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Addressing water scarcity in agriculture: how can indigenous or traditional practices help?

Collection of contributions received

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Topic note

The world's population is growing, with the need to produce more food. This challenge exacerbates water scarcity, which is further compounded by a changing climate. To cope with the challenge, **could indigenous or traditional practices support climate change adaptation efforts on reducing water scarcity in agriculture?**

To address this question, a first step consisted in reviewing traditional/indigenous practices used by rural communities as coping strategies for climate change adaptation in agriculture. An agro-ecology grouping was used, seeking to highlight the potential of transferring practices between areas of similar agro-ecology. **A compendium of such practices was thus compiled and is available for reference.**

The need to mainstream indigenous knowledge and traditional practices into sustainable development has also been well acknowledged, including through the 1989 Indigenous and Tribal Peoples Convention, the 2007 United Nations Declaration on the Rights of Indigenous Peoples and the 2015 Paris Agreement on Climate change.

However, evidence of successful use and transfer of indigenous practices to cope with water scarcity in agriculture remains scattered. This discussion is an opportunity to **systematically identify practices that have demonstrated their effectiveness** in supporting the livelihoods of the communities and to classify them in such a way that they can be upscaled or replicated elsewhere. This is especially crucial for areas with similar agro-ecological characteristics. **It is expected that some of these practices will then support projects aimed at addressing water scarcity in agriculture, with an objective roadmap comprising recommended practices/ technologies and the required supporting policies, as relevant.**

Furthermore, different opinions are still being voiced on semantics (e.g. indigenous knowledge, traditional knowledge, knowledge of indigenous peoples, community knowledge or local knowledge systems...). This discussion will also seek to reach some consensus on the most appropriate terminology to be used in the final version of the compendium.

The purpose of this discussion is thus to call for participants' contributions to the following questions.

1. Sustainability and replicability of the practices

From your experience (or knowledge), which of the indigenous/traditional practices below have been successfully applied and if possible, replicated (different times or places) in order to cope with water scarcity in agriculture? Please provide examples and references.

- Weather forecasting and early warning systems
- Grazing and Livestock management
- Soil and Water Management (including cross slope barriers)
- Water harvesting (and storage practices)
- Forest Management (as a coping strategy to water scarcity)
- Integrated wetlands and fisheries management
- Other (please specify)

2. Moving beyond semantics

Having discussed all these practices/ technologies, which terminology would be most suitable to neutrally label them in the compendium? Please briefly substantiate your argument with most updated references, when available.

We look forward to your inputs to this important discussion.

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| Patrick Bahal'okwibale FAO, Ethiopia | Jean-Marc Mwenge Kahinda CSIR, South Africa |
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Contributions received

1. Pradip Dey, ICAR-AICRP (STCR), Indian Institute of Soil Science, Bhopal, India

Dear All,

I would like to provide the following info:

Traditional Knowledge based Solution to address water scarcity: Climate change is a defining moment of our time with major negative implications on ecology, human culture, livelihoods and food security. The IPCC advocates to search local solutions for climate change adaptations; however, its report does not recognize the breadth and strength of century tested traditional knowledge in combating climate change. Major water concerns are (1) Most critical resource for Indian agriculture; (2) The resource is shrinking; (3) Increased competition from other sectors; (4) Decline in water table; (5) Water-logging and salinity; (6) Increased pollution; (7) Environmental change to affect availability; and (8) Reduction in river flow. The emerging scenario from different parts of the globe suggests that neither the scientific technologies alone nor the traditional knowledge exclusively can completely solve the threats of food and nutritional security challenges emanating from climate change, however, a fusion of the two can. Traditional Knowledge can be defined as the collectively owned non-formal intellectual property comprised wisdom, knowledge and teaching developed by local and indigenous communities over time in response to the needs of their specific local environment and integral to the cultural or spiritual identity of the social group in which it operates, preserved and many-a-time orally transmitted for generations. Traditional water management practices include Stone Bunding, Stones-cum-Earthen Bunding, Stone-cum-Vegetative bunding, Brushwood Waste Weir, Grassed Waterways and Spur Structure. The planners and policy makers have yet another tool and dimension to initiate participatory action plan involving tribal farmers and their rich reserve of traditional knowledge in order to develop adoptable technology that will enable mitigation of water scarcity and problem of climate change for financial inclusion and mainstreaming of indigenous population. The study described in the paper conclusively proved that planners and policy makers have yet another tool and dimension to initiate participatory action plan involving tribal farmers and their rich reserve of traditional knowledge in order to develop adoptable technology that will enable mitigation of water scarcity and problem of climate change for financial inclusion and mainstreaming of indigenous population. Moreover, region-specific amalgamated technological prescriptions refined with targeted policy analysis are required for effective implementation and obtaining positive outcomes within a finite time horizon.

Reference: Dey, P. and Sarkar, A.K. (2011). Revisiting indigenous farming knowledge of Jharkhand (India) for conservation of natural resources and combating climate change. Indian J. Traditional Knowledge 10(1): 71-79.

http://www.fao.org/fsnforum/sites/default/files/discussions/contributions/Indian_J_Traditional_Knowledge.pdf

2. Kuruppacharil V. Peter, Kerala Agricultural University, India

PITCHER system of irrigation is an age old and indigenous system of irrigation followed in Malabar the present North Kerala during summer in plantation crops like coconut, cocoa and arecanut. PITCHER consists of a porous earthen pot which can carry 5-10 liters of water. A hole is made at the bottom plugged by a long wig through which water droplets move to nearby soil to the tree. Each drop of water is used and a not a drop wasted. Once the soil is wetted the movement from the pot is stopped. The main

advantages of PITCHER are conservation of water, needed based watering and very simple in technology. PITCHERS are modified to water vegetable nursery beds, rooting of grafts, management of excess moisture leading to soil borne diseases and above all the most viable and economical.

3. Bill Butterworth, Land Research Ltd, United Kingdom

Composts made from urban wastes will hold between 5 and ten times their own weight of water. Taking urban wastes can also earn cash. So, take the wastes, compost them and create sub-surface layers as “top soil reservoirs”. See details in How to make on-farm composting work and Reversing global warming for profit both by Bill Butterworth and published by MX Publishing, London.

Bill Butterworth

The Director

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4. Jacques Diouf, Senegal

Dear all,

Policies do not omit any slogans when promising the well-being of those they govern.

Meteorological predictions, forest management, resilience to climate changes etc. are common political pronouncements in countries south of the Sahara where farmers constitute the majority and are illiterate.

In these countries, the difficulty of finding water for domestic consumption is exacerbated by severe changes of climate and reduced rains for the producers of staple cereals.

All of us have ideas about development but the need for training producers south of the Sahara has not been met.

As a result of this failure we are opting for the concept of Smart agriculture.

Under this concept we measure all the dangers threatening food security and the best practice solutions to be put in motion for the success of food security policies.

De Jacques

Alliance du Sénégal

5. Ego Lemos, Permaculture Timor-Lorosa'e, Timor-Leste

Dear all,

Here in East Timor (Timor-Leste) community still practices ritual ceremony and traditional knowledge when doing water conservation program.

Please see the link of video about water conservation in Ermera, East Timor. <https://www.youtube.com/watch?v=WZUUK7tM7Fo>

Also please my PowerPoint about water conservation in Ermera. http://www.ukm.my/lestari/ss2015/5_05032015_09.pdf

Hope this information is useful for our discussion to bring up some indigenous knowledge on water conservation in the globe.

Best Regards,

Ego Lemos,

Founder and Executive Diretor of Permatil (Permaculture Timor-Lorosa'e)

6. Amanullah, University of Agriculture Peshawar, Pakistan

The following are important:

1. Growing crops which need less water
 2. Increasing organic carbon or organic matter in soil using plant residues and animal manures
 3. Discouraging plantation of trees which take more water e.g. eucliptus
 4. Decreasing land degradation especially decreasing erosion. Degraded land store less water than fertile lands.
 5. Contouring on slope soils
 6. Mulching
 7. Deep tillage in some areas increase water infiltration in the soil
 8. Cover crops conserve soil moisture
 9. Drip and sprinkler irrigation use less water than flood irrigation
 10. Subsurface irrigation
 11. Cleaning waste water
 12. Use less water for cars cleaning
 13. Use less water for animal's cleaning
 14. Ridge and bed plantation use 50÷ less water than flat plantation
 15. Cementing water channels
 16. Removing weeds which transpire more
 17. Big dams and small dams
 18. Conservation of runoff water
 19. Application of potassium in field crops
 20. Use of beneficial microbes in field crops production
- Etc.

Amanullah

Associate Professor of Agronomy, The University of Agriculture Peshawar PAKISTAN

7. Kudzai Bhunu, WatPro Pvt Ltd, Zimbabwe

Good day,

My experience in irrigation development has made me realize that the major problem that we have is with respect to issues of attitudes of communities. In Zimbabwe you can realize that the knowledge of what needs to be done with respect to saving water is there but the willingness to do so is not there. This has been the situation with years of failure to implement the water management policies at the expense of trying to improve some sections of the economy or the community. This was also evident in Mozambique there is evidence of significant knowledge on water management which needs to be improved. Instead of using unlined canals it would be wide to use piped systems that reduces the losses due to seepage and evaporation. The down side to the establishment of such efficient systems is lack of funding which will always be a problem leading to most of the developments using low efficiency systems yet improved knowledge is available that could increase resilience against climate change.

8. Sonali Phate, Kamalnayan Jamnalal Bajaj Foundation, India

Benefits of Improving Ground Water Recharge

Wardha district is comprised of 1006 villages located in its eight blocks. The total population of Wardha district is 1.29 million (12,96,157); out of this, 4, 20,873 population (32.47%) lives in urban area, whereas 8,75,284 population (67.52 %) is inhabitant of rural areas. The total geographical area of Wardha district is 6309 sq km or 6,29,000 ha of land, of which 4,26,200 ha area is under cultivation. Around 3, 83,300 ha area is covered under Kharif season, while only 43,600 ha area is cultivated under Rabi season. The important crops like cotton, soya bean and pigeon pea (Tur) are raised during Kharif season, wheat and green gram during Rabi season and ground nut during the summer season.

Average rainfall of Wardha district is 1062 mm. The surface rain water runoff takes away fertile top soil and that leads to severe soil erosion. This enormous loss of soil adversely affects its fertility status and land use. About 10 % of the eroded material usually gets deposited in streams and rivers resulting in silting up of river beds and reservoirs, thereby reducing water flows, ground water recharge and water retention capacity of the soil. This, in turn, decreases the crop productivity, ultimately resulting into lower incomes to the farmers.

Measures like rejuvenation of rivers/streams, construction of check dams, percolation tanks, farm ponds, recharging of existing wells, promotion of group lift irrigation, group water lifting device, group wells, etc. along with soil & water conservation measures such as Nala plugging, construction of Gabion structures, farm bunds and contour bunds have been initiated by Kamalnayan Jamnalal Bajaj Foundation with an active participation of the local community. For efficient and judicious use of available water, drip and sprinkler irrigation systems have also been promoted along with less water intensive and short duration cash crops. Following are the few experiences shared by the farmers of the region.

The efforts were made by Kamalnayan Jamnalal Bajaj Foundation for improving productivity with creation of various rain water harvesting structures. Following are the few of the experiences shared by the farmers.

Mahadev Vithobaji Mate is a farmer of village Kinhala of Deoli taluka. Most of the agriculture land in the village is rainfed and the farmers are in loss due to low productivity in absence of irrigation facilities. He was convinced about the benefits of farm pond as discussed in the village level meetings conducted by KJBF. He constructed a farm pond of size 15m x 10m x 3m with a total storage volume of 450 m³. He established drip irrigation system on his farm to optimize the use of water available in the farm pond. He experienced substantial rise in the productivity of cotton and pigeon pea which improved his net earnings from Rs 39000 to Rs. 81500/-



Diwakar Shankarrao Chavare is a farmer of village Andori of Deoli taluk. He has 3 acres of rainfed land and was cultivating crops during Kharif season only. With the creation of group well in 2010 with the support given by KJBF, he began to cultivate crops during Rabi season also, because of which his net earnings were enhanced from Rs. 16500 to Rs. 100500.



Babanraoji Yewale is a resident of Amangaon village of Seloo taluka. He has 5 acres of rainfed land and he was growing cotton and pigeon pea crops only. A percolation tank was constructed in the village by KJBF to improve the rate of recharge of ground water table. Babanraoji began to lift the water available in the percolation tank for irrigation. This has not only improved the productivity of crops but also the number of crops as he began to cultivate vegetables and wheat. As a result, his net earnings got increased from Rs.16700 to Rs.101400.



Anil of Sujatpur village of Samudrapur taluk. was rainfed till 2014. In rainy season, logged and he could not cultivate any other hand, he could not cultivate crops of irrigation facility. In 2014, he was recharge pit of size 22 ft diameter and 7 now irrigate 2.5 acres of his farm in Kharif as well as Rabi which has improved his net earnings from loss to Rs.64900.



Chintaman Itware is a farmer He has 5 acres of land which the land used get water crop during Kharif. On the in Rabi season too due to lack helped by KJBF to construct a ft deep. As a result, he could



Avinash Shambhaji Lende is a farmer of village Andori of Deoli taluka. He has 3 acres of land and a farm well. He was not able to support the required irrigation to the Kharif crops and was also not able to raise Rabi crops due to less water availability in the farm well. In the year 2013, he was guided to have a well recharge pit to improve the water availability in the well. Due to this, the level of water in well got increased by 6 ft and he began to cultivate wheat on one acre of land. The productivity of Kharif crops also got improved as he could provide required number of irrigation cycles. Now, his net earnings have been raised from Rs.16000 to Rs.67000.

9. Benjamin Mapani, University of Namibia, Namibia

Dear Colleagues,

This is a very pertinent issue in the Southern African Region.

We are faced with new threats in the region:

Climate change- the patterns of rainfall have significantly changed, such that now we require food crops that are resistant to drought.

The loss of indigenous seed crop strains in favor of hybrids, has led to a loss of important source of seed for indigenous farmers.

These topics I would like us to explore in depth.

Regards,

Ben

10. Shahid Zia, RBDC, Pakistan

Dr Amanullah left almost nothing for others to add. He has listed almost every possible intervention that we can think of for saving water in agriculture. I will mention couple of that may help us on both water saving and climate change.

1. Rethinking Farming Systems. Need to adapt our farm planning to the changing climate. Crops that need less water and can tolerate medium to long term droughts be made part of crop rotations. Like Sisal crop that many African countries are growing for several decades is now also being Introduced in China and other Asian countries.
2. Rebuilding Soils. In most of the developing countries, organic matter in agricultural lands have declined to alarming levels. Improving farm biodiversity together with mulching, composting particularly vermi-composting can enhance water holding capacity of soils.
3. Redesigning Irrigation Methods. With declining supplies of irrigation water, it doesn't make sense to continue with irrigation methods like flood irrigation. Farmers have to develop indigenous, innovative and low cost more efficient irrigation systems.

Dr Shahid Zia

RBDC, Pakistan

11. Debarati Chakraborty, University of Kalyani, India

Dear All,

I will like to draw attentions to the use of vetiver grass (*Vetiveria zizanioides*), a native Indian grass for addressing the water scarcity. This grass is commonly known as Khas-Khas, Khas or Khus and highly valued for its essential oil. It is highly valued among tribals for its medicinal values and is frequently used in aromatherapy. This grass can be cultivated for multiple issues of in situ soil and water conservation in agrarian land. Vetiver contour hedges in India on cropping land with 1.7 % slope is reported to reduce runoff, soil loss to a huge extent. This grass can tolerate extreme climatic variations like prolonged period of drought, flood, submergence and extreme temperature fluctuations from -14 to 55

°C. It is also tolerant of adverse soil conditions like soil acidity, salinity, sodicity and acid sulphate states. Vetiver leaves can serve as medium for mushroom cultivation. Handicrafts made from vetiver roots serves as sources of income for smallholder farmers of the Western Ghats, India. Moreover, vetiver curtains on windows serves as the traditional way to keep home cool during the scorching summer days and is still used in various parts of India. It keeps home cool and is claimed to be an alternative of air conditioner thereby saving energy.

Hence cultivation of this plant in a better planned way calls for an immediate attention.

Thanks,
Debarati

12. Talal Darwish, National Center for Remote Sensing-CNRS, Lebanon

Indigenous people have been very smart and creational using scarce water resources. For instance, In Africa they have been using the buried clay pot irrigation (pitcher irrigation) even for field crops with very water use sufficiency. In Yemen, they use spit irrigation through water harvest, convey to agricultural fields and merging the clay soil surrounded by earth wall of 1 m elevation. Then water is conveyed to lower plots within the watershed. After water fully absorbed by the soil, farmers get two yields first with short rooted crop and second with deep rooting plant. I Syria and Lebanon, some farmers use alternate irrigation of rows with drip irrigation applying alternate deficit irrigation to save water. Agricultural research institutions can support these native practices by providing good productivity, drought resistant, seeds. With the development of biosaline agriculture, farmers in Gulf countries increasingly and successfully use salt tolerant feed and food crops and irrigate with seawater.

13. Liliana Castillo, Colombia

Despite the topic addresses water scarcity in agriculture, in some places like in the north Coast of Colombia climate change implies water excess during the rainy season, and deficit during the dry one. Under these conditions, the Zenu tribe developed an efficient way to deal and take advantage of water excess during the rainy season, and reduce water scarcity during the dry one. They created a network of canals perpendicular to the main rivers. This network was formed by long and short canals that reduced water speed during the rainy season and lead the water to lower areas where there were crops and where they kept fisheries. The water brought sediments that improved soils fertility. This system also allowed to convey water to areas far away from the main streams, and helped to keep them wet during the whole year. It is a shame I could not find many resources in English, however you can take a look at what they did in: <https://vimeo.com/12811886>

14. Dyana Sari, University of Tribhuwana Tungadewi, Indonesia

There is a tree means that there are possibilities to grow more trees. When the rain comes, the water can be trapped by the trees, make its circumstances is more humid and the crops may grow as there is water supply in the ground. The more trees the more water can be kept in the ground and there is a possibility to make a well someday.

15. Abdou-Raman Mamoudou, Université de Maroua, Cameroon

Original comment in French

Dans un contexte de changement climatique de plus en plus accru, l'agriculture exige des quantités importantes d'eau. Dans les zones sahéliennes notamment dans le septentrion camerounais (bassin du lac-tchad), la ressource en eau constitue une denrée rare et stratégique qui détermine la consistance de la production agricole. La raréfaction de cette ressource dans le sahel camerounais pousse de nombreux agriculteurs à délaisser leurs activités agricoles au détriment du commerce ou l'élevage bovin. Nonobstant ces réalités notées, il existe des pratiques de résilience élaborées par les populations afin d'atténuer la pénurie de la ressource en eau du fait du phénomène des changements climatiques.

On note entre autres techniques ;

- La conservation des eaux de pluie à travers des mares d'eau (qu'on appelle OKOLORÉ dans la langue Locle qui est le Fulfuldé c'est à dire la langue peulhe). Cette eau conservée au niveau même des exploitations permet de mieux irriguer les champs;
- Le développement des puits-forages permettant de tirer l'eau du sous-sol pour l'irrigation des exploitations agricoles ;
- l'intensification de l'éradication des arbres trop gourmands en eau (l'arbre eucalyptus) autour des périmètres agricoles;
- La migration vers des cultures ne demandant pas trop d'eau à l'instar du coton, la patate, le mil, le maïs...

Cette liste des pratiques endogènes n'est pas exhaustive, mais il est clair que le stress hydrique induit d'énormes mutations au niveau des populations locales sur le plan agricole. De plus, cette pénurie en eau est source de conflits entre les agriculteurs eux-mêmes et puis entre les éleveurs et agriculteurs.

Cordialement,

Abdou-Raman Mamoudou

Ingénieur en sciences sociales pour le développement et Étudiant en Master Économie Appliquée, spécialité Stratégie Industrielle et Économie Agricole

Université de Maroua Cameroun

English translation

In a context of ever increasing climate change, agriculture demands important volumes of water. In the Sahelian regions, in particular in the North of Cameroon (Lake Tchad basin) the water resource is a rare and strategic commodity which determines the consistency of agricultural production. The increasing scarcity of this resource in the Cameroonian Sahel drives many farmers to abandon their farming activities to the detriment of business and cattle raising. Despite the above realities, there are methods of adaptation developed by the population so as to reduce the effect of the lack of water resources produced by the phenomenon of climate change.

Among other techniques we note:

- Conservation of rain water in water ponds (called OKOLORÉ in the Locle language which is the Fulfuldé that is the language of the Fulani people). This water preserved near the farming plots allows for better irrigation of the fields;

- Development of wells enables underground water to be drawn on for the irrigation of farming plots;
- Intensification of elimination of trees that need a lot of water (like eucalyptus) near the farming areas;
- Switching to crops that do not demand too much water, like cotton, sweet potato, millet, corn, etc.

This list of home-grown practices is not exhaustive, but it is clear the emphasis on water produces many changes in the local populations' farming. Furthermore, this water scarcity causes many conflicts among the farmers themselves and between the herders and farmers.

Best regards,

Abdou-Raman Mamoudou

16. Halimatou Baldeh, Food Safety and Quality Authority of the Gambia, Gambia

"The Naturally bred rural female farmer" is always the term that I would like to portray my farming experiences in my country and this has given me an adequate knowledge to contribute positively towards any fora that discusses auricular practices most especially within the African concept. In that case I can comfortably put forward my contributions in addressing the above Topic and go ahead to give out some few recommendations that may go a long way in addressing the issue.

In my country, the Gambia, for instance the most important and valuable naturally gifted asset that we have is fresh water. The Gambia, in West Africa is mostly surrounded by fresh water in the forms of rivers, lakes and natural canals. This makes agriculture one of the best income generating activity for the country. In a flash back(that is as far back as I can remember) in the late 1970s towards the early 80s the Government of the Gambia had a great chance to grow rice along the river Gambia using a simple and cheap means of water supply which to water the rice fields and this was called "IRRIGATION". In this system, a simple machine was used to propel water from the river to the rice fields and water was accesses using locally made canals. In that case water was available throughout the dry season which made it possible for rural people of the Gambia to embark on a year round rice production. In that, the Gambia at those time was self sufficient in rice and only locally grown rice was consumed and farmers even had excess to sell to the local market.

My suggestion therefore for indigenous traditional farming practices would be for farmers to go back to the local irrigation system hence we have the river Gambia which is fresh and readily available.

17. Ervé Marcel Ouedraogo, UEMOA, Burkina Faso

Original comment in French

En matière de maraichage en péri urbain, on constate que les autochtones privilégient les arrosoirs simples, des petits récipients et s'attaquent à de petites superficies (10 m²/planche) pour enfin produire les meilleurs rendements agricoles (rendement).

Cela s'explique essentiellement par la maîtrise e la distribution localisée de l'eau au pied des plants, avec un bon entretien. On retrouve un peu cette situation dans le goutte à goutte mais avec moins de performance car avec le goutte à goutte, les superficies sont généralement plus importantes que les 10 m² par planches habituellement mis en valeur par les maraichers.

English translation

As regards market gardening around the city, we note that the natives prefer simple watering cans, small containers and attack small areas (10 m²/ plantation) to finally produce the best agricultural yields (yield).

This is mainly explained by the control and localized distribution of water at the base of the plants, with good care. We find nearly the same situation in the drip but with less efficiency because the surfaces are generally larger than the 10 m² per plantation usually exploited by the market gardeners.

18. Ruhiza Jean Boroto, FAO, Italy

Earlier this month of June 2018, I was fortunate to spend a few days visiting the Cuvelai, Okavango and Zambezi river basins in the north of Namibia to explore opportunities for rainwater and floodwater harvesting. I also met with members of several communities who are essentially pastoralists.

On the question of how the communities coped in the past with water scarcity during the dry season, the answer was that there was (and still is) a practice of preparing hand dug wells along the banks of the river channels, in anticipation of the floods. When the flood came with the river overflowing, these wells were used to trap the flood water. This water would then be stored in the wells after the floods receded and the river eventually ran dry. The water would then be used for the livestock.

This traditional practice is somehow now improved with the current practice of modern earth dams for which the government of Namibia has a standard design, to minimise seepage, evaporation losses and sedimentation.

In addition, the experience shared by Liliana Castillo by the Zenu tribe in north Coast of Colombia is quite similar to what communities do or experience along the Zambezi River do in Namibia, with similar conditions - excess water during the rainy season and deficit during the dry one. They also harvest flood water in natural streams (as opposed to the network of canals in north Colombia) that are perpendicular to the main stem, allowing water to reach areas that are quite far away from the main river. This water is then used during the dry season for livestock and agriculture.

Man made interventions (mostly road infrastructure) are suspected to have interfered with this natural course of flood water. The communities recommended that future designs of such infrastructure takes into consideration this natural movement of water during floods and if possible, further facilitate the process for areas that are naturally prone to receive such excess flood water, which will be used for productive uses, improving food security.

19. Cecilia Akita, FAO off the United Nations, Ghana

Soil and Water Management (including cross slope barriers)

Management of water using the Indigenous knowledge in the Brong Ahafo region in Ghana includes holding some rivers such as the Tano River as a deity or inhabited by a god, hence prohibiting people from fishing in it. This puts fear in the indigenes thus keeping water bodies well protected and well managed for a longer period. Suggestions by the chiefs and elders are that, there should be bye-laws and subsequently seek protection by global instruments.

20. Bill Butterworth, Land Research Ltd, United Kingdom

Water scarcity and Closed Loop Recycling of Wastes

High organic matter soils are reservoirs for water and that reservoir can be made bigger thus making irrigation water go 5 or even 10 times further. As the world gets more populated, it produces more agricultural and urban wastes. As it gets richer, it produces more urban wastes. For the human race to survive, we have to recycle these wastes. Most, if not all crop wastes, and many (most in some areas) urban wastes can be recycled using aerobic digestion, i.e. “composting” and TAD (Thermophilic Aerobic Digestion – pumping air in to raise the temperature). It is easy to accept that crop wastes from farming, or green wastes from urban gardens can be composted, but so can many industrial wastes.

Take hard plastics out of consideration, they are difficult but many plastics can be successfully recycled. For example, urea-formaldehyde is the “glue” used to make boards for furniture manufacture and discarded chip-board and MDF (Medium Density Fibreboard) and, when shredded, are a very useful source of Nitrogen fertiliser and are helpful in composting other materials. Another example is a “base” plastic (used to manufacture a wide range of glues and consumer product plastics) is PVA – Polyvinyl alcohol. This is “rocket fuel” for the micro-organisms in a compost heap but it is not easy to handle. It is liquid at temperatures above 60 or 70 degrees C but becomes progressively sticky as it cools.

Much easier to handle are materials such as crop residues, green wastes from urban gardens or city arboricultural management, cardboard and tissues and some industrial wastes. A good source of Nitrogen fertiliser is sewage and thorough composting above 60 degrees C will control pathogens. (Turn the heap every few days until it gets to 60 degrees, turn again and get up to 60. Three or four times up to 60 will dramatically reduce pathogen transfer risk.)

I shall soon be introducing a regular series on a page at www.landresearchonline.co

21. Vivian Onyango, FAO, Italy

Grazing and livestock management: Living with water scarcity management by pastoral communities.

Pastoralists in many parts of the world are accustomed to dealing with scarcities including of water. This is because areas inhabited by pastoralists are sometimes considered “marginal,” as they lack relative abundance of resources compared to other agroecological areas. However, how pastoralists manage water and hence their landscape is linked to availability of another vital resource; pasture. To prevent degradation of both water and pastures, communal management is often employed that guides movement (mobility) across the landscape in accessing water and pasture resources. Under communal governance systems decisions are negotiated such as when to construct new wells, who is responsible and in effect who has access, when and for how long. This implies a coordinated approach in addressing water scarcity that combines local/ traditional knowledge on the landscape including pasture availability and development of new water infrastructure.

The Boran in East Africa monitor use and conditions of water their resources. The communities for example dig deep well in areas considered dry seasons grazing areas/reserves. These wells are often labour intensive in construction and also in drawing water from, thus necessitating people coming together and on rotational basis fetch water for all entitled households’ livestock. These areas also have restricted access that is mainly tied to adaptation to extreme dry conditions such as drought. Examples include preferences being given to nearby households, and later sometimes only to calves as they cannot travel to other distant water sources. In wet seasons, water is collected in shallow ponds or pans and use is often unrestricted.

Central to these are also principles such as reciprocity and flexibility which are key in adaptation. Inter-village or inter-community understandings are guided by reliance on one another's resources including water from one season to another depending on intensities of extreme events and needs. Yet these rights are often not fixed but negotiated as maybe needed from season to season or event to event.

22. Eileen Omosa, We Grow Ideas, Canada

Forest management for sustainable water supply

Communities which historically relied on natural resources (water, forests, pastures, land) to provide a livelihood have devised forest management methods to ensure continuous water supply.

Long before science reiterated relations between forest conservation and sustainable water supply, rural communities had acknowledged the existing relationships, and developed systems for forest management. For example, in Africa most of the forests commonly known as "community forests" survived due to the use of indigenous/customary rules and regulations on rights, access and management of the shared forest and water resources.

Rights and access to particular forests came with clear roles, benefits and responsibilities: who could access which forest, when, what forest products to harvest (fruits, firewood, timber, herbs), and how much. To ensure adherence to the rules of access and harvest, the communities had narratives and practices spelling out the type of punishment for those who defied the rules. Stories have always formed part of the daily lives of many communities – to entertain, inform and educate. So, who would cut down a tree at the very top of a hill reserved as sacred for prayer sessions when the consequence was death of a loved one or incapability of one's body organs? Who would water livestock at locations reserved for portable water when the punishment would be death of their livestock? So, adherence, mainly through respect to the rules saw many forest areas conserved. As we know of the water cycle, trees contribute to rain formation.

How do we document and incorporate some of the customary conservation practices into our education system and policy formulation as a way to enhance forest management for sustainable water supply?

23. Rob Blakemore, VermEcology, Japan

Hello,

My recent paper shows that organic management compared to conventional/chemical farming provides preserves the endemic earthworms and soil organic matter whilst increasing soil water storage by +28.7% on average (<http://www.mdpi.com/2571-8789/2/2/33>). If the soil bulk density is 1.0 g/cm³, this is directly relates to having the equivalent of 28.7% extra rainfall. These dozen or so studies were mainly from Europe and Asia.

In Africa, for example, Lal (1974) made comparisons in similar situations in Nigeria, where eudrilid earthworms are common, and found about 24 times the numbers of worm casts and infiltration rates almost doubled under zero-till plots. Also in Nigeria, Wilkinson (1975) showed a positive relationship between infiltration rates and earthworms in fallow, and Aina (1984) confirmed a 2.5 times increase in infiltrability due to earthworms in forest soils.

My recommendation would be to vermi-compost all organic wastes for return to the fields, to maintain leguminous cover-crops to fix nitrogen & to protect the soil from erosion, and to use non-chemical weed & pest control to preserve the worms.

Ref - Blakemore, R.J. (2018). Critical Decline of Earthworms from Organic Origins under Intensive, Humic SOM-Depleting Agriculture. Soil Systems. 2(2): 33. [<http://www.mdpi.com/2571-8789/2/2/33>].

Blog - <https://vermecology.wordpress.com/2018/05/27/wormageddon-destruction-in-our-soils/>

24. Gerhard Flachowsky, Federal Research Institute for Animal Health, Germany

Dear Colleagues,

I agree that water is in many regions one of the most important limiting factors for plant growth and human being. I agree also with the FSN activities to find out, how can indigenous or traditional practices may help to overcome water scarcity in agriculture.

But personal, I think that we also need a long term programme to overcome water scarcity. I think that we need more research activities and political willingness for a sustainable utilization of naturally limited and non-renewable resources such as water, fuel, arable land etc.

In the case of water, we need plants:

- **With a more efficient use of water**
- **Which are able to use salt water**
- **Which are more resistant against abiotic and biotic stressors such as drought-tolerant plants**

Therefore, we need a long term programme of plant breeding by public supported research institutes to deal with such substantial questions. The private plant breeding would not be interested in such scientific questions. We have to understand the physiological, biochemical, and molecular processes of these important traits in order to develop such plants (see above).

Gerhard Flachowsky

25. Vijay Vallabh Barthwal, Independent Researcher, India

In India, approximately 36.09 percent of agricultural land is irrigated and rest of the land depends on the vagaries of monsoon or rainwater. Most of the rainwater is not properly utilized for farm purpose due to non-availability of storage facilities and practices. A large amount of rainwater goes to be wasted. If this water is properly stored for the longest time, then It can be used for cropping during the non-monsoon (non-rainy session) . Different types of practices and methods are being adopted in different parts of our country. I would like to mention, such practices which are popularly being adopted in desert districts of Rajasthan (India), where rain is uncertain. And not being properly stored and used for agricultural purposes. However, farmers are trying their best to store this huge amount of rainwater through traditional method, known as TANKA SYSTEM. TANKA is a traditional pitcher of water used in Thar Desert of Rajasthan of a traditional technology. Water is collected in it and taken out using the help of bucket. These are mainly made in rural areas of Rajasthan. But their storing capacity is too low to store plenty of rainwater. If storing capacities of these tankas are increased and quality of its construction is improved, then more rainwater can be stored and used for agricultural purposes. This method is beneficial for marginal and small farmers.

Dr V.V. Barthwal
India

26. Andrew Isingoma, Rwanda Agriculture Board, Rwanda

1. Sustainability and replicability of the practices

I would like to describe practices which can help below

1. Grazing and Livestock management

Grazing management is a practice of looking after domestic animals in good and proper managerial way, this is done to protect natural vegetation. It is self explanatory for every one that good vegetation contribute to rainfall hence, water we are in need of, and vice versa.

2. Soil and Water Management (including cross slope barriers)

Soil management involves local construction of barriers to stop soil and water runoff, these practices does not necessarily involve expensive constructions, (like using cemented canals) no way, it is done by local in habitants by planting terebusacum, elephant grasses, and some acacia trees on the lidges/ borders of their field. Sometimes they dug terraces in their fields for those living in sloppy areas, these practices are done using local hoes not necessarily caterpillars, and or tractors. Farmers do them and protect water runoff by themselves, they sometimes request some simple incentives to by local drinks while doing these activities, or they can amelgment their little money and buy drinks for themselves.

3. Water harvesting (and storage practices)

This practice involves construction of Pond water in the sloppy fields and put big sheeting in the pond to hold water and can be used for irrigation. it also involves putting water channelling materials on iron sheet roof houses and direct water in big tanks. These activities does not require a big project with a lot of dollars, it only require good governance, and important international organization guide lines like FAO-UN works, and mobilise policy to rural in habitants. Water harvesting practices is very useful locally and succeeded to help people in many areas. It help in the irrigation of kitchen gardens for vegetables like, tomatoes, onions, carrots, etc. water harvesting is very fabulous in food security development at home level.

4. Forest Management (as a coping strategy to water scarcity)

Forest management involves good practices of planting of reducing deforestation in an area where forest have been or have not been before. Forest is necessary in rainfall synclonization and cannot happen without. Forest management should be strongly be put in consideration in order to keep water availability.

5. Integrated wetlands and fisheries management

Wetlands once bad managed it can result into draught causative agent in the very area of practice, wetlands should not be abused by cultivators of animal grazers, mining, constructions etc., these practices should not be done in wetland areas, because it can result into drought. Fisheries management involves practices of proper use and construction of fish ponds these practices have been constructed locally in many areas and very successful.

6. Weather forecasting and early warning systems

I have included this point as the last in the help because it involves higher metrological technics of weather professionals with little involvement of rural inhabitants or little in habitants of local citizens, therefore little help in water management.

27. Mithare Prasad, Shuats, Up, India

Mithare Prasad

Assistant Professor (Agronomy), Department of ILFC, Karnataka Veterinary Animal and Fisheries Science University, Bidar Karnataka (India)

Addressing water scarcity in agriculture: how can indigenous or traditional practices help?

- Water scarcity in agriculture is increasing day by day for which, various factor are responsible; like climate change, improper rainfall, excess runoff, decline in water table, extensive use of water without necessary (Wastage of water), water logging, salinity-alkalinity and reduced in water flow in rivers & lakes and increased water pollution.
- The emerging scenario from different parts of the globe, which shows the scarcity of water for irrigation purpose in agriculture for crop production and livestock production. Indigenous or traditional practices which address the scarcity of water which follows certain practices like: Stone bunding, stone-cum vegetative bunding, Spur structures, Grassed water ways, Brushwood water ways, contour bunding, terracing, trenching, basin-listing and check dams etc. These are the knowledge based and skill based practices which are come from our ancestors and even today these are working very effectively in rural areas of India.
- Ground water is most important source in agriculture sector for various purpose but today today the water table has lost its stability to supply the sufficient amount of water for livelihood, for this purpose the ground water recharge is very necessary aspect for the future purpose: The various measures are followed for recharging the ground water are Rejuvenation of streams, inter-linking of rivers, construction of check dams, construction of percolation tanks, and farm pounds. Other way soil and water conservation measures are also very essential for water storage & avoid soil erosion; Construction of Farm bunds, contour bunds, graded bunds, mulching with crop residues and planting with erosion restricting crops all along the bunds (ex; Vitever grass).
- Water scarcity can also be reduced with proper grazing management in livestock production: Livestock need abundance of water for its various purpose so restricted use and efficient use of water in dairy & livestock will be ultimately profitable to tackle the water scarcity in agriculture.
- Pitcher Irrigation practice is an ancient and traditional system followed in Karnataka, Kerala & Tamilnadu states of (India). It is extensively used in plantation crops like coconut, Areca nut, Cocoa, Black pepper, Beetle wine, cardamom, vanilla, cinnamon and many vegetables etc. It consist of small porous earthen pots which are 10-15 litres carrying capacity of water and a small trench is dugged in the root zone of the plantation crop, by which a drop by drop water is supplied to the plant directly to root zone so that the maximum water use efficiency can be achieved during the water scarcity.
- Forest Ecosystem and Bio diversity will play an important role in fight against water scarcity: When it comes to the water, the rain is the only major source of water for all agriculture sectors, for which the forest & biodiversity will play an important role in rainfall occurrence. The forest areas receive the high amount of rainfall and also involved in the water cycle which contribute to rain formation in the atmosphere.

· In India approximately 35-40 % of agriculture land is irrigated & 60% of area is entirely dependent on rainfed ultimately (Dryland farming). India is having two types of monsoon; South west monsoon (75%) & north east monsoon (25 %). Large of the rainfall is received by south west monsoon and cropping intensity will be more during it, but also the large amount of rain water is lost in the form of runoff & soil erosion, for collection & storage of excess water there are various traditional or indigenous practices are playing an vital role in conservation of water and utilization of such water during the lean period for agriculture & livestock for: **Addressing Water Scarcity in Agriculture.**

Various traditional or indigenous practices followed in India since ancient time to till date:

Note for kind information: These bold letters sub-heading are typically a Sanskrit/Hindi local words of India which cannot be translated as similarly in English.

Jhalara: Jhalaras are typically rectangular-shaped stepwells that have tiered steps on three or four sides. These stepwells collect the subterranean seepage of an upstream reservoir or a lake. Jhalaras were built to ensure easy and regular supply of water for religious rites, royal ceremonies and community use.

Talab/Bandhi: These are reservoirs that store water for household consumption and drinking purposes. They may be natural, such as ponds at Tikamgarh in the Bundelkhand region or man made, such as the lakes of Udaipur (India). A reservoir with an area less than five bighas is called a talai, a medium sized lake is called a bandhi and bigger lakes are called sagar or samand.

Bawari: Bawaris are unique stepwells that were once a part of the ancient networks of water storage in the cities of Rajasthan and Deccan region of India. The little rain that the region received would be diverted to man-made tanks through canals built on the hilly outskirts of cities. The water would then percolate into the ground, raising the water table and recharging a deep and intricate network of aquifers. To minimise water loss through evaporation, a series of layered steps were built around the reservoirs to narrow and deepen the wells.

Taanka: It called as tank in English is a traditional rainwater harvesting technique indigenous to the Thar Desert region of Rajasthan and Gujarat (India). A taanka is a cylindrical paved underground pit into which rainwater from rooftops, courtyards or artificially prepared catchments flows. Once completely filled, the water stored in a taanka can last throughout the dry season and is sufficient for a family of 5-6 members. An important element of water security in these arid regions, taankas can save families from the everyday drudgery of fetching water from distant sources.

Johads: These are one of the oldest systems used to conserve and recharge ground water, are small earthen check dams that capture and store rainwater. Constructed in an area with naturally high elevation on three sides, a storage pit is made by excavating the area, and excavated soil is used to create a wall on the fourth side. Sometimes, several johads are interconnected through deep channels, with a single outlet opening into a river or stream nearby. This prevents structural damage to the water pits that are also called madakas in Karnataka and pemghara in Odisha (India).

Khadin: These are indigenous constructions designed to harvest surface runoff water for agriculture. The main feature of a khadin, also called dhora in India, it is a long earthen embankment that is built across the hill slopes of gravelly uplands. Sluices and spillways allow the excess water to drain off and the water-saturated land is then used for crop production.

Kund: A kund is a saucer-shaped catchment area that gently slopes towards the central circular underground well. Its main purpose is to harvest rainwater for drinking. Kunds dot the sandier tracts of western Rajasthan and Gujarat (India). Traditionally, these well-pits were covered in disinfectant lime and ash, though many modern kunds have been constructed simply with cement.

Baolis: These were secular structures from which everyone could draw water. These beautiful stepwells typically have beautiful arches, carved motifs and sometimes, rooms on their sides. The locations of

baolis often suggest the way in which they were used. Baolis within villages were mainly used for utilitarian purposes and social gatherings. Baolis on trade routes were often frequented as resting places. Stepwells used exclusively for agriculture had drainage systems that channelled water into the fields.

Nadi: These are village ponds that store rain water collected from adjoining natural catchment areas. The location of a nadi has a strong bearing on its storage capacity and hence the site of a nadi is chosen after careful deliberation of its catchment and runoff characteristics. Since nadis received their water supply from erratic, torrential rainfall, large amounts of sandy sediments were regularly deposited in them, resulting in quick siltation.

Bhandara Phad: The system starts with a bhandhara (check dam) built across a river, from which kalvas (canals) branch out to carry water into the fields in the phad (agricultural block). Sandams (escapes outlets) ensure that the excess water is removed from the canals by charis (distributaries) and sarangs (field channels).

Zing: These can be found in Ladakh region of Himalayas (India), are small tanks that collect melting glacier water. A network of guiding channels brings water from the glacier to the tank. A trickle in the morning, the melting waters of the glacier turn into a flowing stream by the afternoon. The water, collected by evening, is used in the fields on the following day. A water official called a Chirpun is responsible for the equitable distribution of water in this dry region that relies on melting glacial water to meet its farming needs.

Kuhls: Kuhls are surface water channels found in the mountainous regions of Himachal Pradesh (India). The channels carry glacial waters from rivers and streams into the fields. An important cultural tradition, the kuhls were built either through public donations or by royal rulers. A kohli would be designated as the master of the kuhl and he would be responsible for the maintenance of the kuhl.

Zabo: The Zabo (meaning 'impounding run-off') system combines water conservation with forestry, agriculture and animal care. Practised in Nagaland and Indian sub-continent. Rainwater that falls on forested hilltops is collected by channels that deposit the run-off water in pond-like structures created on the terraced hillsides. The channels also pass through cattle yards, collecting the dung and urine of animals, before ultimately meandering into paddy fields at the foot of the hill. Ponds created in the paddy field are then used to rear fish and foster the growth of medicinal plants.

Bamboo Drip Irrigation: This is an indigenous system of efficient water management that has been practised for over two centuries in northeast India. The tribal farmers of the region have developed a system for irrigation in which water from perennial springs is diverted to the terrace fields using varying sizes and shapes of bamboo pipes. Best suited for crops requiring less water, the system ensures that small drops of water are delivered directly to the roots of the plants.

Jackwells: The Shompen tribe of the Great Nicobar Islands lives in a region of rugged topography that they make full use of to harvest water. In this system, the low-lying region of the island is covered with jackwells (pits encircled by bunds made from logs of hard wood). A full-length bamboo is cut longitudinally and placed on a gentle slope with the lower end leading the water into the jackwell. Often, these split bamboos are placed under trees to collect the runoff water from leaves. Big jackwells are interconnected with more bamboos so that the overflow from one jackwell leads to the other, ultimately leading to the biggest jackwell.

28. Patrick Bahal'okwibale, FAO, Ethiopia

Dear Colleagues,

The contributions you have been providing are so impressive. As I was reading through them, I am realizing how much valuable knowledge is embedded in local, traditional or indigenous practices. The most promising is that your contributions represent testimonies that the practices could offer such huge opportunities for adaptation to climate change and address the increasing water scarcity.

I have also experienced a traditional practice of sensing the environment to predict an imminent rain: if it feels warm, it will likely rain. Similarly, if a sunny day feels so cool, one should not expect any rain. Every time I check this, it reveals true to me. While I learned this long ago from my grandparents, I have never had the chance to see published evidence that explains this phenomenon. However, I later realized that the same sensations are experienced when an air conditioner is set to increase humidity in the environment: The sensation of heat on the skin could thus be greatly influenced by air humidity. With regards to the indigenous early warning practice, the sensation of heat (or cool) was thus simply a reflection of increasing air moisture leading to a forecasted rainfall (or decreasing air moisture leading to the forecast of absence of rains).

I am surely not the only one to have been impressed by such traditional effective practices, yet poorly documented in scientific journals. It would thus be opportune if contributions could also address such a barrier.

At this stage, we would be happy if members could read through others' contributions and check if they have additional references that support any of the member's submission. We would really love to receive any such links before the closing of the forum.

Many thanks in advance!

Patrick

29. Bongani Ncube, Cape Peninsula University of Technology, South Africa

Dear Colleagues,

It is good to see such a comprehensive collection of indigenous practices from across the world. My contribution is not necessarily on practices, because most of my research findings from the Karoo (South Africa) are already captured in this draft. I, however, have a few contributions/comments:

1. The South African case studies should also look at the following book:

Alcock, P.G., 2010. Rainbows in the Mist: Indigenous Weather Knowledge, Beliefs and Folklore in South Africa. Pretoria: South African Weather Service.

2. I think more work/discussion or debate is needed on how we define indigenous knowledge. The adopted definition portrays indigenous knowledge as an attribute of less technologically advanced societies, yet our findings in the Karoo show that IK also sits with commercial farmers, and this knowledge dates back to the 1700s. Yet, on the one hand, commercial farmers may not necessarily be seen as indigenous.

3. It is possible that IK is site or society specific in many instances, and may be defined by the history of a society/community. The question, therefore, is whether IK is transferable, in other words, can IK be adopted like we study the adoption of agricultural technologies? My challenge after collecting and documenting IK was how to translate and make it useful for the communities that we had studied, and the surrounding communities. There is need to translate IK into the local languages and to enable linkages between communities. We found a lot of very beneficial technologies, that farmers were using both in small-scale and commercial farming conditions. What is the best way of cross-pollinating the knowledge and making it relevant to all farmers? Is it possible to take IK out of one society and make it

more relevant for other communities, for example, certain water conservation technologies? We should also realise that some IK is not transferable, for example, weather prediction indicators.

Lastly, how can we make IK part of the early warning systems? An Officer who had worked in the Karoo for more than 25 years told me in 2013 that it takes about 3 years for a drought to approach, and he accurately predicted the drought that followed. How can we integrate that kind of knowledge to scientific methods?

4. What place does IK hold in the current climate change debate? There is a lot of information documented on how communities cope and adapt, but where does that information fit into the bigger challenge of climate change.

5. This document is about addressing water scarcity in agriculture. I expect the last chapter of the report to synthesise some of those IK practices in agriculture that will make agricultural water more available or used more efficiently.

30. Mwanza Floribert Kiebo, paysan voulant servir de modèle de développement à d'autres paysans pour les stimuler à l'action, Democratic Republic of the Congo

Original comment in French

Ce pont est sur la rivière Mulungwishi. Celle-ci est vitale pour la localité qui porte son nom, localité située à 150 km de Lubumbashi dans la province du Haut-Katanga en Rép. dém. du Congo. Elle inonde une très vaste marée où sont creusés plusieurs drains d'irrigation traditionnelle d'une ferme et des centaines et centaines de champs.

Mais, maintenant, des rejets miniers chinois sont déversés dans cette rivière. La ferme n'est plus cultivable comme plusieurs champs. Avec d'abondantes pluies de cette année, la crue a été exceptionnelle ou jamais vue suite à ces dépôts miniers. Des champs, des maisons détruits sans que le gouvernement, ni personne n'assiste les sinistrés jusqu'à ce jour.

Un fléau pour la rivière qui irrigue Mulungwishi.

English translation

This bridge is over the river Mulungwishi. This is vital for the local population which bears its name, located 150 Km from Lubumbashi in the province of Haut-Katanga, Democratic Republic of Congo. The river floods a huge low lying area where many traditional farm irrigation ditches have been excavated and hundreds and hundreds of fields.

But, at present, Chinese mining wastes are discharged into this river. The farm is no longer cultivable as many fields. With heavy rains this year, the flooding has been exceptional or never before seen as a result of this mining waste. Fields and homes destroyed with so far no help from the government, or anyone else, for the people affected.

A curse for the river that irrigates Mulungwishi.

31. Debarati Chakraborty, University of Kalyani, India

Dear All,

I will like to draw attention towards a very important indigenous practice of water conservation named sacred groves. Sacred groves are extremely important in terms of biodiversity, cultural, religious and ethnic heritage and are intertwined with numerous traditional legends, lore, and myths. They are home

to many rare and endemic wild plants having agricultural and medicinal value. International Union for Conservation of Nature and natural Resources (IUCN) treats them as sacred natural sites (SNS). These relic forest patches often protects watersheds and are source of water for agricultural fields nearby. Several sacred groves have been reported throughout the world being intimately connected with indigenous local communities. Examples can be given of Yoruba of Ara in southwestern Nigeria, the Kuna Indians of Panama, South America, the Cocnucos and Yanaconas of Colombia, the Tukano of the Uaupés basin on the Brazil–Colombia border, coastal sacred groves (Kayas) of Kenya. India is home to about 100,000 sacred groves being protected by indigenous communities throughout the country. Some of the famous Indian Sacred groves occurs in Khasi Hills of Assam, in the Arvalli ranges of Rajasthan, all along the Western Ghats in the southern peninsula, in the districts of Bastar and Sarguja in Madhya Pradesh, in the Chanda district in Maharashtra, in the Bankura, Birbhum and Purulia districts of West Bengal.

Sacred groves maintains ecological services like preserving local hydrological cycles, preventing soil erosion, serving as firebreaks, and serving as areas of recruitment of species, allowing for ecosystem renewal during various disturbances. Especially in mountainous terrain, their rich vegetation plays crucial role in slope stabilization and soil conservation. As the runoff water is reduced, paving way for greater infiltration, soil erosion and sedimentation of downstream areas are minimized. Grove soil is usually rich in organic matter due to efficient decomposition of leaf litter, dead wood and other remnants. Water seeping out of sacred groves into the surrounding cultivation areas is considered nutrient rich by village communities. Hence my suggestion is conservation of sacred groves with emphasis on their role in agricultural water management and biodiversity conservation should be prioritised.

32. Almaquio Romo Gómez, UTN PESA FAO México, Mexico

Original comment in Español

En México en algunas zonas indígenas de la mixteca poblana, aún se pueden ver las conducciones de agua a base de tallos huecos de algunas plantas endémicas de la región; estos tallos acomodados siguiendo una curva a desnivel hacen que el precioso líquido llegue desde donde nace agua en los terrenos accidentados de las sierras hasta las pequeñas explotaciones de las familias indígenas.

English translation

In Mexico in some indigenous zones of the Mixteca Poblana region, you can still see water pipes made of hollow stems of some endemic plants; these stems, arranged following an uneven curve, make the precious liquid arrive from the rugged terrain of the mountains to the small farms of the indigenous families.

33. Bruno Kestemont, Federal Public Service Economy, Belgium

Original comment in French

Les règles de réciprocité assurent en partie, de manière universelle, la gestion du bien commun, dont les forêts (sacrées), les terres cultivables, les pêcheries ou l'eau. Sabourin (2011) reprend de nombreux exemples chez les Balantes et Bijagos de Guinée-Bissau, les kanaks de calédonie, les paysans du nord-est du Brésil, la Bolivie etc.

La part de la réciprocité et la part de la loi moderne varie selon les pays et les époques (l'Etat ou le marché y prend une part plus ou moins grande). Toutes les sociétés résistent à une trop grande

privatisation ou étatisation en maintenant des règles d'éthique, comme par exemple une règle d'hospitalité dans les pays chauds: " **l'eau ne se refuse pas**". En France, on peut entrer dans un café et demander un verre d'eau, de l'eau est disponible gratuitement aux fontaines publiques depuis la nuit des temps et au restaurant, on peut demander une carafe d'eau, à volonté, gratuitement. Il en va de même dans toutes les sociétés rurales d'Afrique ou d'Asie. Une autre règle éthique concerne la **gestion d'un cours d'eau** en zone aride ou irriguée, de l'amont à l'aval: on se doit de laisser de l'eau (propre) aux cultivateurs en aval. La gestion traditionnelle est organisée en bassin versant, système qui a été redécouvert dans l'Europe moderne (contrats et Commissions de rivières). Dans le monde moderne, ce sont les communautés qui ont poussé à ce que ces règles de base entrent dans la loi, voire dans la constitution. Ce sont les Conseils ethniques qui ont obtenu de réserver une série de droits de base et de règles de gouvernance (laissant une place aux décisions traditionnelles) d'abord dans des lois (en Bolivie, Colombie, Equateur à la suite de la Loi des Communautés Indigènes de 1974 au Pérou) voire dans les Constitutions modernes p.ex. en Equateur (2008) et en Bolivie (2009). Divers articles de la constitution équatorienne garantissent une co-gestion traditionnelle des terroirs et de leurs ressources, ainsi que le droit inaliénable des populations concernant les ressources principales y compris l'eau. La notion éthique du droit au "bien vivre", issue de la réciprocité traditionnelle y est incluse. Biblio: voir Sabourin 2011.

La tradition organise la gestion des ressources communes par l'intermédiaire de conseils des anciens, chefs de familles réunis sous l'arbitrage du descendant de la première famille à s'être installée sur un terroir donné (dans le cas des sédentaires). Le territoire et ses "frontières" est géré et organisé en fonction de la ressource. Par exemple, une ressource en eau (rivière) est gérée en fonction du bassin concerné, de l'amont à l'aval, par toutes les familles concernées.

Chez les balandes de Guinée-Bissau, la gestion traditionnelle des rizières de mangrove est reconnue comme plus efficace que toute gestion moderne (Kestemont, 1989). Les sols de mangrove, sulfatés acides, sont en effet très fragiles et risquent de se transformer en déserts acides en cas d'erreur de gestion de l'eau, comme on l'a vu dans des projets modernes en Casamance. La gestion traditionnelle a prévu de laisser chaque famille gérer chaque "corde" (succession de rizières d'amont pluvieux à aval salé) séparément, de manière à éviter les problèmes de voisinage dans la gestion essentielle de **l'eau pour la préservation du sol et des rendements** (voir Kestemont 2003 pour références et anecdotes).

See the attachment below

[Kestemont1989 balantes.pdf](#)

Biblio:

Sabourin, E 2011. Organizações e sociedades camponesas uma leitura através da reciprocidade. Porto Alegre. Ed da UFRGS

-Kestemont Bruno, 2003. "Critique des conditions de la durabilité: application aux indices de développement durable". Travail de fin d'études. DEA en gestion de l'environnement, IGEAT-ULB, 214 pp.

KESTEMONT, B., 1989, "Les Balantes Brassa Bungue de la région de Tombali, GuinéeBissau", Sémin. Civ.Afr. (la plus gde dist.), ULB, mars, 27 pp (voir annexe)

English translation

The rules of reciprocity partly ensure, in a universal way, the management of the common patrimony, covering woods (sacred), cultivable land, the fisheries or water. Sabourin (2011) refers to many examples from the Balantes and Bijagos of Guinea Bissau, the Kanaks of New Caledonia, the peasants of the North-East of Brazil, Bolivia, etc.

The role of reciprocity and the role of modern law vary according to the country and the times (the State or the market have a larger or smaller part to play). All societies resist too much privatization or nationalization by maintaining ethical rules, for example a rule of hospitality in hot countries: "water is not refused". In France, one can go into a cafe and ask for a glass of water, water is available freely in public springs from the beginning of time and in restaurants, one can ask for a pitcher of water, at will, freely. It is the same in all rural societies in Africa and Asia. Another ethical rule concerns management of a water course in an arid or irrigated area, from upstream to downstream: one should leave water (clean) for the farmers downstream. Traditional management is organized by watershed, a system that has been rediscovered in modern Europe (contracts and River Boards). In today's world, it is the communities who have pushed for these basic rules to be embodied in law, even in the Constitution. It is the ethnic Councils which have managed to establish a series of basic rights and rules of governance (reserving a role for traditional decisions) firstly in the laws (in Bolivia, Colombia, and Ecuador following the Indigenous Peoples Law of 1974 in Peru) as seen in modern Constitutions, for example in Ecuador (2008) and Bolivia (2009). Several articles of the Ecuadorian Constitution guarantee a traditional joint management of land and its resources, as well as the inalienable right of the people to the main resources which include water. The ethical notion of the right to "live well," embodied in traditional reciprocity, is included. Bibliography: see Sabourin 2011.

Tradition organizes the management of common resources through councils of elders, heads of families meeting under the arbitration of the descendant of the first family who settled in a given land (in the case of settled people). The land and its boundaries are handled and organized according to the resource. For example, a water resource (river) is managed as a function of the water basin involved, from upstream to downstream, by all the families concerned.

With the Balande in Guinea Bissau, the traditional management of paddy fields in mangrove is recognized as more efficient than all modern management (Kestemont, 1989). The mangrove soils, acid sulphates, are in fact very fragile and are at risk of becoming acid deserts in case of a water management error, as has been seen in the modern projects at Casamance. Traditional management has foreseen the need to allow each family to manage each "rope" (series of paddy fields with rainwater upstream to salty downstream) separately, so as to avoid problems with neighbors in the essential management of the water for the preservation of the soil and productivity (see Kestemont 2003 for references and anecdotes).

34. Audrey Pomier Flobinus, Humanity for the World (HFTW), France

Original comment in French

Bonsoir à tous,

La Martinique est un petit bout de **France** située dans les Caraïbes, nous bénéficions donc d'un climat tropical.

Trouvez ci-joint ma contribution pour ce qui concerne :

- Récupération de l'eau (et pratiques de stockage)

Je me souviens que mes ancêtres avaient pour coutume de stocker l'eau des pluies, dans des contenants divers et variés (Vase en terre cuite, fût en bois, fût en plastique, bidon en plastique, calebasse, ...etc.) en fonction de la période, de leur capacité, et de leur niveau social.

Très souvent, ces contenants étaient couverts pour protéger l'eau.

Pour l'assainissement de cette eau, ils faisaient usage, de matières naturelles comme le charbon de bois et/ou le soufre, qu'ils laissaient au fond du récipient.

Ces pratiques jugées à l'époque archaïques avaient été abandonnées au profit de la modernité de l'évolution du monde et des cultures.

En 2018, les pratiques ancestrales en matière de stockage sont de nouveau à l'ordre du jour même si elles ont été quelques peu revisitées.

En effet, les modalités de la nouvelle feuille de route en matière de développement durable transversal (**ODD6 : Eau propre et assainissement**) reprises par le **Ministère de la transition écologique et solidaire** de la France, recommande dans le cadre de l'amélioration de la gestion, de la préservation des ressources naturelles, notamment de l'eau en cas de sécheresse, l'option de citernes pour les usages domestiques.

Des aides d'états sont allouées pour permettre à chacun de posséder une citerne (**aux normes sanitaires européennes**) pour le stockage de l'eau des pluies.

English translation

Dear all,

Martinique is a French territory located in the Caribbean, so we have a tropical climate.

Find enclosed my contribution to those whom it may concern:

- Water recovery (and storage methods)

I remember that my ancestors had the habit of keeping the rain water, in several different kinds of containers (clay pots, wooden and plastic barrels, plastic buckets, gourds, etc.) according to the season, their capacity and their social level.

Very often, these containers were covered to protect the water.

For the purification of this water, they used natural substances like wood charcoal and/or sulphur, which they left at the bottom of the receptacle.

These practices considered old fashioned at the time have been abandoned in line with the modernization of the evolution of the world and customs.

In 2018, these old ways of storing are again in general use even if they have been a bit modernized.

In fact, the methods of the new roadmap in terms of transverse sustainable development (SDG 6: Clean water and sanitation) adopted by the Ministry of Ecological and Inclusive Transition, recommend in the context of improving the management and preservation of natural resources, in particular water in case of drought, the option of cisterns for household use.

State assistance is provided for to allow everyone to have a cistern (conforming to European sanitary norms) for the storage of rain water.

35. Edson Cagape, CSO, Philippines

Sirs/Madams:

Agriculture is one of my passions through a disruptive common element. The other passions are disruptive energy and disruptive medical-music (mosquitoes). These disruptive measures interconnect with each other which is water relevant.

For almost 4 years I have been using the disruptive common element (I don't know how to term it) on my 12-hectare farm and I had reached a definitive conclusion that this might be one of the many factors to end hunger in the tropical and sub-Sahara zone countries.

Comparing the annual harvest production between the tropical and sub-Sahara zone countries to that of the semi-temperate and temperate countries they have more annual bountiful harvest.

I am really looking for possible ways to perform a hands-on demonstrations.

Thank you.

Respectfully,

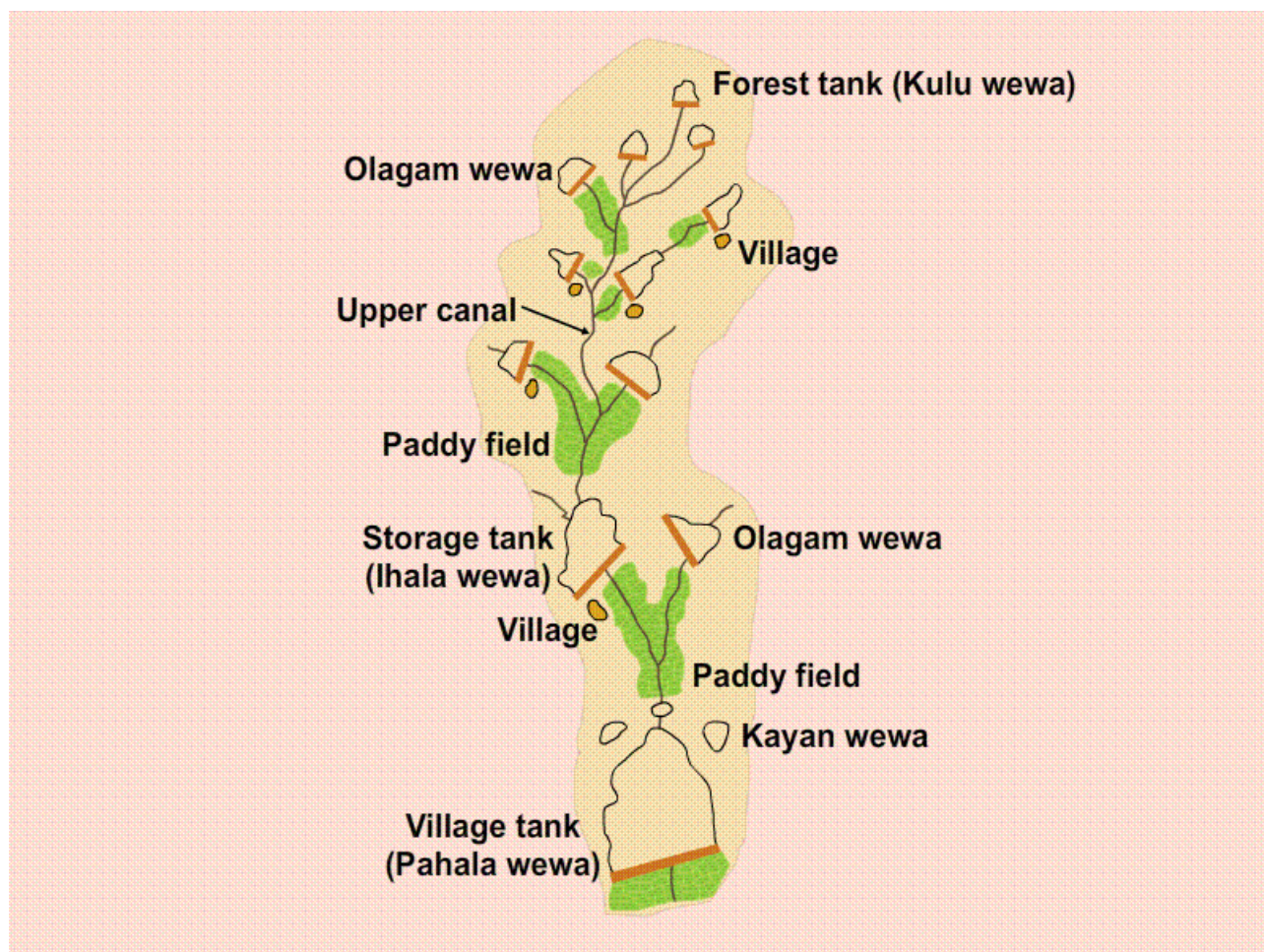
Edson Rabuyo Cagape

36. P.B. Dharmasena, Sri Lanka

In Sri Lanka, people have been practicing irrigated rice cultivation using small tanks, which are found mostly as clusters known as tank cascade systems.

There are 1,162 such cascade systems functioning at present in the dry and intermediate zones of Sri Lanka. They traditionally utilize water resource in an integrated manner. The rice is cultivated below these tanks with the influence of groundwater raised due to these water bodies. They cultivate according to rainy seasons taking maximum benefit of rainfalls. Tank water has been released during the major rainy season only when the crop is not supported from groundwater and rainfalls during dry spells.

This practice could save major portion of the tank water for subsequent minor season, where rainfall is too small. Some tanks built up in the upper area of the cascade system can release water to lower tanks in any emergency, when the crop is affected with water scarcity during the minor season. This system is operational even at present, however silting of the tanks due to soil erosion has led to reduce its potential.



Dr. P.B. Dharmasena,

Former National Consultant of FAO (Agriculture and Water Management)

37. Ines Gasmi, Institut des Régions Arides, Tunisia

The current situation of water resources and their uses in the southeast of Tunisia presents some stakes that are common to many regions of the Mediterranean basin. Limited water resources are widely used to meet the growing need and increasing commodification of resources, which required the implementation of Natural Based Techniques for the valorisation of runoff water with the protection of downstream villages from floods. There are several traditional and modern of rainwater Harvesting (RWH) techniques currently used. However, the most important traditional RWH techniques in the southeast of Tunisia are the "Jessour" and the "cisterns" which conserve water for irrigation during drought season and protecting the downstream villages from flooding during rainfall exceptional events (https://books.google.tn/books/about/Etude_des_Jessours_dans_les_Monts_de_Mat.html?id=CiqbjgEACAAJ&redir_esc=y)

38. Qand'elihle Simelane, Swaziland

In 2013, SADC, through the Global Water Partnership (GWP), conducted a study on Local Indigenous Knowledge Systems and Practices (LIKSP) and how they contribute to enhancing climate resilience of communities in the SADC region. The study produced country reports as well as a regional report.

Although I have no online access to either national or reports, an online article on this is available on the GWP-SA website here,

<https://www.gwp.org/en/GWP-SouthernAfrica/About-GWP-SAF/more/News/Local-Indigenous-Knowledge-for-coping-with-water-related-disasters/>

I have no doubt that GWP-Southern Africa would be willing to share the findings if not the full report.

Regards,

Qandelihle Simelane

39. Hafeez Rehman, University of Agriculture, Faisalabad, Pakistan

Alternate wetting and drying (Tar-Watar) is commonly practiced in many crops particularly in rice in Pakistan as usually flooded conditions are difficult to maintain throughout growing season. This improves growth, yield and stabilize quality. Now rice is being propagated by direct seeded method in many parts, also irrigated by Tar-Watar method and under growing water scarcity in Pakistan, it will complement to existing water crisis in Pakistan and also to stabilize the rice prices including quality due to reduced cost of production.

40. Mylene Rodríguez Leyton, Universidad Metropolitana de Barranquilla, Colombia

Water in agriculture: how do indigenous or traditional practices help?

Based on your experience (or knowledge), which of the following indigenous / traditional practices have been successfully applied and replicated (at different times or places) to address water shortages in agriculture? Please provide examples and references.

In Colombia, Article 366 of Chapter 5 of the Political Constitution establishes that the general welfare and improvement of the quality of life of the population are social purposes of the State and defines the fundamental objective of its activity the solution of unmet health needs, education, environmental sanitation and drinking water.

Likewise, various regulatory efforts have been made to guarantee water governance, identifying water management as a complex issue where historical processes and cultural diversity generate particular conditions where it is prudent to promote the dialogue of knowledge that facilitates the interaction of water. Scientific, empirical and ancestral or traditional knowledge regarding the use and management of water in harmony with the environment. The complexity of the sustainable management of water in Colombia has to do not only with cultural aspects but also with issues of economic, political and even of armed conflict that for years have influenced agricultural development.

This complexity makes it difficult to identify the role played by peasant communities and ethnic groups in particular on practices for effective water management; as if they are observed in other countries of America specifically the Andean countries.

There is evidence of water management not precisely in the face of scarcity but aimed at coping with floods and adaptation to climate change, this is the case of the Project for the reduction of flood risk and

adaptation to climate change in La Mojana. It is a region located on the Colombian Caribbean coast, comprising one of the most complex water deltas in the world as it collects the inflows of three of the most important rivers in Colombia such as the Cauca, San Jorge and Magdalena rivers (Brazo de Loba). This region comprises 11 municipalities that are part of 4 departments.

This is a project of integral intervention for the reduction of flood risk in the region of La Mojana and its objective is to develop actions that lead to a better adaptation of its inhabitants to the environmental and hydro-meteorological conditions, as well as to the social characteristics and economic in the region.

These types of initiatives are aimed at improving the living conditions of the farmers and aim to reduce the poverty conditions in which they live.

- On the other hand, as a second example, related to Soil and Water Management, Colombia is a coffee producing country in different regions. The guild of coffee growers establishes a series of Recommendations for the adequate management of water for Colombian coffee zones, based on the postulate that the proper management of water in crops, drainages and buildings contributes to reduce the risk of occurrence of landslides and erosion, for this reason the following recommendations are given:

- Avoid building and living in areas of high risk, such as those traditionally flooded (IDEAM, 2010)
- Channel the waters coming from the roofs of houses and other constructions, and lead them to a protected natural drainage; check hoses, water pipes, sewers and in case of finding water leaks, changing or repairing them, as well as tanks or water reservoirs; Periodic maintenance of the septic tanks and conduct the overflow waters to a protected site.
- Do not divert or clog sewers or drains, maintain natural drainage or beds of well protected glens with live plant material, always maintain a buffer zone with dense vegetation on the banks of the water sources, be careful with accumulation of rainwater in coffee plantations or in different places, since this can generate mass movements, monitor the flow of rivers, streams and drains, a decrease in the normal flow can mean that a dam is being formed upstream (IDEAM, 2010).

Maintain the soil with coverings, carry out the integrated management of weeds in their crops (Hincapié and Salazar, 2007).

What terminology would be the most appropriate to classify them impartially in the compilation? (for example, indigenous knowledge, traditional knowledge, knowledge of indigenous peoples, knowledge of the community or local knowledge systems ...).

The practices of rural communities in agriculture, including those related to water management to mitigate their scarcity in the drought seasons, in my opinion, are part of popular wisdom, which is the product of intuition, of one's own experience and of The need of human groups to adapt to the environments where they live have developed to survive, in most cases they are effective.

The rural communities of the world being in their various indigenous cases, do not always correspond to this ethnic group, there are also Afro-descendants, mestizos and Rhom or gypsy communities, for that reason I propose that from the semantic point of view they should not associate only with the indigenous communities but that could be called traditional knowledge or local knowledge, since they arise from their own knowledge, from their customs, value systems, beliefs that are called popular, they do not derive from the paradigm of the scientific method.

See the attachments below

<http://www.fao.org/fsnforum/sites/default/files/discussions/contributions/art%20agua%20y%20pueblos%20indigenas.pdf>

<http://www.fao.org/fsnforum/sites/default/files/discussions/contributions/agua-biodiversidad.pdf>

<http://www.fao.org/fsnforum/sites/default/files/discussions/contributions/gobernabilidad%20del%20agua%20en%20colombia.pdf>

<http://www.fao.org/fsnforum/sites/default/files/discussions/contributions/gobernabilidad%20del%20agua%20en%20colombia.pdf>

http://www.fao.org/fsnforum/sites/default/files/discussions/contributions/traditional_knowledge_a_dvantage_s.pdf

Mylene Rodríguez Leyton

Professor Investigator Metropolitan University of Barranquilla

Nutrition and Dietetics Program

Group of feeding and human behavior

41. Mwanza Floribert Kiebo, paysan voulant servir de modèle de développement à d'autres paysans pour les stimuler à l'action, Democratic Republic of the Congo

Original comment in French

L'eau: c'est la vie. Les perturbations climatiques nous apportent maintenant ou trop de pluie ou peu de pluie. Un autre mal vient s'ajouter à Mulungwishi, contre l'irrigation des cultures, ce sont les rejets miniers qui sont déversés dans les rivières du Katanga, en Rép. Dém du Congo. Mulungwishi est une illustration. Cette année a été pire: Champs, ferme et habitations ...détruits. La couche de ces rejets dans la rivière, avec beaucoup de pluie, la crue a été du jamais vu. Ces gangues acides déposées dans des champs, ces champs sont finis et l'autorité gouvernementale est silencieuse. Quelle irrigation maintenant ?

English translation

Water is life. The climatic disturbances bring us now either too much or too little rain. Another evil is being added to Mulungwishi, against the irrigation of crops, namely the mining waste that is being dumped into the rivers of Katanga, in the Democratic Republic of Congo. Mulungwishi is an example. This year has been worse: Fields, farm and houses...all destroyed. The layer of these discharges into the river, with a lot of rain, caused unprecedented flooding. Once these acid gangs are deposited in fields, these fields are over and the government authority remains silent. What kind of irrigation do we need now?

42. Vivian Onyango, FAO, Italy

I just read on another platform an idea that links quite well with this discussion and that is the role of technology in enhancing or improving traditional/local approaches to water scarcity.

Still on pastoral communities where my initial comment was on the importance of negotiation of rights of access to water and pastures within and between communities, normally scouts would be sent in advance to the resource endowed areas to find out about availability then come back and inform their village elders who would then follow up with negotiations before communities would move to these areas for access.

Now, some good suggestions are being made on how technology is currently facilitating these practices and the opportunity to improve in the future exists. These include the role of mobile phones for facilitating communication, motor bikes for quick movement and also the role of satellite generated data

that communities can access in real time in observing resource fluctuations and strengthening inter and intra community contacts to advise on when and how to move.

43. Chandima Gunasena, Freelance Reseacher, Sri Lanka

Structural and non-structural water management concepts and community participation in managing land and water resources in ancient Sri Lanka

Hydraulic civilization was prominent in Anuradhapura and Polonnaruwa eras till the 13 century Anuradha Senaviratne (1987). Cascade system was identified as the managing land and water systems in dry zone areas Madduma Bandara in 1995. Sustainable system of managing each and every component of the landscape and water resources was discussed in details by P.B. Dharmasena in 2010 and emphasized the community participation in managing these systems identified as “Ellangava”. Abayasinghe in 2018 highlighted the need of restoring the cascade system or the “Ellangava” system of management as a remedy for the unidentified conical kidney deices.

Community participation in land and water management could be identified as one of the successful management strategy practiced in ancient hydraulic civilization in Sri Lanka. Structural and not structural land and water management techniques used in the ancient past were based on several hydraulic control systems namely, increase of infiltration by providing detention ponds or depression areas, water quality control by using grass covered areas or constructed wetlands or bio retention areas, increase of flow path to increase the time of concentration and thereby to reduce the flow velocity and the discharge quantity, replenish groundwater aquifers by using structural ponds, grass covered swells etc.

All these ancient water harvesting systems help to retain water not only for human consumption but also for other living flora and fauna allowing retaining the bio diversity. Therefore, ecosystem resilience is well managed at micro scale while development work is carried out by the humans to improve their livelihoods at macro scale. Macro scale development model could be identified as an aggregation of several micro level management systems run by the community.

Micro level geographical units of management or micro catchments are managed by the community and community participation was kept at maximum to manage the land and water resources. This model has been now identified as “Ellangava” management system or cascade management system.

Principle behind the cascade or “Ellangava” system could be identified as a system which used to classify the landscape according to the topographical features and manage natural hydrological functions within those micro level catchments without any disturbances to the valuable ecosystem services. This management system also support ecosystem services and to maintain the resilience while improving the livelihoods of the stakeholders with the community participation.

This principle could be used globally to address the climate change scenarios to improve the land and water management strategies adapted in any country with the community participation to improve the ecosystem resilience as well as the livelihoods of the stakeholders.

Present paper discusses four cases to illustrate the present status of the hydrological controls adopted in Rnamasu Uyana, Segiriya lion rock area, Polonnaruwa ruin city and Udawaththa forest reserve in Kandy.

See the attachment below

[Land and water management in Sri Lanka.pdf](#)

44. John Ede, Ohaha Family Foundation, Nigeria

Water harvesting is an age long tradition that has been implemented and still practiced by local farmers especially in the desert prone areas, but that is usually not sufficient because of the changing climatic conditions.

Most farmers now rely more on local dams and government water storage facilities to help cope with the water scarcity. This is because; these local farmers can't afford to build their own storage facilities to cope with the water needs of their farms. Also it leads to over population around the water storage sites which could pose a potential threat of land grabbing, conflicts resulting in the depletion of the land resource used for production.

The water storages also come with the high cost of purchase of water pumping machines and water hose covering long distance to reach the farm lands; that some of these local farmers can't afford.

To control water use because of the water need of vegetable, local farmers use the traditional ridging irrigation system throughout the year for crop production to ensure vegetable supplies.

On the flip side, there is the competition for the stored water especially in the outer fringes of northern Nigeria where rainfall is not insufficient to meet their agricultural needs therefore having herders and farmers competing for the little water stored to provide water their animals by the nomadic Fulani herders and the local farmers.

There is currently farmers/herders in part of Nigeria leading to hunger, malnutrition, killings, and forced displacement due to the competition for the limited land and water resources in the areas affected.