-1416.

Foley, J.A., DeFries, R., Asner, G.P., et al. (2005). Global consequences of land use. *Science* 309(5734), 570-574.

de Fraiture, C. and Giordano, M. (2013). Small private irrigation: a thriving but overlooked sector. *Agricultural Water Management* 131, 167-174.

Friedman, T. (2013). Mother Nature and the middle class. *New York Times*, September 21. www.nytimes.com/2013/09/22/opinion/sunday/mother-nature-and-the-middle-class.html.

Garnett, T., Appleby, M.C., Balmford, A., et al. (2013). Sustainable Intensification in Agriculture: Premises and Policies. *Science* 341: 33-34.

Gerland, P., Raftery, A.E., Ševčiková et al. (2014). World population stabilization unlikely this century. *Science* 346, 234-237.

Godfray, X. et al. (2010). Food Security: The challenge of feeding 9 billion people. *Science*, 327(5967), 812-818.

Godfray, H.C.J. and Garnett, T. (2014). Food security and sustainable intensification. *Philosophical Transactions of the Royal Society* B 369, 20120273.

Grönwall, J. (2014). *Power to segregate: improving electricity access and reducing demand in rural India (2014)*. SIWI Paper No. 23. Stockholm: SIWI.

GTTWFH (Gulbenkian Think Tank on Water and the Future of Humanity) (2014). *Water and the future of humanity*, New York. Springer.

Hall, K.D., Guo, J., Dore, M. and Chow, C. (2009).The progressive increase of food waste in America and its environmental impact. *PLoS ONE* 4(11), e7940.

Hausmann, C. and Patrick, S. (2013). Contingency planning: trade's role in sustainable

world food security. *Aquatic Procedia* 1, 20-29.

Hawkesworth, S., Dangour, A.D., Johnston, D. et al. (2010). Feeding the world healthily: the challenge of measuring the effects of agriculture on health. *Philosophical Transactions of the Royal Society B*. 365(1554), 3083-3097.

Hoekstra, A. Y. (2012). The hidden water resource use behind meat and dairy. *Animal Frontiers*. Vol 2, No 2, April. http://dxdoi.org/10.2527/af.2012-0038.

ICEM (International Centre for Environmental Management) (2010). *MRC strategic environmental assessment (SEA) of hydropower on the Mekong Mainstream*. Hanoi: ICEM.

IFAD (International Fund for Agricultural Development) (2007). *Gender and water: securing water for improved rural livelihoods: The multiple-uses system approach*. Rome: IFAD. http://www.ifad.org/gender/thematic/water/gender_water.pdf.

IFAD (International Fund for Agricultural Development) (2009). *Engagement with Indigenous Peoples*, Policy. Rome, IFAD. http://www.ifad.org/english/indigenous/documents/ip_policy_e.pdf.

IFPRI (International Food Policy Research Institute). (2014). *The global nutrition report. Actions and accountability to accelerate the world's progress on nutrition*. Washington, DC: IFPRI.

IHME (Institute of Health Metrics and Evaluation) (2012). Global Burden of Disease Study 2010. Global Burden of Disease Study 2010 (GBD 2010) Results by Risk Factor 1990-2010. Seattle, United States. (Entry last modified: Aug 6, 2014)

ILO (2014). Better Data to Better Monitor the Status of Women in Informal Employment, Unpaid Work and Work in Rural Areas and Agriculture.. http://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/newsitem/wcms_317515.pdf

IPCC (2014) Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, V.R., Dokken, D.J Mach, K.J. Mastrandrea, M.D. et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IWGIA and Tebtebba (International Work Group for Indigenous Affairs and

Indigenous Peoples' International Centre for Policy Research and Education) (2014). Briefing note - post 2015 development process: water. Copenhagen: IWGIA.

Joffre, O., Kosal, M., Kura, Y. et al. (2012). *Lessons learned brief 2012-03*. Phom Penh: WorldFish.

Jägerskog, A. (2003) *Why states cooperate over shared water: The water negotiations in the Jordan River Basin*, Linköping University, PhD Dissertation, Linköping Studies in Arts and Science.

Jägerskog, A. and Kim, K. (2015). Land acquisition as a means to mitigate water scarcity and reduce conflict? *Hydrological Sciences Journal*. Accepted.

Jägerskog, A., Cascao, A., Hårsmar, M. and Kim, K. (2012). *Land acquisitions: how will they impact transboundary waters?* Report Nr. 30. Stockholm: SIWI.

Jägerskog, A., Swain, A. and Öjendal, J. (2014). Water Security – International conflict and cooperation. Volume II. In A. Jägerskog, A. Swain and J. Öjendal (Eds). *Water Security*. London: SAGE Publications.

Kabeer, N. (2010). Can the MDGs provide a pathway to social justice? *The challenge of intersecting inequalities.* New York: United Nations Development Programme (UNDP).

Kathleen A. Lohse, David A. Newburn, Jeff J. Opperman and Adina M. Merenlender, 2008, *Ecological Applications*, Vol. 18, No. 2, p. 467-482.

Kelman, J. (2015). Water Supply to the Two Largest Brazilian Metropolitan Regions. *Aquatic Procedia.* Elsevier

Kirby, M., Bark, R., Connor, F., et al. (2014). Sustainable irrigation: how did irrigated agriculture in Australia's Murray–Darling Basin adapt in the millennium drought? *Agricultural Water Management* 145, 154–162

Klingbeil, R. and Byiringiro, F. (2013). *Food Security, Water Security, Improved Food Value Chains for a more Sustainable Socio-economic Development.* mimeo. UNESCWA

Konikow, L.F., (2013), Groundwater depletion in the United States (1900–2008): U.S. Geological Survey Scientific Investigations Report 2013–5079, 63 p., http://pubs.usgs.gov/sir/2013/5079.

Kuwayama, Y. and Brozović, N., (2013), The regulation of a spatially heterogeneous

externality: tradable groundwater permits to protect instream flows, *Journal of Environmental Economics and Management*, DOI: 10.1016/j.jeem.2013.02.004.

Larson, D.F. (2013). Introducing water to an analysis of alternative good security policies in the Middle East and North Africa. *Aquatic Procedia* 1, 30-43

Lima, A.A., Moore, S.R., Barboza, M-S. et al. (2000). Persistent diarrhea signals a critical period of increased diarrhea burdens and nutritional shortfalls: a prospective cohort study among children in northeastern Brazil. *Journal of Infectious Diseases* 181, 1643-51.

Liu, J., Lundqvist, J., Weinberg, J. and Gustafsson. J. (2013a). Food losses and waste in China and their implication for water and land. *Environmental Science and Technology* 47(18), 10137-10144.

Liu J., Zang C., Tian S., et al. (2013b). Water conservancy projects in China: achievements, challenges and way forward. *Global Environmental Change* 23(3), 633-643.

Lohse, K.A., Newburn, D.A., Opperman, J.J. and Merenlender, A.M. (2008), *Ecological Applications*, Vol. 18, No. 2, p. 467-482.

Lundqvist, J., Barron, J., Berndes, G., et al. (2007). Water pressure and increases in food and bioenergy demand. Implications of economic growth and options for decoupling. In: *Scenarios on economic growth and research development: Background report to the Swedish Environmental Advisory Council Memorandum* 2007:1. pp. 55-152. http://www.sou.gov.se/mvb/pdf/WEBB- per cent20PDF.pdf.

Lundqvist, J., Liu, J. and Lundberg, J. (2015). Consumers, food supply chain and the nexus. In K. Hussey, J. Pittock and S. Dovers (Eds.). *Climate, Energy and Water: Managing the Holy Trinity.* Cambridge: Cambridge University Press.

Lymer, D., Teillard, F., Opio, C. and Bartley, D.M. (2015) Freshwater fisheries yield replacement estimates (land and water) for protein and the micronutrients contribution in the lower Mekong River Basin and related countries. *Freshwater fish and the future*. FAO/MSU Global conference on inland fisheries, Rome, Italy.

MacDonald, A., Bonsor, H., Dochartaig, B. and Taylor, R. (2012). Quantitative maps of groundwater resources in Africa. *Environmental Res. Letters* 7(2), 024009.

McGuire, V.L., (2014), Water-level changes and change in water in storage in the

High Plains aquifer, predevelopment to 2013 and 2011–13: U.S. Geological Survey Scientific Investigations Report 2014–5218, 14 p., http://dx.doi.org/10.3133/sir20145218.

Mekonnen, M.M. and Hoekstra, A.Y. (2011) National Water Footprints Accounts: green, blue and grey water footprint of production and consumption. Value of Water Research Paper Series no 50. UNESCO-IHE, Delft. The Netherlands.

Mills, D. J. L. W., Gertjan De Graaf, Yumiko Kura, Rolf, and A. K. K. Willman. (2011). Under-reported and Undervalued: Small-scale Fisheries in the Developing World. In: A. N. Pomeroy R [ed.], *Managing Small Scale Fisheries: Frameworks and Approaches.* CABI.

Mukherji, A., Rawat, S. and Shah, T. (2013) Major Insights from India's Minor Irrigation Censuses: 1986-87 to 2006-07. *Economic and Political Weekly*. Vol - XLVIII No. 26-27, June 29.

Namara, R.E., Hope, L., Owusu Sarpong, E. et al. (2014). Adoption patterns and constraints pertaining to small-scale water lifting technologies in Ghana. *Agricultural Water Management* 131, 194-203.

Needham, S. and Funge-Smith, S.J. (2014). *The consumption of fish and fish products in the Asia-Pacific region based on household surveys.* FAO Regional Office for Asia and the Pacific. Bangkok, Thailand: RAP Publication.

Nellemann, C., MacDevette, M., Manders, T., et al. (eds). (2009). The environmental food crisis – The environment's role in averting future food crises. A UNEP rapid response assessment. United Nations Environment Programme, GRID-Arendal. www.grida.no.

Newburn, D.A., Brozović, N. and Mezzatesta, M. (2011), Agricultural water security and instream flows for endangered salmonids, *American Journal of Agricultural Economics*, 93(4), p. 1212-1228.

Ng, M., Fleming, T., Robinson, M. et al. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: a systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*. 384: 766–81.

ODI (Overseas Development Institute) (2014). *Future diets. Implications for agriculture and food prices*. www.odi.org/futurediets.

OECD (Organisation for Economic Co-operation and Development). (2012). *Environment Outlook to* 2050: Freshwater Chapter. Paris: OECD.

OHCHR (2011): Guiding Principles on Business and Human Rights: Implementing the United Nations 'Protect, Respect and Remedy' Framework. HR/PUB/11/04. http://www.ohchr.org/Documents/Publications/GuidingPrinciplesBusinessHR_EN.pdf.

Orr, S., Pittock, J., Chapagain, A. and Dumaresq, D. (2012). Dams on the Mekong River: Lost fish protein and the implications for land and water resources. Global *Environmental Change*, 22(4), 925-932.

Öjendal, J., Mathur, V. and Sithirith, M. (2002). *Environmental Governance in the Mekong: Hydropower Site Selection Processes in the Se San and Sre Pok Basins.* SEI/ REPSI Report Series No. 4. Stockholm: Stockholm Environment Institute.

Pittock, J. and Connell, D. (2010). Australia Demonstrates the Planet's Future. In: *International Journal of Water Resources Development* 26 (4): 561 - 578.

Pretty, J., Toulmin, C., and Williams, S. (2012). Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability*, 9:1: 5-24.

Rockström, J., and Karlberg, L. (2010). The Quadruple Squeeze: Defining the safe operating space for freshwater use to achieve a triply green revolution in the Anthropocene. *Ambio* 39:257-265.

Rockström, J., Steffen, W., Noone, K., et al. (2009). A safe operating space for humanity. *Nature* 461: 472-475.

Royal Society. (2009). *Reaping the Benefits: Science and the Sustainable Intensification of Global Agriculture*. Royal Society, London.

Schreiber, A. (2014). India's cold chain only fit to store potatoes. http://www.foodnavigator-asia.com/content/view/print/913537.

Selby, J. (2013). 'Cooperation, domination and colonisation: The Israeli-Palestinian Joint Water Committee', W*ater Alternatives*, 6(1), 1-24.

Shaffer, D., Yip, N.Y., Gilro, J., et al. (2012). Seawater Desalination for Agriculture by Integrated Forward and Reverse Osmosis: Improved Product Water Quality for Potentially Less Energy. *J Membrane Science* 415-416: 1-8.

Shah, T. (2014). *Groundwater Governance and Irrigated Agriculture.* TEC Background Paper No 19. Stockholm: GWP. www.gwp.org/Global/ToolBox/Publications/Backgroundper cent20papers/GWP_TEC_19_web.pdf.

Shen, D. (2014). *The Agricultural Water Management in Northern China.* London: Overseas Development Institute.

Shrimpton, R. and Rokx, C. (2012). *The double burden of malnutrition: a review of global evidence.* Health, Nutrition and Population (HNP) discussion paper. Washington DC; World Bank. http://documents.worldbank.org/curated/en/2012/11/18004669/double-burden-malnutrition-review-global-evidence.

Siebert, S. and P. Döll (2010). Quantifying blue and green virtual water contents in global crop production as well as potential production losses without irrigation. *J Hydrology* 284: 198-217. www.saiplatform.org/uploads/Library/SiebertandDoell2010_quantifyingblueandgreenvirtualwatercontentofcrops.pdf.

Silva, S., Johnston R. and Try. T. (2013). *Rice and Fish: Impacts of Intensification of Rice Cultivation*. Issue brief #4, June 2013. IWMI: Colombo.

Smakhtin, V. (2008). Basin closure and environmental flow requirements. *International Journal of Water Resources Development.* 24(2): 227–233

Smil, V. (2000). *Feeding the World: A Challenge for the Twenty-First Century.* Cambridge, MA, USA: MIT Press

Special Rapporteur on the Human Right to Food (2011). *Report submitted by the Special Rapporteur on the right to food*, Olivier De Schutter. A/HRC/19/59. www.ohchr.org/Documents/HRBodies/HRCouncil/RegularSession/Session19/A-HRC-19-59_en.pdf.

Starr, J.R. (1991). Water wars. *Foreign Policy* 82: 17-36.

Tilman, D., Fargione, J., Wolff, B. et al. (2001). Forecasting agricultural driven global environmental change. Science 292(5515), 281-284.

The Economist (2014). The drying of the West. February 22, pp. 33-34. http://www.economist.com/news/united-states/21596955-drought-forcing-westerners-consider-wasting-less-water-drying-west.

Torkelsson, Å. (2012). Sex Disaggregated Data on Agriculture, Water and Food Security: Lessons from the Kenya. World Water Week Seminar on Global Practice in Promoting Gender Equality in the Water Sector. August 30, 2012, Stockholm. http://www.worldwaterweek.org/documents/WWW_PDF/2012/Thur/Gender-equality/Torkelsson-Gender-Disaggregated-Data-Results.pdf

UN Global Compact CEO Water Mandate, Pacific Institute, and Shift Project (2015): Guidance for Companies on Respecting the Human Rights to Water and Sanitation: Bringing a Human Rights Lens to Corporate Water Stewardship. Oakland and New York: Pacific Institute and Shift Project.

United Nations Inter-agency Task Force on Rural Women (2012). *Rural Women and the Millennium Development Goals*. New York: United Nations.

UNEP (United Nations Environmental Programme) (2010). *Blue Harvest: Inland Fisheries as an Ecosystem Service.* Penang: WorldFish Center.

Valery, P. (1937). Notre Destin et Les Lettres. *Journal de l'université des Annales* 19, 341–354.

van Vliet M.T.H., Yearsley, J.R., Ludwig, F. et al. (2012). Vulnerability of US and European electricity supply to climate change. *Nature Climate Change*, 2(9): 676-681.

Vrieze, P. (2011). *Development, or Destruction?* Stakes are high as decision on first Mekong Dam draws closer. Cambodia Daily, February 12-13.

2030 WRG (2030 Water Resource Group) (2013). *Managing Water Use in Scarce Environments.* A Catalogue of Case Studies www.waterscarcitysolutions.com

Weiskal, T. (1988). *The Anthropology of Environmental Decline*. Summary Statement for hearings of the Committee on Environment and Public Works. U.S. Senate, Washington DC, 14 September.

Welcomme, R. L. and Petr, T. (2004). Proceedings of the Second International Symposium on the Management of Large Rivers for Fisheries Volume I. In Welcomme and Petr, [eds.], *Second International Symposium on the Management of Large Rivers for Fisheries* RAP Publication 2004/16/17. Bangkok: FAO Regional Office for Asia and the Pacific.

Weiss, D.J., Weidman, J. and Pinkalla, S. (2013). States of Denial: States with the Most Federal Disaster Aid Sent Climate-Science Deniers to Congress. https://www.americanprogress.org/issues/green/report/2013/09/12/73895/states-of-denial-states-with-the-most-federal-disaster-aid-sent-climate-science-deniers-to-congress-2/.

Whitehead, R.J. (2014). Wanted: Investment by food processing entrepreneurs to combat wastage. *Foodproductiondaily.* 17 September 2014. http://www.foodproductiondaily.com/Processing/Wanted-Investment-by-food-processing-entrepreneurs-to-combat-wastage

Wilhite, D.A., Sivakumar, M.V.K. and Pulwarty, R. (2014). Managing Drought Risk in a Changing Climate: The Role of National Drought Policy. *Weather and Climate Extremes* 3: 4-13. Elsevier Publishers.

Windfuhr, M. (2013). *Water for Food: A Human Rights Obligation.* Study for the German Institute for Human Rights. 33 Berlin: German Institute for Human Rights.

Winkler, I. (2015). Water for producing food for basic consumption: guaranteed by the right to water or food? In: *The Right to Water: Theory, Practice and Prospects*, M. Langford and A. Russell (eds.), Cambridge University Press, Cambridge (Forthcoming). http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2575234.

WHO (World Health Organization) (2008). *Safer Water, better health; Costs, benefits and sustainability of interventions to protect and promote health.* http://whqlibdoc.who.int/publications/2008/9789241596435_eng.pdf.

World Bank (2012). Africa can help feed Africa. Removing barriers to regional trade in food staples. http://siteresources.worldbank.org/INTAFRICA/Resources/Africa-Can-Feed-Africa-Report.pdf

WEF (World Economic Forum) (2015). *Gobal Risks 2015*. http://reports.weforum.org/global-risks-2015/.

2030 WRG (2030 Water Resources Group) (2015). http://www.waterscarcitysolutions.org/assets/WRG-Managing-Water-Scarcity-Catalogue.pdf

WWF, IWGIA, KULU, Nepenthes and DIIS (World Wildlife Fund, International Work

Group for Indigenous Affairs, Kvindernes U-landudvalg, Nepenthes and Dansk Institut for Internationale Studier) (2005). Integrating Indigenous and Gender Aspects in Natural Resource Management – Guidelines for Practitioners. http://www.iwgia.org/iwgia_files_publications_files/0579_Guidelines_for_Practitioners.pdf.

Zeitoun, M. and Warner, J. (2006). Hydro-hegemony a framework for analysis of transboundary water conflicts. *Water Policy* 8, 435-60.

Zeitoun, M. and Mirumachi, N. (2008). Transboundary water interaction I: reconsidering conflict and cooperation. *International Environmental Agreements* 8(4), 297-316.

Zhao X., Liu J., Liu Q., et al. (2015). Physical and virtual water transfers for regional water stress alleviation in China. *Proceedings of the National Academy of the Sciences of the United States of America* 112(4), 1031-1035.

Personal communication:

Serina Ahlgren, Ph.D., Department of Energy and Technology, Uppsala, Sweden

Annika Åhnberg, *doctor honoris causa*, Swedish University of Agricultural Sciences, former Minister of Agriculture, Food and Fisheries, Sweden

Kenneth M. Persson, Professor, Water Resources Engineering.
Lund University, Sweden.

This FAO Committee discussion paper highlights the key role of water for food security, globally and for different groups. Climate change projections suggest many regions will become drier and hotter, and droughts are expected to become more frequent and severe. Population growth will most likely largely be in poor parts of the world where agriculture is the main source of livelihood, but where yields are low, partly due to uncertainty in water supply. Elevated risk and other challenges apply both for the part of agriculture that has access to irrigation, and even more for farmers who depend on increasingly uncertain rainfall. The paper analyses 'Society's New Normal' as an inconvenient truth of global water resources and the rapid increase in groundwater extraction.

The paper emphasizes that requirements for innovation and reforms leading to water savings are large. Policy decisions must also take into account new knowledge about the distortions in food security, and special consideration given to vulnerable groups. Although the challenges are significant, there are great opportunities to make better use of limited water resources. Solutions from different parts of the world are submitted, including commitments to water-saving programmes by major food-producing companies as part of their Corporate Social Responsibility, and introduction of new crops and management principles. Several ways forward are presented: since trade in food is also trade in water it enables water stressed countries to achieve a certain degree of food security; a renewed partnership between public and private sectors and civil society for water governance, food waste reductions, innovations and finance, is necessary. Futhermore, effective water use presumes coordination with energy planning.

FAO, the Food and Agriculture Organization of the United Nations, is the UN specialized agency for agriculture, forestry and fisheries. The organization was founded in 1945 and its mandate is to contribute to global food security and the eradication of hunger and malnutrition.

The Swedish FAO Committee was formed in 1950, the same year that Sweden became a member of the FAO. The task of the Committee is to assist the Government in its work for food security for all, while taking account of global development and the preservation of biodiversity in the areas of agriculture, forestry and fisheries. It is also to spread knowledge about and raise interest in the work of the FAO. The Committee comprises 12 members and its chair, Elisabeth Backteman, State Secretary to the Minister for Rural Affairs at the Ministry of Enterprise and Innovation.

Swedish FAO Committee
c/o Ministry of Enterprise and Innovation
SE- 103 33 Stockholm, Sweden

www.regeringen.se