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WATER for food and agriculture

HUMAN RIGHT TO WATER
Meeting the needs of the poor and vulnerable

NAMIBIA
Translating bush encroachment into economic value

WOMEN EMPOWERMENT
Unleashing the potential of mechanisation

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Dear Reader,

Water is the basis of all life on Earth. Without water, agriculture, and hence food production, would not be possible, and this sector accounts for more than two thirds of global freshwater consumption. However, constituting a mere 2.5 per cent of global water supplies, freshwater is a scarce resource. And it is becoming ever scarcer. The United Nations Educational, Scientific and Cultural Organization (UNESCO) estimates that by 2025, 1.8 billion people will be living in countries or regions with absolute water scarcity. Global warming is one of the reasons for this development. And the United Nations Convention to Combat Climate Change (UNCCD) reckons that, with the existing climate change scenario, by 2030, water scarcity will displace up to 700 million people in some arid and semi-arid regions.

As early as 1985, the then United Nations Secretary General Boutros Boutros-Ghali predicted that coming wars would be fought over water. This forecast has not yet materialised, at least not at national level. But where crop farmers and pastoralists have to compete for increasingly insecure water reserves, where people in giant refugee camps such as Cox's Bazar multiply local water demand in next to no time, and where the riparian countries of transboundary rivers such as the Euphrates and the Tigris, the Nile or the Mekong are literally cutting the ground together with the water from their feet with large-scale dam projects, the conflict potential tends to be high. Here, clever solutions are needed, solutions addressing the needs of all stakeholders, especially of the poorest and most vulnerable – in line with the "Leave no-one behind" principle of the Sustainable Development Goals.

We are presenting some of these inclusive approaches in this edition. They focus on socio-political aspects such as implementing the human right to water or preventing conflicts with water diplomacy, technological aspects like the use of water-saving irrigation infrastructure or tapping unconventional water sources, organisational aspects such as smallholders joining forces in water user organisations or multi-stakeholder action for the formation of water-resistant value chains. Benefiting from knowledge that has been there for centuries and adapting it to today's conditions, as is done, for example, in the practice of rainwater harvesting and management, represents another issue.

However, "water for food and agriculture" also means that one has to take a look at the flipside of the coin. This includes water pollution through pesticide and fertiliser runoff or through seepage of saline groundwater into water courses because of irrigation, as well as higher energy consumption because of an increasing amount of technology being applied in food production. Here, solar-powered irrigation presents a sustainable solution.

When we were discussing the concept for this edition about half a year ago, nobody had any idea that the novel Corona Virus Sars-CoV-2 would be spreading so rapidly, and in such a large number of countries. Perhaps we would have otherwise focused on water, sanitation and health. But you will see that our authors have consistently taken the water-food-livelihood nexus as well as the linkages with energy and the environment into account.

We wish you inspiring reading.

On behalf of the editorial team,

Silvia Richter

Partner institutions of Rural 21

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SCIENTIFIC WORLD

INTERNATIONAL PLATFORM

Photo: Manon Koningstein/ IWMI

Photo: Jörg Böthling

Moving from water problems to water solutions in a climate-challenged world

By Luna Bharati and Stefan Uhlenbrook

Photo: Jim Holmes/ IWMI

Photo: Jörg Böthling

The beginning of life on Earth has been linked to water. Modern humans (Homo sapiens) have inhabited this planet for some 300,000 years, most of that time as hunter-gatherers. Some 10,000 years ago, when people increasingly adopted an agrarian way of life, humans started establishing permanent settlements. All of the early civilisations were established close to large water bodies – rivers, lakes and the sea. About 70 per cent of our planet's surface area as well as of human bodies consists of water. Therefore, water is literally life.

Water underpins nearly everything we do: agriculture, industries, energy production, recreation, drinking, cooking and hygiene. It is also the foundation of every ecosystem on the planet. As such, the management of water cuts across sectors and international boundaries. Furthermore, cities are growing population hotspots, and the increasing populations and changing socio-economic expectations will impact water. The management of water also connects themes such as governance, equity, natural resources management, climate change and economic development. This fluidity of water requires equally fluid management systems.

How much water do we have, and can we access it?

The oceans hold about 97.5 per cent of the Earth's water resources as saline water. Therefore, only 2.5 per cent of all the water on the planet is fresh, making it a relatively limited resource. Furthermore, of this fresh water, around 68.7 per cent is frozen as glaciers and ice caps. And 30.1 per cent is difficult to access as it is stored below the surface as groundwater. This means only 1.2 per cent of all fresh water on the planet is accessible as surface water through lakes, wetlands, rivers, streams, soil moisture or biological water. The hydrological cycle basically consists of flows of water between various stores or storages (e.g. the atmosphere, oceans, snow and ice, rivers, lakes, reservoirs, wetlands, soils and aquifers).

Water availability calculations are based on the water resources available per spatial unit (e.g. basin or country) and time (daily, monthly, seasonal, annual or even longer time scales). The mismatch between water availability and demand leads to water scarcity issues and adds stress to societies. There are wide variations in water availability vs. demand between the different regions world-wide (see Figure on page 6). Water available in a particular country might or might not be generated within its own borders. For instance, upstream countries like Bhutan, Nepal, Ethiopia or China generate basically all their water within their geographical boundaries, while downstream countries like Bangladesh, Egypt, parts of Vietnam or the Netherlands receive the vast majority of their water from across their geographical boundaries.

In certain places, such as uplands in mountainous areas, water availability might be low even though a large river flows just a few hundred metres away in the valley below. If the upland areas have the economic means to access the river water through pumping, they do not have water scarcity issues. Similarly, groundwater or even shallow groundwater might be available, but lacking infrastructure to pump groundwater and necessary capacity, many countries face what is called economic water scarcity. This is especially true in many areas in Africa and South and South-East Asia.

Water and food systems – intrinsically linked

Agriculture is the largest water user, responsible for about 70 per cent of all freshwater withdrawals, most of which is used for irrigation. The 2018 United Nations World Water Development Report forecasts a 60 per cent increase in food demand by 2050, which will require more arable land and intensification of production and will also translate into more use of water. The recent EAT-Lancet report on sustainable diets makes clear that the way we currently produce our food and what we consume is becoming one of our greatest challenges, with the health of people and the environment depending on finding solutions. More than 820 million people have insufficient food, and many more consume an unhealthy diet that contributes to obesity, premature death and diseases. At the same time, global food production severely impacts climate stability and ecosystem integrity and constitutes the single largest driver of environmental degradation, climate change and the stability of the Earth system.

Agricultural systems are dependent both on hydrology and on related institutions, i.e. systems of governance that support sustainable and wise use of land and water. Sustainable, efficient and affordable water management is key to the transformation of the global food and agricultural systems. There is no agriculture without water. Thus sustainable water management is foundational for producing more food with less resources – referred to as sustainable agricultural intensification (SAI). Furthermore, water is a major contributor to the environmental footprint of agricultural practices. Examples include overdraft from rivers and groundwater leading to unsustainable depletion and transportation of pollutants to adjacent water bodies.

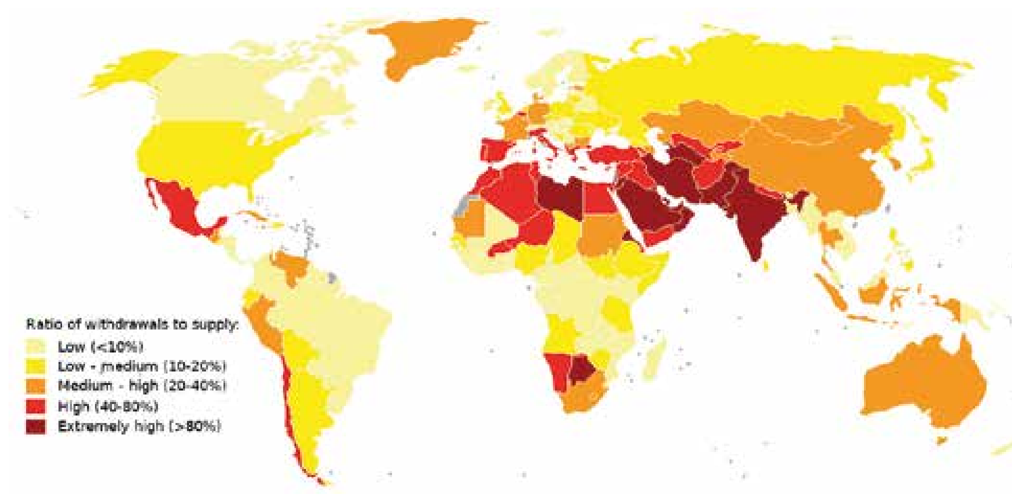
According to estimates by Gosling and Arnell, by 2050, up to three billion people may be living with increased water scarcity because of climate change, which is reconfiguring the water system. The fifth Intergovernmental Panel on Climate Change (IPCC) assessment

Photo: Hamish John Appleby/ IWMI

Photo: Jörg Böthling

reports with medium confidence that global surface temperatures in 2016–2035 will be 0.3°C to 0.7°C higher relative to 1986–2005. Towards the end of the 21st century, global surface temperature is projected with high confidence to exceed 1.5°C relative to temperatures in the 1800s. Of course various levels of anthropogenic emission scenarios give us different numbers, underscoring the need for action on emissions.

Variations in the degree of water stress in areas across the globe



Source: WRI

How climate change affects water availability

The IPCC warns that although projected changes particularly in precipitation are not uniform globally, extreme precipitation events will become more intense and frequent in many regions. Global warming has been linked to a wide range of water-related risks that also impact indirectly or directly on agricultural production – including animal husbandry and fisheries – and hence on food production and food security:

- intensification of the global water cycle leading to increasingly extreme events such as floods, droughts and tropical storms;
- changing variability in seasonal patterns of rainfall, onset and length of seasons, heat waves and extreme cold spells;
- less snow cover, loss of glacier ice and changes in river runoff impacting water availability;
- sea-level rise leading to salt water intrusion in coastal systems;
- lower water quality because higher temperatures strongly influence increases in organic matter, nitrate and phosphorus levels in river water;
- increased water pollution, because of more frequent extreme events and higher loads of sediments, nutrients, dissolved organic carbon, pathogens, pesticides and salt;
- significant changes in river flow patterns and hence impacts for the habitat of aquatic biota;
- impacts on groundwater availability. For instance, groundwater storage in the Murray-Darling basin declined substantially from 2000 to 2007 in response to a sharp reduction in recharge during the 1996–2010 Millennium Drought in Southern Australia.

As we understand more about the challenges posed by global warming, it has become widely accepted that water is the principal medium through which society feels the climate-related stresses. Smith et al. have identified water as the "teeth and claws" of climate change. But we have an opportunity to flip water from being a challenge into an opportunity. The world's community of water professionals largely share the view that water is not just a risk but is also the key to climate change adaptation. The world has a chance to align policy and implementation for water and climate change adaptation agendas around water resilience. This close connection between adaptation and water resources management has been increasingly recognised, and some even called the COP 25 – the 2019 United Nations Climate Change Conference – a 'water COP' because of the wide-ranging discussions on water-related climate issues.

Integrated approaches that go with the flow

The direct impacts of climate change on water will be effectively "multiplied" via the effects on the other sectors linked together in the water-energy-food-environment-livelihood nexus. So it's clear that we need integrated approaches. Improved water management options from farm-level water management to basin level, if done appropriately, will not only reduce current water-related risks and insecurities but also mitigate many of the potential negative impacts of climate change. Increasing the adaptive capacity and simultaneously enhancing water, food and energy security are often among the 'ripple effects' of improved water management and increased resilience of society.

To harness the climate adaptation potential of water – and minimise the climate-related risks – we need integrated management systems. Several concepts, such as the Integrated Water Resources Management, the Water-Energy-Food nexus and the Water Security frameworks, have been promoting various integrative and holistic approaches for basin water management. There have also been many initiatives, such as the establishment of river basin authorities, to introduce related processes around the globe that promote integrated river basin management and development. For example in the European Union, Integrated River Basin Management (IRBM) is fostered by two Framework Directives, which were established to realise sustainable, integrated and effective river basin management. The first one is the Water Framework Directive from 2000 with the objective to assess water quality and achieve a good status for all water bodies. Furthermore, the Food Risk Management Directive deals with the assessment and management of flood risks. Despite these examples, the actual management of water in most countries, and especially in the Global South, is still very fragmented and sectoral. This leads to inefficiency, un-sustainability and, under certain conditions, even to conflicts.

A holistic approach to water management is needed

In recent decades, adaptation to climate change impacts has become one key development agenda often also included in national plans and policies. There remains, however, a big gap in translating these global and national policies to local action plans and services. Furthermore, coordination between management and governance systems is a key challenge to ensure that water resources management is done with the purview of balancing benefits across various sectors, stakeholders and future climate risks. Here, it is important for water resources resiliency and adaptation planning to consider the varying levels of climate vulnerability in a basin given existing structural inequities in gender, income level, class, race, ethnicity, etc.

Above all in the Global South, achieving water sustainability faces a wide range of challenges. Often, data and comprehensive analysis of water resources are lacking at basin/country levels, and development planning and management is usually sectoral ('silo mentality') and fragmented. In addition, current governance structures and processes do not facilitate reaching a shared vision to develop a basin/country sustainably regarding water. And there is lack of understanding of the direction and magnitude of future changes and risks related to water and all its implications for the environment, society and economy.

Globally, the 17 Sustainable Development Goals with their 169 associated targets are demanding for holistic and integrated development. The shift in focus from merely growing productivity to also considering equity, social justice, environmental health and all other aspects for sustainability has brought development discourses to a crossroads. New targets and indicators are changing the ways success is measured. Integrated water management will play a key role in the implementation of all SDGs because of the interdependencies between many of the goals and targets. Therefore, understanding and managing trade-offs well will be essential.

We are moving into a world where rather than managing water for individual sectors, such as health and sanitation, we must integrate these with other needs such as water for irrigation, hydropower, industry, and ecosystems. This integration must be across multiple users and uses.

Future water resources management and development should ideally include all sectoral demands and achieve various societal objectives in a balanced way, under a wide range of plausible futures (robust) and incorporate adaptive and flexible solutions. And we need to support these solutions through enabling governance structures and policies that allow us to navigate our water resources challenges in turbulent waters. Our survival depends on this.

Integrated water management is key to harnessing the climate adaption potential of water.

Photo: Samurdhi Ranasinghe / IWMI

ANALYSING HISTORICAL DATA IS NO LONGER ENOUGH

For at least two centuries, the underlying assumption for managing water variability and extremes has been that we can assess future weather patterns, predict water risks, or design infrastructure, by analysing the historical data. Climate change and other environmental changes have invalidated this assumption – we cannot predict and plan for the future based on past trends anymore. Flood management, for instance, has traditionally used past records to determine parameters such as 1 in 100 years flood peaks. However, as we can expect the frequency and severity of flood events to increase because of climate change and often also in connections with other environmental changes (land use changes, urbanisation, channelling of rivers, etc.), risk calculations from the past are not usable. For example, precipitation levels during Hurricane Harvey in the Houston, Texas area in the USA in 2017, surpassed a return period for three-day extreme precipitation of 1 in 1,000 years for most locales and in one city, 1 in 9,000 years. Similar patterns are emerging for droughts. Cape Town's "Day Zero" drought that ended in 2018 has been estimated as a 1 in 300 years event as documented by 400 years of historical records. When two large tropical cyclones, Idai and Kenneth, hit South-eastern Africa in 2019, it was, according to the World Meteorological Organization (WMO), the first time on record that two storms of such intensity struck Mozambique in the same season.

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A Hmong ethnic girl using a household water source in Ban Sopphouan, Lao PDR. SDG 6 pays special attention to the needs of women and girls and those in vulnerable situations. Photo: Jim Holmes/ IWMI

Water for all – making SDG 6 a reality

"Water for all" is an important concept embedded in Sustainable Development Goal 6 on Water and Sanitation. However, implementation does not currently target differential access for women and marginalised people. Our authors show what actions are needed to resolve growing tensions around water scarcity and degradation, thus meeting the needs of the poor and vulnerable.

By Claudia Ringler, with Lyla Mehta, Barbara Schreiner, Theib Oweis and Shiney Varghese

Inequity in availability, access, use and stability of water resources adversely affects the livelihoods and food security of the poor. Increased water variability, growing water shortages and rapidly increasing pollution are costly, particularly for those who lose access first – and for those who have never had the possibility to access safe water for WASH (Water Supply, Sanitation and Hygiene) or productive uses. The reasons for these inequities lie in exclusions due to gender, caste, ethnicity as well as power imbalances and policy biases and failures.

The World Health Organization (WHO) estimates economic losses associated with inadequate water supply and sanitation at 260 billion US dollars annually, or 1.5 per cent of Gross Domestic Product from reduced health costs and time savings for the countries studied. Other benefits from WASH, such as the potential of nutrient reuse, an overall cleaner environment and enhanced dignity were not valued in this analysis. More than one third of total investment needs are in sub-Saharan Africa.

But water is needed for more than drinking and washing. The 2015/16 ENSO (El Niño/ Southern Oscillation) drought of East Africa showed the importance of stability of access to water for productive uses. The event led to a drop in cereal production in Ethiopia's highly vulnerable lowlands by 10 per cent while livestock herds shrank by 23 per cent. Agricultural gross domestic product across the country fell by 3.6 per cent, while gross domestic product across all sectors in the drought-prone lowlands fell dramatically, by over 11 per cent.

Sustainable Development Goal (SDG) 6, on Water and Sanitation ("Ensure availability and sustainable management of water and sanitation for all"), seeks to achieve universal and equitable access to safe and affordable drinking water and adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations (see Box on page 12). SDG 6 also includes a focus on improving water quality and on protecting water-related ecosystems. This should help address inequality in access to clean water and the degradation of ecosystems on which some marginalised populations rely for their livelihoods – and which are also the foundation of our food and agricultural system. The SDGs attempt to address inequality by focusing on universality.

Measuring and monitoring progress in water targets for the marginalised

However, the indicators used to measure progress in the SDG 6 targets miss accounting for improvements amongst the most marginalised and poorest populations. Without proper accounting and accountability, progress has remained mixed. According to Unicef and WHO, in 2017, 2.2 billion people lacked access to safely managed drinking-water, and access to safely managed sanitation services was not available to 4.2 billion people. At the same time, water pollution levels continue to worsen in much of the Global South as investments in treatment and management fall far short of needs while water-related ecosystems continue to degrade. Additional pressure on water resources is exerted from climate variability and change, which dries up the rivers and shallow groundwater resources of the poor and most marginalised, who are thus deprived of water sources for their daily productive and reproductive needs.

> National law is one source of rights, but customary, religious, and international law can also be important, especially for water rights.

Today, more than 200 million people still depend on drinking water obtained from sources with collection time in excess of 30 minutes, mostly in sub-Saharan Africa. The burden of water collection falls disproportionately on women and, in some cases, also on children, preventing them from caring for children, obtaining an education or generating income. Adequate support is needed for all countries to be able to monitor changes for women and other marginalised groups in key water targets, including those described in SDG 6. Without proper accounting and accountability, governments will likely prioritise access for those reached more easily, such as urban dwellers and the rich, while rural populations and the poor will continue to be left behind.

Acknowledging the linkage of the right to water with the right to food

In 2010, the United Nations General Assembly and the UN Human Rights Council recognised access to safe drinking-water and sanitation as a human right, while the human right to food had already been recognised as part of the Universal Declaration of Human Rights in 1948. While much progress has been made over the past ten years, globally many vulnerable women and men routinely face violations to their basic rights to water and sanitation.

At the local level, water, land and food are of particular relevance to local people's livelihoods and survival strategies and are tightly linked – an aspect that the human rights framework has failed to reflect, so that important action areas for poor and marginalised people are missing. When water and food shortages hit, families often have to make difficult choices. Should time be spent on water collection or food production, and should scarce financial resources be used on clean water for children or on meeting their food requirements? In these instances, either one or both human rights are violated.

A broader conceptualisation of the right to water would reflect how water is understood and embedded in the daily lives of local women and men around the world. Incorporating water for meeting individual and household food and nutrition requirements would increase the obligations of states to meeting the rights of the poor and marginalised as a priority for both water and food.

Recognising water rights, especially for the poorest

In many parts of the Global South, there are plural, overlapping and sometimes competing formal and informal legal and customary water rights systems, and most countries in sub-Saharan Africa are characterised by primarily informal water users' practices. Pastoralists and those engaged in freshwater fisheries or in traditional agricultural practices are generally engaged in a mix of informal and formal arrangements of accessing and using water, with many sources serving multiple functions. Processes that formalise water rights often fail to recognise customary rights, leaving small users without legal protection of their water rights in many instances, particularly in sub-Saharan Africa. Moreover, water use rights often depend on having access to land, making land tenure systems a key determinant of access to water.

A **human rights approach** focuses on 'substantive' equality, meaning that all people, regardless of race, class, gender, or other differences, should be allowed to enjoy their fundamental human rights. A human rights approach thus allows for positive discrimination to favour the most vulnerable. States are obliged to take targeted steps to realise their human rights commitments.

Statutory water laws with nation-wide permit systems were introduced in several African countries in the 1990s. However, the permit systems, which can be traced back to colonial roots, have widened inequalities in access to productive water use for millions of small-scale water users and irrigators on the continent. A hybrid system that recognises customary law while reserving permits for high-impact, large-scale commercial water users is called for to increase equity in access to water for everyone.

However, establishing water rights is far from straightforward, and the process itself can create conflict, particularly when statutory rights are inconsistent with customary or religious rights. Water rights shape people's incentives and authority to manage natural resources. For example, a group of irrigators with secure rights to a water source are more likely to be able to create and enforce rules for equitable sharing of the water than a group that does not have recognised water rights. The unique aspects of water, such as its mobility and the vital nature of water for all life, can complicate

Processes that formalise water rights often fail to recognise customary rights, leaving small users without legal protection of their water rights. Photo: Jörg Böthling excluding others from accessing and using water. These features make water rights different from land rights, and difficult to enforce.

Establishing clear water rights may reduce conflicts and uncertainty, increase economic efficiency, and avoid situations of otherwise assumed environmental degradation and wastage. Recognising such rights can, in turn, support effective water governance that ensures equitable and gender-just decision-making and allocation processes around water.

Realising investments in water security

Creating access to water for WASH and productive uses for the poorest and most marginalised farmers requires pro-poor investments that are linked to conducive enabling conditions, such as strong water rights systems that allow smallholder farmers and other marginal water users access to increasingly contested water resources.

Where rainfall can be stored for agricultural purposes, rainwater harvesting, which alters the runoff of rain, allowing for rainfall to infiltrate the soil and be stored for plant use, is a key intervention that not only supports food production but can also control soil erosion. In other areas, low-cost irrigation technologies, such as manual and, increasingly motorised pumps, including solar irrigation pumps as well as low-cost irrigation scheduling tools such as wetting-front detectors, can help farmers access and manage water resources. The Innovation Laboratory for Small-Scale Irrigation – an Initiative of the U.S. Government's 'Feed the Future' Programme – has developed a series of tools and practices to support small-scale farmers. Supporting low-cost agricultural water management approaches also requires increased investment in agricultural research and development for technical and institutional innovations that counter adverse impacts from climate-change induced, larger crop water requirements, increased heat and drought stress and more concentrated, shorter-duration precipitation events that are linked to flash floods, soil erosion and reduced soil water storage. For any of these measures to meet the needs of vulnerable and marginalised farmers, community involvement will be essential, and particularly the involvement of both rural women and men. Continued investment, recognising locally embedded cultural factors and needs as well as behavioural change are similarly important for increased WASH access for the poor and vulnerable. Technologies that are co-developed by those in charge of supplying water for domestic uses and that are low-cost, accessible throughout the year and provide safe water are those most likely to lead to sustainable change. For sanitation and hygiene, social learning interventions that help change mental models of the costs and benefits of improved sanitation and hygiene have shown great promise.

SDG 6 targets and indicators on water and sanitation

SDG 6 targets	SDG 6 indicators
6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.	**6.1.1** Proportion of population using safely managed drinking water services
6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.	**6.2.1** Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water
6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.	**6.3.1** Proportion of wastewater safely treated
	6.3.2 Proportion of bodies of water with good ambient water quality
6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.	**6.4.1** Change in water-use efficiency over time
	6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.	**6.5.1** Degree of integrated water resources management implementation (0-100)
	6.5.2 Proportion of transboundary basin area with an operational arrangement for water cooperation
6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.	**6.6.1** Change in the extent of water-related ecosystems over time
Implementing mechanisms	
6.A By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.	**6.A.1** Amount of water- and sanitation-related official development assistance that is part of a government-coordinated spending plan
6.B Support and strengthen the participation of local communities in improving water and sanitation management.	**6.B.1** Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management

Can SDG 6 become a reality?

Many countries in the Global South lack data to adequately monitor changes in drinking water and sanitation for assessing progress in SDG 6; according to UN-Water, only 20 per cent of the UN member states have reported on the water quality indicator over the last five years, and information collected on water-related ecosystems is currently insufficient to understand regional changes in ecosystem quality.

We believe that universality in access can only be achieved through a pro-poor focus of interventions. To drive this, measuring and monitoring progress for the marginalised, acknowledging a broader conceptualisation of the right to water as a conduit to the right to food, recognising water rights for the poor and marginalised and realising investments for water security for the underserved can resolve growing tensions around water scarcity and degradation.

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Facts and figures on ...

... water scarcity

- Globally, water scarcity already affects four out of every ten people. (WHO)
- By 2025, 1.8 billion people are expected to be living in countries or regions with absolute water scarcity, and two-thirds of the world population could be under water stress conditions. (UNESCO)
- By 2030, water scarcity in some arid and semi-arid places will displace between 24 million and 700 million people. (UNCCD)
- A third of the world's biggest groundwater systems are already in distress. (Richey et al. 2015)
- Two thirds of the world's population currently live in areas that experience water scarcity for at least one month a year. (Mekonnen and Hoekstra 2016)

... water and gender

- About three quarters of households in sub-Saharan Africa fetch water from a source away from their home, and 50 to 85 per cent of the time, women are responsible for this task. (UNESCO 2016)
- Reducing the time it takes to fetch water from 30 to 15 minutes increased girls' school attendance by 12 % according to a study in Tanzania. (UNICEF)

... transboundary waters

- 145 states have territory within transboundary lake or river basins, and 30 countries lie entirely within them. (UNECE/UNESCO 2015)
- Since 1948, history shows 37 incidents of acute conflict over water, while during the same period, approximately 295 international water agreements were negotiated and signed. (UNECE/UNESCO 2015)
- Around two thirds of the world's transboundary rivers do not have a cooperative management framework. (SIWI)

... water and ecosystems

- Since the 1990s, water pollution has worsened in almost all rivers in Africa, Asia and Latin America. (UNEP 2016)
- Globally, it is likely that over 80 % of wastewater is released to the environment without adequate treatment. (UNESCO 2017)
- An estimated 20 % of the world's aquifers are over-exploited. Deterioration of wetlands worldwide is reducing the capacity of ecosystems to purify water. (UNESCO 2014)

... water and agriculture

- Agriculture accounts for 70 per cent of global water withdrawal. (FAO)
- Over 324 million hectares are equipped for irrigation worldwide. (FAO 2012)
- 42 per cent of worldwide irrigation is located in two countries: China and India. (FAO)

... water and sanitation

- Today 1 in 3 people or 2.2 billion people around the world lack safe drinking water. (WHO/UNICEF 2019)
- Globally, at least 2 billion people use a drinking water source contaminated with faeces. (WHO 2019)
- Over half of the global population or 4.2 billion people lack safe sanitation. (WHO/UNICEF 2019)
- Approximately 50 litres of water per person per day are needed to ensure that most basic needs are met while keeping public health risks at a low level. (WHO 2017)
- 2 out of 5 people or 3 billion people around the world lack basic handwashing facilties at home. (WHO/UNICEF 2019)
- Universal access to safe drinking water and adequate sanitation and hygiene would reduce the global disease burden by 10 %. (WHO 2012)

Source: UN Water

In-situ RWHM: stone terraces in semi-arid Tanzania for cereal and horticulture crops.

Ex-situ RWHM: a rainwater storage tank for dry season irrigation in India.

In-situ RWHM: zai pits in Burkina Faso to regenerate degraded land.

Rainwater harvesting – more than sound water management

Rainwater harvesting and management (RWHM) is an effective approach to ensure that the production capacity of rainfed systems is sustained. Our author summarises some recent global and local knowledge related to this long-standing practice, with special reference to dryland crop systems.

By Jennie Barron

Rainfed agricultural systems dominate our global agricultural production. Globally, rainfed production systems constitute rainfed cropland (1.25 gigahectares – Gha) and rainfed pastureland (3.5 Gha). These areas support not only the produce of more than 60 per cent of nutritious food, but also a range of fodder, fibre, biofuel and other economically important crops for livelihoods and wellbeing. Given that rainfed systems cover in the order of one third of the Earth's land area, rainfed agricultural systems also affect a number of ecosystem services and functions in a range of highly populated landscapes. For example, such ecosystem services are related to water quantity and quality flows from field to catchment, carbon sequestration, nutrient (especially nitrogen and phosphorous) cycling and habitats for flora and fauna. Hence, it is of critical importance to manage rainfed agricultural systems both for crop production and for broader sustainability in order to maintain production and reduce negative environmental or climatic impacts.

Our rainfed systems are under imminent threat through land degradation, rainfall variability increase under climate change and conversion of highly productive rainfed land to other uses. This will undermine both rainfed systems and our ability to meet various Sustainable Development Goals such as SDG 1 (zero hunger) and other ecosystem services related to the SDGs on water (SDG 6), climate adaptation (SDG 13) and life on land (SDG 15).

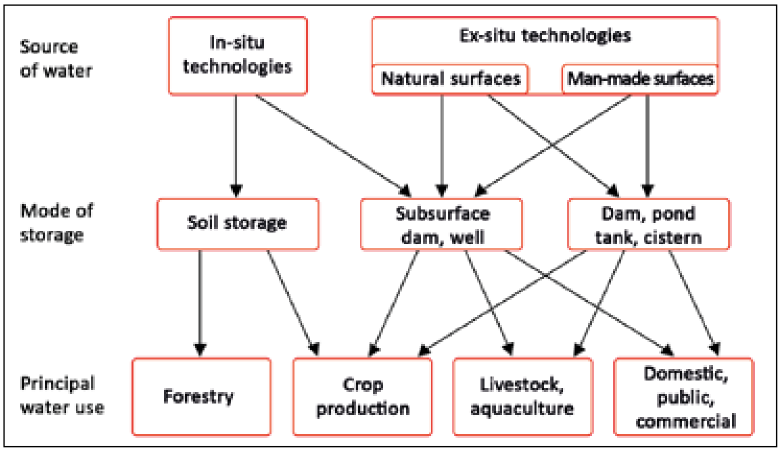
The practice of rainwater harvesting and management (RWHM) at field to landscape scale has been done in multiple rainfed systems, in some cases for thousands of years. The main aim is to reduce impacts of rainfall variability and improve crop productivity per area land, per unit rainfall and per unit labour (energy) input. It is an essential practice to secure the production capacity of rainfed systems in current increasingly variable weather conditions and in future conditions brought about by climate change, in particular in semi-arid and sub-humid climate regions (drylands). Globally, we have a wealth of experience to share and to inform best practices in RWHM. However, RWHM has often been treated as a water management approach, when essentially it is a combined effort of integrated soil, crop management and rainfall capture. Here, we outline new perspectives on how rainwater harvesting and management can contribute to safeguarding and increasing efficient use of rainfed agricultural systems for current and future human wellbeing and environmental sustainability.

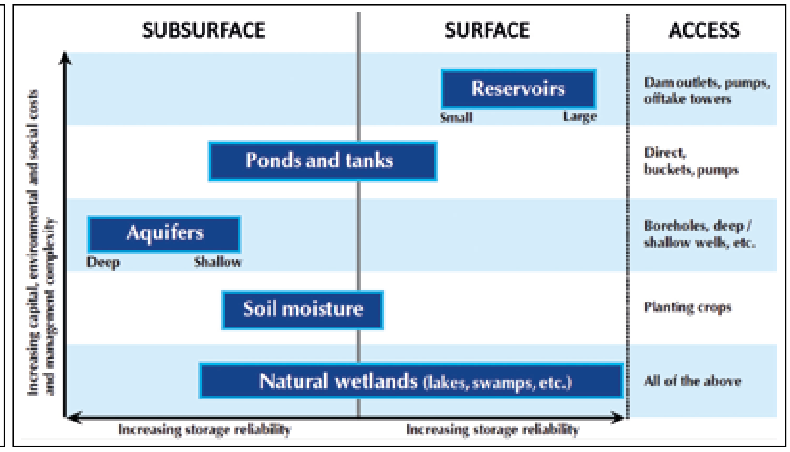
There is no universal definition of rainwater harvesting and management (RWHM). Instead, the concept of RWHM can be used for the collected technologies and practices for the active retention, infiltration and storage of rainfall and surface runoff at the local scale in agricultural landscapes (see Figure). The objective is to manage soil moisture or stored water (for supplemental purposes or irrigation) to bridge the natural occurrence of dry spells affecting crop production. These RWHM practices can also be referred to as sustainable land management (SLM) practices and, in the case of India, watershed management, constituting an important set of technologies at farm to community level to enhance soil and water use.

Estimating the potential

The selection of RWHM technologies all operate according to the principles of soil and water management, i.e. to retain rainfall, and store it in the soil or a water storage facility, and avail water in the root zone through various soil and crop management strategies (see Box on page 14). Both retention and storage principles need to be in place to ensure that the harvested rainfall is used optimally for crop and pasture production. The retained rainfall storage time of harvested water ranges from a few days (in the root zone of the soil) to a number of months (for local surface runoff storage in ponds, tanks or small reservoirs) to cover dry season periods.

A typology of rainwater harvesting technologies based on spatial scale of source of rainfall, and temporal turnover time in storage





Source left: after Douxchamps 2012/ McCartney et al. 2009 Source right: after UNEP 2009

Most farmers, especially in semi-arid and sub-humid climate zones practising rainfed agriculture with a highly variable rainfall amount and distributions, actively use RWHM principles to retain rainfall and maximise infiltration, through so-called in-situ RWHM (see Figure). Technologies include a range of artificial, sometimes mechanical soil bunds, soil pits, crust breaking and combinations with biological measures such as grass strips and mulching. For example, recent syntheses by Adimassu et al. (2016) for Ethiopia and Magombeyi et al. (2018) for the Southern Africa context suggest that without management of the agronomic aspects, in-situ RWHM may have only marginal crop yield benefits. The yield gain of RWHM is higher in low rainfall areas (<500 mm/year) than in rainfall areas exceeding 1,000 mm/year. A slightly different result was obtained by a meta-analysis evaluation of watershed work in India dryland systems that largely consisted of in-situ and ex-situ RWHM technologies for intensified crop production. The evaluation suggests that these interventions are most effective in the 700–1,000 mm/year areas (Joshi et al. 2008). Bouma et al. (2016) used a meta-analysis for cases in Africa and Asia and concluded that overall in-situ RWHM resulted in a yield increase averaging more than 70 per cent compared to a control context. However, the study did not differentiate between the physical RWHM vis-à-vis the combined physical context with biological and/or nutrient management examples. Thus, there may be specific design aspects to take into account to realise the yield benefits of RWHM technologies. Not applying some elements of RWHM in combination with agronomic practices in these regions of 300–800 mm/year may imply a yield loss of between 20 and more than 100 per cent.

Despite the lack of yield gain under RWHM practices in some cases, there is almost always a positive environmental and sustainability aspect with a reduced loss of sediment and surface water through runoff. The sources above suggest that soil loss could be reduced by 1.1 t per hectare and year (Joshi et al. 2008), or in Ethiopia, retaining more than 20 per cent of nitrogen and phosphor soil fertility using RWHM in combination with biological materials. In the case of Southern Africa, Magombeyi et al. maintains that RWHM practices retain up to 80 per cent of sediments and, on average, 60 per cent of surface water runoff for the Southern Africa region. These environmental benefits are typically not well accounted for when discussing RWHM. Hence, there is a need to recognise the farmer effort to manage field to landscape ecosystem processes more explicitly, in terms of implementing RWHM also for the benefit of the environment and ecosystem services.

Areas of ex-situ harvesting and storage such as small tanks, infiltration ditches and small reservoirs are increasingly being invested into to complement perceived or actual increased rainfall variability, and/or local water scarcity. Such storages of water have the added benefits of enabling use of water for multiple purposes – not just for crop water uptake as in in-situ RWHM, but also for irrigation, livestock, and, in some cases, even for domestic purposes.

Opportunities offered by RWHM and its future potential

Forthcoming climate change, with both rainfall and temperature changes for rainfed systems, means that there will be an increase in drylands of more than seven per cent, encompassing 3.3 to 5 billion people, as suggested e.g. by Koutroulis (2019). Even if not all food, fodder and fibre needs to be grown locally, these changes in climatic conditions expanding dryland conditions suggest that rainfall needs to be managed more carefully, unless more irrigation development, with associated freshwater outtake needs to be developed. The need to implement RWHM will be fundamental to secure sustainable and productive food as well as water supplies.

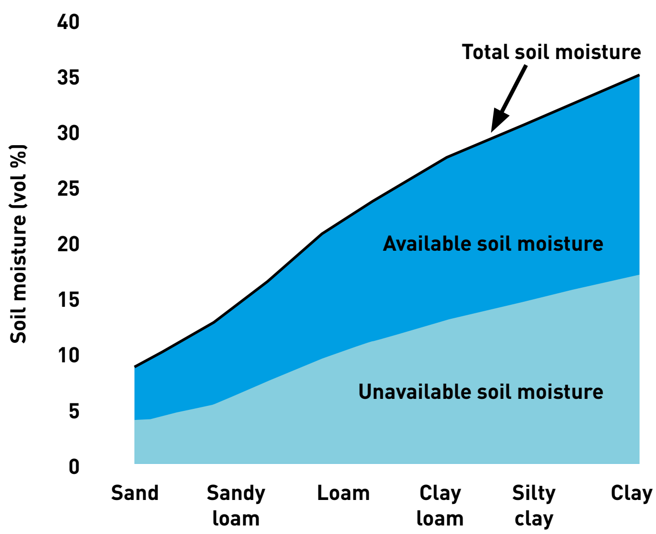
Already, there are a number of studies indicating that RWHM could potentially increase production and productivity and thereby ensure food security and sustainable land and water resources. For example, Rockström et al. (2009) modelled that better so-called soil moisture (green water) management through maximising use of rainfall can alleviate national water stress and food insecurity, and reduce populations under chronic water stress. A global study by Jägermeyr et al. (2016) differentiating between in-situ and ex-situ RWHM suggests that implementation on 50 per cent of current farmland could result in a potential 10-30 per cent yield increase. Under climate change, the benefits of RWHM on cropland can support an additional 10-30 per cent yield increase, compared to 'business as usual' without active RWHM, which would result in crop yield decreases of 5-20 per cent from current yield levels, in most dryland areas.

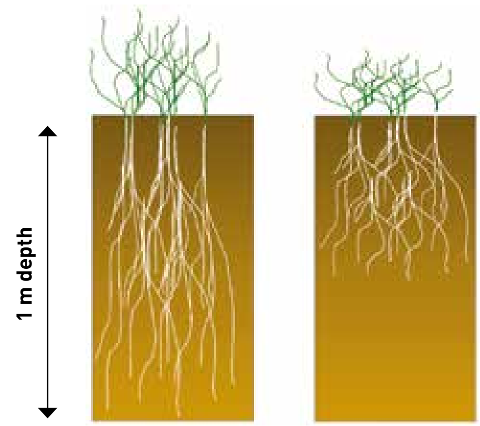
However, the success of implementation of RWHM does not only depend on the physical environment of water, crop and soil conditions. Including the aspects of social suitability combined with agro-ecological conditions, the study found that at least 15 per cent of global

THE IMPORTANCE OF SOIL TEXTURE AND ROOT DEPTH FOR YIELD INCREASE IN RWHM SYSTEMS

Two factors affect the available crop water for plants. Firstly, the soil texture and structure provides each soil with an inherent capacity to store the rainfall infiltrated into the soil. Different soils have different capacity to hold water in the root zone (left Figure). For example, a sandy texture soil will typically only be able to store a third to half of what a clay soil can store in the same root depth, due to soil texture and structure. Secondly, the plant root development in any given soil makes a critical difference for use of any infiltrated rainfall (right Figure). Guiding values of water storage per unit soil depth range from a maximum available amount of water of 6 mm per 0.1 m soil for sandy soil to 15-19 mm per 0.1 m soil for loamy clay and well-structured clay soils. A typical well-developed cereal crop has a crop water demand of 2-5 mm per day, depending on weather conditions and crop type. Therefore, a crop can easily utilise a soil moisture availability of 30 mm in six to eight days, and thereafter experience water stress, affecting final yield.

So it is critical to combine any RWHM technology with good soil health and good crop management. This combination will ensure that soil can hold the infiltrated rainfall and that crop root development can maximise uptake of available water once it is in the soil.





Max available water in root depth

	(mm) for 1 m	(mm) for 0.5 m
Sand	60	30
Loam	150	75
Clay	190	95

cropland is suitable for in-situ and/or ex-situ RWHM technologies, and that in these regions RWHM could increase yields with typically 50 per cent or more (Piemontese et al., in review). However, more importantly, the paper by Piemontese et al. discusses the current area under RWHM. Today, very little data exists on how much cropland is already under RWHM. There are different studies at local to national level assessing farmers' practices. For example, Conservation Agriculture could possibly be considered as a RWHM technology through the combination of no/low tillage with mulching and crop rotation, and it has been particularly successful in mechanised rainfed dryland agricultural systems in the USA, Australia, Brazil and Argentina, among other countries. The latest estimates suggest that 180 million ha, or 12.5 per cent of current cropland worldwide, is under RWHM.

There are no global estimates for a range of RWHM technologies. But some national statistics can provide guidance. In Ethiopia, sustained public investments, farmer in-kind contributions through labour and international development programmes have invested in various soil and water conservation measures that have acted as RWHM for more than 40 years. Adimassu et al. (2018) estimated that 20 per cent of crop area was under terraces alone, not accounting for other common RWHM practices or the combination of soil and water conservation combined with biological practices such as mulching or manure application. In Burkina Faso, Morris & Barron (2014) suggested regions in the 400-800 mm/year rainfall area implemented RWHM through soil and water conservation on 10-30 per cent of cropland, whereas in rainfall higher than 800 mm/year, corresponding coverage was mostly 0-10 per cent of crop area. Data by Wang et al. (2018) indicates that more than 11 per cent of cropland in China is under terrace practices acting as RWHM. These snapshots only focus on RWHM on cropland, and in particular the in-situ technologies of terracing (Ethiopia, China) and 'zai' pitting and stone bunding (Burkina Faso). There is an urgent need to understand which croplands in the world are already under RWHM practices, and to assess the yield levels achieved. This would help to advance and target RWHM practices more efficiently, both to improve already existing RWHM practices to maximise their benefit and to ensure that new developments in RWHM are being implemented by farmers to secure rainfall use and benefits.

Practices come at a cost and require a mindshift

Despite RWHM being a common practice (albeit not well documented for the range of technologies being used in various regions), there is little understanding on the costs related to implementation and maintenance. Lasage & Verburg (2015) summarised for ex-situ household or communal water storage in the order of 100 to 1,000 USD (2009 value) per construction, with a 0.1- 10 USD cost per cubic metre of water storage. Often this price did not include in-kind labour supported by beneficiaries in the household or community. Adimas-

Ex-situ RWHM: a small reservoir for dry season irrigation and other purposes in Ghana.

su et al. (2018) estimated the investment cost, accounting for in-kind community labour in the order of 1.2 billion USD per year across four regions in Ethiopia, or in the order of 150 USD per hectare. However, this is still only about a quarter of what erosion costs Ethiopia, which is estimated to be 4.3 billion USD per year. In work by the International Food Policy Research Institute (IFPRI – 2017), a cost of 179 USD per ha was used for implementing soil and water conservation practises in the sub-Saharan context. Hence, there seems to be a real cost for implementing RWHM even for a smallholder farmer, despite potential benefits in yield. In these estimates none of the positive environmental and ecosystem functions, such as reduced sediment transport and infiltrated and possibly recharged groundwater, was accounted for.

As RWHM evolves over time, it is also important to consider today's thinking and approaches in taking action for RWHM implementation. Since promotion and implementation initiatives of RWHM have developed over time, we may need to reconsider how and where RWHM makes a difference going forward. An example of evolving discourse is presented by Douxchamps et al. (2014), where RWHM technologies as well as the considerations for implementation and partners have changed over 40 years. Today, it is increasingly important to consider multiple technologies, as well as suitability not only for the agro-ecology but also for the household and community context. Going forward, RWHM must further be assessed in terms of its relevance and feasibility for women and youth, as well as with regard to reducing the manual labour input, which is a challenge for the most vulnerable and disadvantaged. Issues such as secured land tenure may also be of importance for the scaling of RWHM in various regions.

Conclusions

Rainwater harvesting and management encompasses a range of technologies in-situ and ex-situ to retain rainfall and store water in the soil or in small structures such as tanks or reservoirs. The main aim is to increase yields through reducing intra- and inter-seasonal dry spells, which can lower crop yields significantly. Both local/national meta-analyses and global modelling are showing the same range of benefits and opportunities of yield increases in existing low rainfall areas, as well as under a future increase of drylands and increased climate variability. However, new research also suggests that RWHM needs to be explicitly combined and aligned with other best practices in soil and crop management in order to maximise the value of the additional water retained. For example, two substantial meta-reviews from Ethiopia and Southern Africa have demonstrated that ensuring the use of biological measures in combination with physical measures increased yields, whereas RWHM did not necessarily show substantial yield returns if good agronomic practices were not in place, especially in agro-ecological conditions of less than 500 mm rainfall/year. These reviews also demonstrated the value of seeing RWHM as 'working with nature', and enhancing nature's capacity to retain water both for root zone soil moisture and for recharge of groundwater. One huge benefit of implementing RWHM is the control of sediment loss through the physical structures that have been implemented; in the order of 20-60 per cent could be mitigated. Given this service to nature and the environment, one should consider whether farmers ought to be better compensated for these practices in cases where sediment control is desirable. More effort should therefore be made to assess the added value and benefit for RWHM, and compensate farmers for the positive environmental benefits also achieved through RWHM implementation.

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References: **www.rural21.com**

Water – a shared resource requiring inclusive water diplomacy

Changing climate and extreme weather events have fundamental impacts on all aspects of our lives and our planet, including the management of the world's shared water resources. In order to meet the challenges of today and tomorrow we must broaden our conception of who the relevant decision-makers are and promote inclusive decision-making. Lessons learnt from inclusive water diplomacy can help show us the way.

By Elizabeth A. Yaari and Martina Klimes

Ever growing uncertainties with regard to future water availability and demand stemming from the impacts of climate change have human security implications. Expected changes will foundationally direct how individuals are going to be affected by the changing availability of water and, from the national and regional security perspective, how these changes will affect geopolitics and inter-state relations between countries sharing a freshwater resource. A study released in June 2019 and carried out jointly by environmental and conflict researchers indicates that armed violence across the globe is expected to rise by 26 per cent in a scenario involving a four-degree Celsius rise in global temperatures. Understanding, learning from, and enhancing water diplomacy processes (see Box) is essential for countries and communities to prepare and respond to the expected challenges to come.

Participants at the annual Women in Water Diplomacy in the Nile workshop organised by SIWI, 2019.
Photo: Elizabeth Yaari

Build a bigger (negotiation) table

As a dynamic, multi-track process, water diplomacy enables a broad sector of stakeholders sharing water resources to discuss and identify solutions for sustainable management of shared resources, as well as to mitigate shared risks. In contrast to traditional diplomatic efforts focused on relations between states (typically through ministries of foreign affairs), water diplomacy is able to actively engage a range of diverse stakeholders and decision-makers including diplomats but also technical experts, experts on socio-economic indicators, as well as civil society and representatives of affected communities, among others.

Indeed, inclusive participation is an instrumental characteristic of effective water diplomacy. By engaging not only formal state actors with the authority and mandate to make decisions on behalf of their governments or institutions, referred to as Track 1 processes, but also complementing official processes with informal relationship building and trust-building activities, i.e. Track 1.5 and Track 2 processes, water diplomacy is able to prompt positional and behavioural changes including by introducing new ideas and perspectives that inform official negotiations. These multi-track water diplomacy processes are also able to better capture user priorities, enhance and maintain buy-in and support for policies, provide early warning for risk identification and improve water access for marginalised groups. By maintaining multiple complementary channels of communication and points of contact, risks to process politicalisation are mitigated as informal actors can maintain a dialogue should formal relations deteriorate. And, as trust is a key component in water diplomacy, non-state actors often play an important role in contributing to improved dialogue among riparian countries by clarifying misunderstandings and acknowledging ambiguities and uncertainties in terms of information, action, and perception – pertaining to water management decisions. For example, in the case of Iraq, the Farmers' Union has a consultative process role with the government (Ministry of Agriculture and Irrigation) which directly informs the government's policy on agriculture water availability. In the lower Jordan Basin, mayors have maintained communication and cooperation cross-border in the absence of a formal governance structure for the shared management of the river.

Water diplomacy's multi-track approach is also multi-disciplinary, which is critical to facing growing uncertainties with evidence-based responses. One of the main challenges remains how to transfer and communicate knowledge from technical tracks to official level political dialogues. Long a challenge in climate change processes, lessons learnt from ongoing transboundary water negotiations indicate that technical knowledge is more likely to be captured when there is strong internal coordina-

Young leaders from Central Asia engaged in SIWI's transboundary water negotiation role play at the annual Central Asian Leadership Programme organised by CAREC, 2019.

Photo: CAREC

tion at multiple levels, i.e. horizontally across relevant line ministries and vertically from state to community-based actors. For example, in several contemporary water negotiation processes such as in the Nile basin and the Euphrates and Tigris region, and along the Hari River, negotiation teams are strategically composed of both ministry of foreign affairs representatives and representatives of water-line ministries. This approach greatly improves horizontal internal coordination and knowledge sharing between technical experts and political decision-makers.

Elevate women and youth in leadership and decision-making

Water diplomacy processes are additionally enhanced by ensuring that negotiation teams are reflective of the diverse societies they represent. Here, much effort is still needed as evidence reveals a persistent gender gap in the water sector, particularly at the transboundary level, which continues to be overshadowed by men. This happens despite evidence that balanced gender representation in peace processes results in agreements that are more durable and less likely to relapse. Unique initiatives such as the Women in Water Diplomacy Network in the Nile Basin aim to mitigate this deficit by elevating women water decision-makers and disseminating a shared perspective such as their 2020 Joint Statement in support of enhanced inclusive transboundary water cooperation through their Network.

Moreover, emphasis is also needed to leverage the leadership and engagement of young people in water diplomacy processes. As seen with regards to climate action, it is often the young voices that drive fundamental behaviour changes. This is particularly relevant to transboundary water management in conflict sensitive basins as riparian countries experience heightened youth population growth. Recurrent activities such as the annual Central Asian Leadership Programme on Environment for Sustainable Development, organised by the Regional Environmental Centre for Central Asia (CAREC), aim to strengthen young voices and develop the next generation of water and environment leaders, including water diplomats. Ample evidence exists to show how young farmers who lost both their livelihoods and future employment prospects as a result of protracted water scarcity have been targeted by recruiters from terror and criminal networks, especially in countries like Iraq and Afghanistan. Effective internal water management as well as sustainable transboundary water cooperation in regions where the agricultural sector is heavily dependent on shared water resources have thus become paramount for sustaining regional security in fragile regions prone to armed violence.

Why water diplomacy?

Water diplomacy is an integrative approach to address complex water problems. It

- enables a variety of stakeholders to assess ways to contribute to finding solutions for joint management of shared freshwater resources;
- is a dynamic process that seeks to develop reasonable, sustainable and peaceful solutions to water management while promoting or informing cooperation and collaboration among riparian stakeholders.

To achieve sustainable and effective transboundary water management requires an 'all hands on deck' approach. We simply cannot afford the costs of maintaining the status quo. Success requires a pro-active effort to create inclusive and strong engagement, both top-down and bottom-up, and involving the whole of society in our shared water agenda. By leveraging more actors and communities into inclusive water diplomacy processes, we are able to foster a cadre of water champions, mitigate human security implications and improve inter-state relations between countries sharing a freshwater resource.

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References: **www.rural21.com**

Public-private partnerships in irrigation – how can smallholders benefit?

Although the positive effects of irrigation on food security and poverty alleviation are well-documented, public investments in this area have been on the decline since the 1990s. Comparing irrigation schemes in Zambia and Morocco, our authors have examined whether private sector investments are suitable to fill this gap and what preconditions have to be met to ensure that PPPs offer advantages for small-scale farmers.

By Annabelle Houdret, Michael Brüntrup and Waltina Scheumann

Switching to irrigation requires investments in water storage and irrigation infrastructure, but also technical expertise. Photo: Jörg Böthling

The benefits of irrigation are undisputed. It can help to improve and stabilise agricultural productivity, thereby contributing to food security and to resilience against climate change. Irrigation – either full or supplementary – reduces reliance on erratic rainfall, improves drought resilience and increases yields; it extends cropping periods and cycles, allows the cultivation of a broader spectrum of crops and provides stable conditions for applying further yield-increasing means (fertilisers). Irrigation also encourages farmers to invest, on the one hand, and financial institutions to provide credits, on the other. Moreover, as evidence from Asia shows, irrigation has the potential to reduce poverty rates and income inequalities. But mobilising investments is key to taking advantage of this potential, which can be a problem, especially in sub-Saharan Africa.

Tapping the irrigation potential in Africa

Throughout the entire African continent, only about 13 million hectares of arable land is under irrigation today, which is equal to six per cent of the total cultivated area (compared to 37 per cent in Asia and 14 per cent in Latin America). Of this, more than two-thirds is concentrated in Egypt, Madagascar, Morocco, South Africa and Sudan. Looking at sub-Saharan Africa (SSA), only 3.5 per cent of the area cultivated is equipped for irrigation. According to the UN Food and Agriculture Organization's (FAO) projections up to 2030, the irrigable area can be substantially expanded. In Zambia, for instance, only about 10 per cent of the economically irrigable potential is under irrigation, which is around 155,000 hectares. Mozambique's potential is estimated at 3 million hectares only 120,000 of which is already connected to water infrastructure, while only 62,000 is in use. Note that all estimations of actual and particularly potential irrigation areas in SSA are subject to large data uncertainties.

However, switching to irrigation requires not only costly investments in water storage and irrigation infrastructure, but also technical expertise and funds for network maintenance and effective water payment schemes. In addition, water alone is not enough to reap the full benefits of these efforts, which call for additional investments and the use of (organic and chemical) fertiliser, new varieties and crops, and new value chains for inputs and outputs.

According to the Alliance for a Green Revolution in Africa, in SSA, about 70 per cent of the population are smallholder farmers who are not well equipped to meet these requirements. Additionally, constrained public budgets and the lack of human resources in agriculture and water administrations limit public sector support to smallholders. This situation has resulted in under-investments in irrigation since the 1990s, and there is no indication of substantial improvements in the coming years. How then can irrigation be expanded, and which role can private sector funding play? And will smallholders benefit from these investments?

Bridging the investment gap

International finance institutions such as the World Bank or the Asian Development Bank have promoted private sector involvement in irrigation. However, the private sector has been proven to be very reluctant to enter into

ZAMBIA'S KALEYA AND MANYONYO SCHEMES

Photo: Waltina Scheumann

The **Kaleya irrigation scheme** has 161 farmers cultivating 2,165 hectares in Southern Zambia's Kafue River basin. Irrigation infrastructure was publicly financed, but operation and maintenance has always been the responsibility of the Kaleya Smallholders Company Ltd. (KASCOL), a private company owned by independent individual and institutional investors. Smallholder farmers collectively hold 19 per cent of the company's shares. KASCOL owns the land, and recruits farmers by offering them land on a four-year lease base. It holds a water-use permit but receives additional bulk water in drought periods supplied by Zambia Sugar Plc. at an advantageous fee. On-farm irrigation and farming operations are carried out by farmers on their individual (leased) plots. Benefits from this arrangement have been manifold, but farmers particularly complain about the short-term land lease arrangement.

The **Manyonyo smallholder irrigation scheme** is located in the same river basin. It was initiated by the Zambian Ministry of Agriculture, who assisted farmers in forming a liability company and running the irrigation scheme. Each of the 145 households contributed four hectares of their land which are clustered into and managed as one single farm. The farmers maintain their property as well as individual land titles, thus guaranteeing membership to the scheme but also reversibility of membership. The company holds a group permit for water abstraction from the river. The water infrastructure is constructed by using public funds and is leased out to the farmer-company through a suitable PPP arrangement. The company is a stand-alone firm, but its production is sold to nearby Zambia Sugar Plc. The model provides security for smallholders vis-à-vis the (farmer-owned) company and its management.

financing, construction, operation and maintenance of irrigation schemes, at least in SSA and if it is not for a single plantation under its own single management. There are several reasons for this lack of engagement. First of all, this is because enterprises are often specialised and exert their activities (e.g. irrigation management, cropping, transformation) in joint ventures. Second, and even more importantly, public agencies are often involved in such ventures. The reasons are the high complexity and associated challenges of irrigation projects in these settings: finding 'bankable' solutions for infrastructure investments in insecure economic contexts, highly complex and partly informal systems of land tenure and established, traditional practices of water allocation. Moreover, the "common pool resources" character of water and – correspondingly – of irrigation schemes and potential environmental effects (for example unsustainable water use or salinisation of soils due to poor water management practices) increase investment risks.

In many instances, it is farmers themselves (as land-owners or users) or governments (as custodians of land) who push private sector companies into accepting farmers and their associations as part of the business model. The reason for this is that it allows increasing inclusiveness and equality, technical spillovers, reduces political resistance and enables measures to prevent non-reversible deals, which leave whole regions at the mercy of one or just a few companies. The involvement of private companies in large-scale irrigation is thus often embedded in cooperation agreements with national and/or local governments, in some cases development agencies, and farmers or farmer organisations.

Making PPPs more inclusive – the example of Zambia

So far, there have not been many examples in SSA of PPPs involving irrigated agriculture. Some of them are found in Zambia, which has developed models of inclusive PPPs with smallholders. These PPPs have in common that smallholders have established farmer-owned liability companies to run profitable commercial businesses. The farmers are organised in water user associations, which are represented on the management board of irrigation projects along with representatives of the government and the farmers' union. While the farmers hire irrigation professionals to run the irrigation scheme profitably, the management units organise agricultural production in parallel, assuring professional cultivation.

These farmer-owned companies are often linked to large enterprises (e.g. Zambia Sugar) as contract farmers (Kaleya Smallholders Company Ltd.), but some, such as the Manyonyo smallholder irrigation scheme, are also stand-alone firms (see Box on top of page). In one or the other way, smallholders contribute to debt financing (cash or land contributions) and share operation and maintenance costs of providing irrigation services. Individual farmers can benefit from improved income, job opportunities and the dividends generated by their equity stake in the collective company. Finally, involving local communities in PPPs is in many cases also a means to integrate them in larger value creation and rural development by improving e.g. access to electricity, health services and transportation.

The projects in Zambia successfully address two other common challenges of irrigation schemes: inequitable water distribution and frequently unclear water and land ownership and use rights. Concerning water distribution, farmers at the head of a canal are often privileged compared to 'downstream' users at the tail end. In cases where water provided by the PPP does not cover all water needs, financially strong farmers are privileged as they can invest in deep drilling to complement this, while poorer farmers cannot do so and are in addition faced with rapidly sinking water tables due to the boreholes of their rich neighbours. Such situations arise where farmers are very heterogeneous, as in the Moroccan El Guerdane case (see Box on page 20) .

The collective ownership chosen for the PPPs in Zambia instead provides for an innovative solution to these two distribution challenges; at least until now, inequitable water distribution has not been reported. The collective model also helps to address the challenging issue of unclear water and land use rights, which is particularly complex in settings with many smallholders. Hybrid and sometimes contradictory forms of collective and individual land, water and other resource ownership and user rights coexist in a continuum from customary tenure systems to formal ownership systems, often with the state as final custodian and owner. Mostly, these tensions are not clarified and

MOROCCO'S EL GUERDANE PROJECT

The **El Guerdane** project, operational since 2009, is considered as the first public-private partnership in irrigation in which the private partner participates not only in the financing and construction, but also in the operation and maintenance of the system. In contrast to the Zambian cases, the private partner is not involved in agricultural development.
A complex of two dams feeds a 90 km irrigation canal to carry 45 million m^3 of water per year to the 300 km distribution network that makes up the El Guerdane scheme situated in a highly water-scarce valley. The project is designed to supply 597 citrus farms, covering 9,600 out of the 30,000 irrigable hectares. The 80 million US dollars of investment costs was covered by the Moroccan State (48 %), the National Investment Company (SNI, 44 %) and the farmers involved (8 %). However, the project has contributed to increasing inequalities between family farming and agro-investors: the investment costs required, the type of crop targeted (citrus fruits), the quality requirements for export and the political choice to initially restrict the call for tenders to pre-selected farmers have marginalised smallholders. The average size of project farmers' plots is one indicator of this trend: they cultivate an average of 16 ha – more than five times more than the average size of farms in the project's immediate surroundings in Taroudant. Moreover, the project provides water to only a small proportion of the farmers in the region (597 farms, equivalent to about 11 per cent of the total number of farms in the area).

formalised. The resulting uncertainty is detrimental to investments, regardless of who invests, not only in irrigation but also in all kinds of machinery, equipment and long-term land improvement. The way land can or cannot be used as collateral has implications for the ability of individual actors to engage in PPPs. In the Manyonyo PPP, for instance, where farmers hold individual land-use rights, it is prohibited to use land as collateral for loans so as to avoid the danger of farmers losing the land to "bogus investors" offering "slave loans". Banks seem to be ready to provide credits relying on the soundness of business models.

What are the success factors?

Successful irrigation PPPs which are not only able to mobilise investment but also provide long-term perspectives for local smallholders require sound design and monitoring of networks and contracts with respect to equitable cost-benefit sharing and environmental impacts. However, many smallholders as well as local administrations currently lack the capacities to fully oversee potential impacts of such projects and related contracts. Similar to PPPs implemented in the drinking water sector, local administrations may find themselves caught up in highly complex contracts to their disadvantage (as has even happened in Europe with contracts concluded for the provision of water services). Taking smallholders' concerns, but also local government and administrations' capacities, into account when developing PPPs in irrigation is therefore a key prerequisite for achieving mutual benefits.

Given the important role of governments in irrigation PPPs, they must be pro-active in creating security and stability for investments in relation to land- and water-use rights, in protecting public goods and the smallholder economy. Development cooperation can support local public and non-state stakeholders by providing capacity development and specific expertise in order to secure fair, equitable and environmentally sustainable conditions of PPP implementation.

Lessons from PPPs implemented so far also teach us to look beyond the irrigation scheme as such since potential socioeconomic and environmental benefits and threats extend way beyond the geographical area of the scheme. Primarily targeting financially strong farmers or not actively supporting the smaller ones creates an unequal race for access to potentially irrigable land and sometimes scarce water resources. Neither does it necessarily assure an optimal return on investment since smaller farmers can be very efficient in value and employment creation, also compared to larger entities. Finally, the public sector must ensure the long-term ecological viability of a project as well. Many of these insights on PPPs confirm earlier findings on the effects of irrigation on poverty reduction. In Asia, the International Water Management Institute (IWMI) identified irrigation as an important potential contributor to poverty alleviation – but the magnitude of these impacts strongly depended on equity in land and water distribution, good infrastructural conditions and improved cultivation technology, cropping patterns, and the marketing of inputs and outputs.

Thus, PPPs in irrigation need to be embedded in comprehensive development plans and include specific support measures to ensure sustainable and equitable development. This may include access to extension services and financial products, input supply, and – above all – access to stable markets. The PPPs we reviewed in SSA have in common that smallholders have established farmer-owned liability companies to run commercial businesses. These companies have entered into contracts with private sector companies for irrigation management, service provision and market access. Farmers are represented on the management boards of their companies. For such arrangements, smallholders need long-term support along with assistance in designing contracts and acquiring management skills. If one compares the Zambian schemes with the Moroccan ElGuerdane, these PPPs are better characterised as PPPs in irrigated agriculture, i.e. investments in agricultural production that include irrigation components.

In short, PPP arrangements require country- and site-specific solutions and must address the risks of the various parties involved, including nature, to ensure that such projects are development-friendly and economically viable while protecting natural resources.

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References: **www.rural21.com**

Groundwater management: significance of rural well drillers underrated

A new survey of water well drillers and their associations suggests that they could play a key role in achieving the Sustainable Development Goals (SDGs). Yet they face a number of obstacles, as the survey of practices in five African countries and the USA shows.

By Mike Gardner

Groundwater is seen as a key factor in achieving the Sustainable Development Goals of the United Nations, given its significance e.g. in maintaining river base flow and preventing seawater intrusion, but also as a solution in the context of climate change adaptation. Falling groundwater levels and deteriorating water quality in some regions call for action based on a sound understanding of local contexts. Water well drillers are particularly familiar with conditions on the ground. According to a survey by Uyoyoghene Traoré of drillers' associations in six countries, drillers can play a major role in influencing policies and urging governments to address water issues. The survey was conducted as part of the 2018 Young Professional Engagement Strategy run by the Rural Water Supply Network (RWSN; see Box).

Looking at Angola, Burkina Faso, Mozambique, Nigeria, Uganda and the USA, the survey "Challenges of Water Well Drillers & Water Well Drillers Associations" highlights the difficulties that drillers face, especially in the five African countries under review. In the latter, lack of capacity, both among drillers and institutions, to implement policies and lack of funding for water well monitoring appear to represent major problems. Moreover, little awareness has developed of the contribution that groundwater makes to sustaining livelihoods in these countries.

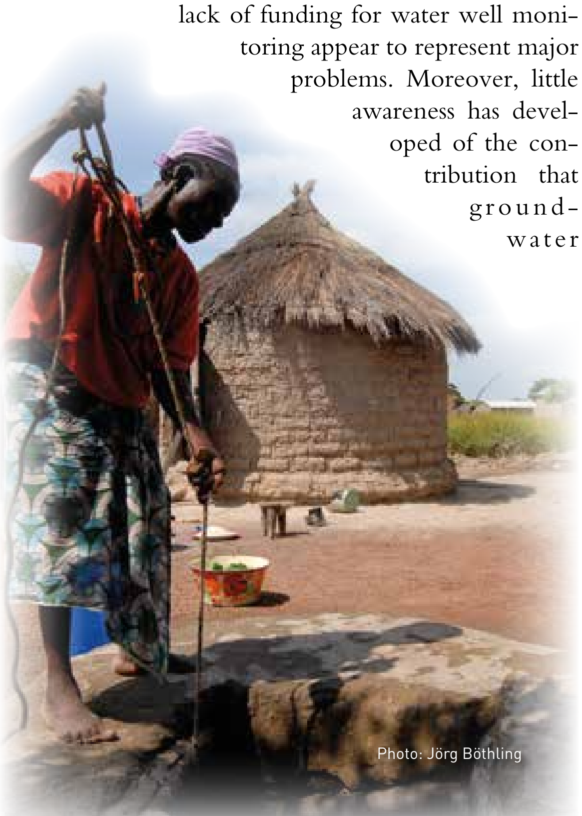
Photo: Jörg Böthling

Non-payment of drillers for dry boreholes based on so-called "turnkey contracts" is a further critical issue in all but one of the reviewed African countries, namely Angola. Furthermore, absence of hydrological data in Angola, Burkina Faso, Mozambique and Nigeria can result in errors in estimating the drilling effort in difficult terrain. In addition, a single pricing system is often used for all wells, regardless of terrain, all of which leaves the drillers with a high entrepreneurial risk and low-quality jobs. Nigeria and the USA were the only countries that did not mention the issue of delayed payment of contracts in the survey.

Out of the six countries surveyed, only the USA, Nigeria and Uganda have associations that are confirmed to be active and currently operating, while those in Burkina Faso and Mozambique appear to be dormant and Angola has an informal group for drillers. One challenge that all associations share is a lack of interest among non-members, be it because the latter see no benefits from membership or need for getting organised or because there are no incentives for them. Second, the sustainability of the associations in the African countries is frequently under threat owing to a lack of finance, which may be due to low membership levels, a lack of support from development agencies or the absence of dedicated professionals to run their affairs. Third, except for the USA, wherever organisations do exist, they tend to lack transparency, also because they do not have the means to employ external auditors. Finally, again with the exception of the USA, there is a lack of continuous capacity building of members. The survey also points to a generation gap of experts in the water well drilling sector.

Summing up, the survey emphasises the potential that water drillers associations hold for achieving the water targets of the SDGs. Associations can create a platform to engage with governments and other stakeholders and help to easily identify challenges. They can back and organise capacity building programmes for drillers and support the adoption of the latest technologies in the water sector as well as the setting of realistic prices for services. In particular, with their wealth of information, they can actively accompany the collection of data, which is urgently required for the water sector in Africa in particular.

Based on its findings, the survey makes a number of recommendations for water drillers and their associations regarding the sustainable management of groundwater resources. It sees a need for establishing associations and rekindling non-active ones and also for capacity building in terms of the technical and managerial skills of water well drillers. In the latter area, a sustainable platform for continuous professional management ought to be put in place. The survey stresses the urgency of drawing the attention of national institutions to groundwater issues. A global platform of young professionals could be created aimed at deepening understanding and awareness of youth from different countries regarding groundwater issues. And in the longer term, a global platform could be established for drillers, experts and institutions working on groundwater issues aimed at learning and sharing best practices.

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The Rural Water Supply Network

The Rural Water Supply Network (RWSN) seeks to contribute to achieving access for all rural people across the world to sustainable and reliable water supplies which can be effectively managed to provide sufficient, affordable and safe water within a reasonable distance of their homes. It stresses collaboration and learning as key to eliminating poverty, and its mission and values align with UN Sustainable Development Goal 6. The RWSN links rural water supply professionals and organisations across the world who are committed to improving their knowledge, skills and professionalism and to focusing on water user needs.

More information:
https://rural-water-supply.net/en/

Capacity development for solar-powered irrigation

Solar-powered irrigation is a technology that promises an increase in production without emitting further greenhouse gases. However, technical knowledge and awareness of the technology is still lacking in many countries. This is where the "Toolbox on Solar Powered Irrigation Systems" comes in. Not only does it pave the way for applying climate-friendly technology, it can also support women's empowerment.

By Lucie Pia Pluschke, Janna Schneider and Maria Weitz

If used effectively, solar-powered irrigation systems can lead to an increase in agricultural productivity. This holds great promise for food security. For instance, today only six per cent of agricultural land in sub-Saharan Africa is irrigated, which can mean dramatic crop losses in periods of drought. According to the UN Food and Agriculture Organization (FAO), irrigation holds the potential to increase the harvest of some of the main crops on the continent by an estimated 100 to 400 per cent.

Yet, this potential is not simply realised by setting up a solar pump, it requires expertise in the design, installation and maintenance as well as knowledge of efficient water use, sustainable management of water resources and input management. "We need to generate awareness amongst the farmers to use water judiciously with an objective to improve productivity and reduce input costs. Only then can solar-powered irrigation lead to access of appropriate and nutritious food at affordable prices," states Jacinta Gatwiri. She is a renewable energy expert from Women in Sustainable Energy and Entrepreneurship (WISEe), a women energy cooperative in Kenya that promotes women in solar energy installation and entrepreneurship in the entire country through capacity building and networking. And she is one out of five women experts who have been trained in the context of the project "Sustainable Energy for Food – Powering Agriculture" run by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The project follows a capacity development approach to promote and anchor solar-powered irrigation.

From technical skills of electricians and technicians to knowledge of adaptive water management by farmers, capacity-building is key to unleashing the potential of solar-powered irrigation. Photo: GIZ/ Jörg Böthling

Paving the way for sustainable irrigation practices

Despite relatively high upfront investment costs, the operation of solar pumps is virtually free. Therefore, solar pumping is often perceived as an irrigation method leading to unsustainable water abstraction rates, so that the issue of agricultural water management needs to be addressed. Water resources, particularly groundwater, are at risk when extracted faster than they can be replenished, leading to water scarcity, irreversible salinisation, loss of ecosystems and wetlands, land subsidence and social conflicts over competing water uses. However, groundwater depletion can be prevented through good agricultural and water management practices. Jacinta Gatwiri, aware of the problem, proposes a central role for the government to monitor and curb the excessive abstraction of ground or surface water in order to ensure that irrigation practices are sustainable. Especially in regions with little experience in irrigation, it is crucial to train farmers on simple and effective water management, such as rainwater harvesting, efficient irrigation techniques and agronomic practices.

Furthermore, the economic viability of such an investment often depends on the long-term vision a farmer has for his farm, and the information he or she has at hand about financing options. Despite an increasing palate of innovative and affordable solutions, such as pay-as-you-go models, solar pumps have not yet gained acceptance, especially among smallholder farmers. Small farmers often lack access to finance, needed in particular to cover the high cost of purchasing a pump. A greater effort is needed to support farmers in their economic planning and financial literacy, while a direct dialogue with financial institutions and private sector is required to develop more tailored financial products for farmers.

Solar powered irrigation systems hold a great potential, but to unleash it, more work is needed to build capacities – from technical skills of electricians and technicians to knowledge of adaptive water management by farmers – reflecting the cross-sectoral nature of the systems.

The SPIS Toolbox

The Toolbox on Solar Powered Irrigation Systems (SPIS), developed by GIZ and the United Nations Food and Agriculture Organization (FAO), is an initial step towards offering a comprehensive training approach. It provides manuals and tools to guide advisors

Women of the WISEe cooperative participating in the Training of Trainers workshop.

Photo: Strathmore University, Nairobi

on some of the crucial questions of economics, design and installation, and irrigation management. The Toolbox has been employed in the context of the Powering Agriculture Project since 2015. Over the course of four years, it has grown from being a simple Excel-Tool to a comprehensive learning experience available in English, French and Spanish. It features tried and tested training modules, an e-learning course, online instruction videos and a pool of trainers who themselves were trained by the Powering Agriculture team. This way, the Toolbox offers different avenues of learning. The online classroom is a flexible environment that accommodates different learning styles, while the person-to-person workshops allow for a practical application of knowledge through field visits and marketplaces, where research institutions and the private sector can present their technologies.

From the beginning, the idea was not to give trainings in isolation, but to provide them as part of a project or broader curricula. FAO came on board to develop the irrigation-related modules of the Toolbox further, using it in its projects around the world. Training workshops were organised in cooperation with other GIZ projects and partners, catering to specific target groups, such as policy-makers, entrepreneurs and extension officers. Moreover, the Toolbox has now been integrated into the training curricula of several organisations, including the master programme on "Land and Water Resource Management: Irrigated Agriculture" at the Mediterranean Agronomic Institute of Bari, in Italy, and the Solar Water Pumping Training at Strathmore University in Kenya.

A catalyst for change

As interest in the Toolbox grew, it became clear that a more systematic and sustainable trainer network was needed. The first step towards this was a collaboration with Women in Sustainable Energy and Entrepreneurship (WISEe) in Kenya.

Like in so many other countries, the uptake of renewable energy in Kenya is hindered by inadequate technical support to the rural households, which are mostly not served by the national grid. Here, off-grid solar solutions can present a real opportunity, but the few qualified solar PV practitioners can primarily be found in big urban centres where it is easier to do business. Indeed, data from the Energy Regulatory Commission (ERC) shows that over 65 per cent of the 356 registered technicians by 2018 operate around Nairobi and only a handful are female. WISEe was founded to remedy this, training women on basic technical photovoltaics skills, empowering them to educate others, developing entrepreneur skills to set up their own businesses, and making them champions of solar technologies.

> **Capacity development is key, because it will ensure that information on solar-powered irrigation trickles down to practitioners and end users rather than remaining in the domain of equipment manufacturers, suppliers and experts.**
> Jacinta Gatwiri

As such, WISEe was an obvious partner to build up a trainer pool in Kenya and the wider East African region. After a five-day Training of Trainers (ToT) workshop, five women, including Jacinta Gatwiri, were invited to contribute to – and eventually lead – SPIS training workshops. Three ToTs have been organised by the Powering Agriculture team in both English and French in order to penetrate multiple language regions. So far, 29 trainers have been qualified. On the one hand, the ToT improves the scalability of activities through these trainers, while on the other, benefiting from their knowledge of local issues and markets.

The WISEe trainers can now offer their newly acquired skills as a service to interested organisations, making it a far more likely that trainings continue at the end of the Powering Agriculture project, and hence contributing to the sustainability of the Toolbox. The fact that WISEe was conceptualised and is managed by women to empower women in a largely male-dominated sector makes it a catalyst for change.

Jacinta Gatwiri and her colleagues have by now led multiple trainings on solar-powered irrigation in Kenya and other countries for both GIZ and FAO. "It was a good experience as trainees were really interested in the knowledge and seemed enthusiastic to put it into practice," says Gatwiri." Tameezan wa Gathui, chairperson of WISEe, agrees. "I enjoyed the experience of using flexible teaching methods depending on the background of the trainees, and the fact that there was room for trainees themselves to suggest modifications to suit their local needs based on their experiences in the field," she recalls. Building capacity at the local level has the potential for enhancing collaboration and networking among those trained. Hopefully, the trainings will also help to promote the broader vision of WISEe of getting more women to work in the solar industry.

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For more information on the SPIS Toolbox, see: **www.rural21.com**

Marginal-quality waters for irrigation in water-scarce areas

Achieving food security for all amid a growing population is a grand challenge for the world at large given increasing global water scarcity. As rainfall, river runoff and snowfall in water-scarce areas are becoming insufficient to meet the water demands, there is a need to consider planned use of waters of marginal quality for irrigation to support sustainable increase in crop production systems.

By Manzoor Qadir

Water-scarce regions and countries must sustainably access and utilise every available option for water resources in order to minimise the pressure that continues to grow on conventional water provisioning approaches relying on snowfall, rainfall and river runoff. Unconventional water resources are an opportunity to narrow the water demand-supply gap in these regions. Some unconventional water resources are of marginal quality but can be effectively used for irrigation. They may need suitable pre-use treatment or require pertinent on-farm management when used for irrigation. In response to growing water scarcity, there are scattered but increasing examples of marginal-quality water resources being used for irrigation.

There are two broader categories of marginal-quality water resources. The first is municipal wastewater, which is generated as a possible combination of domestic effluent consisting of black water from toilets, greywater from kitchen and bathing and other household uses, waste streams from commercial establishments and institutions, industrial effluent where it is discharged into the municipal sewerage systems, and stormwater and other urban runoff ending up in municipal sewerage systems. The second is saline water generated by irrigated agriculture and surface runoff that has passed through the soil profile and entered the drainage system as well as saline groundwater stemming from different sources, such as underlying saline formations, seawater intrusion in coastal areas and infiltration from agricultural drainage and wastewater irrigated areas.

Municipal wastewater – high value, but still underexplored

Once stigmatised as waste, municipal wastewater is increasingly recognised as a valuable source of irrigation water and nutrients. Annual availability of municipal wastewater across the world stands at 380 billion m^3 (1 m^3 = 1,000 l), which is a volume five times that of water passing through the Niagara Falls annually. The potential of irrigation with municipal wastewater is by far under-explored as large volumes of wastewater are not even collected but released into the environment in treated form or even untreated, causing environmental and health impacts.

Where available, the farmers in many water-scarce developing countries tend to opt for wastewater irrigation for a number of reasons. Wastewater is a reliable, if not the only, water source available for irrigation throughout the year. Using it for irrigation often reduces the need for fertiliser application as it is a source of nutrients. Furthermore, wastewater use involves less energy cost even when pumping, if the alternative clean water source is from deep groundwater. Finally, it creates additional benefits such as greater income generation from cultivation and marketing of high-value crops such as vegetables, which provide year-round employment opportunities.

As wastewater irrigation is in most instances part of the informal irrigation sector, authorities face challenges controlling or regulating the practice. The protection of consumer and farmer health and environment are the main concerns. Thus, sustainable use of wastewater must address three major aspects: pertinent policies, regulations and institutional arrangements, wastewater treatment per intended reuse option and risk management practices that eliminate or minimise the health and environmental impacts, particularly when wastewater treatment is limited. The perceived high cost of establishing wastewater collection networks and treatment plants capable of satisfactory wastewater treatment is a major constraint leading to uncertainty in terms of adopting comprehensive wastewater treatment and reuse programmes. Initial improvements in water quality can be achieved in many developing countries by at least primary treatment of wastewater, while secondary treatment can be implemented at a reasonable cost in some areas to standards which can be attained in the local context.

Some countries in dry areas such as Tunisia, Jordan, Israel, and Cyprus have implemented

Municipal wastewater is a valuable source of water and nutrients. Photo: Manzoor Qadir national standards and regulations for water reuse. Policy-makers in these countries consider reuse of reclaimed water as an essential aspect of strategic water and wastewater sector planning and management. For example, the wastewater policy in Jordan has three major considerations: reclaimed water needs to be part of the water budget in the country, water reuse is to be planned on a basin scale, and fees for wastewater treatment are collected from the water users. Water reuse in Jordan occurs through planned direct use within or adjacent to wastewater treatment plants, unplanned reuse of reclaimed water in *wadis* and indirect reuse after mixing with surface water supplies, which is mainly practised in the Jordan Valley where reclaimed wastewater provides about half of the irrigation water used in the valley.

The implementation of research-based technical options for wastewater treatment and reuse in dry areas in developing countries, supported by flexible policy level interventions and pertinent institutions with skilled human resources, offers great promise for environment and health protection as well as livelihoods resilience through agricultural productivity enhancement, although this may not be achieved in the next few years. Therefore, interim measures would be needed to address water recycling and reuse to gradually reach a level when most wastewater in these countries would be collected, treated and used safely and productively in treated form. The good news is that a shift is underway in research and practice supporting collection, treatment and productive use of treated municipal wastewater for irrigation, as the example of Jordan shows.

Three options for the use of saline drainage and groundwater

Saline water from agricultural drainage systems and saline groundwater can be used for pertinent crop production systems and could be a significant contribution to food, feed and renewable energy production. Despite the absence of a comprehensive global assessment of the extent of saline drainage and groundwater resources, broader estimates suggest that their volumes are greater than the volumes of municipal wastewater. Contingent upon the levels and types of salts present, there are three major approaches that involve the use of saline drainage and groundwater for crop production:

The **cyclic strategy** involves the use of saline water and non-saline irrigation water in crop rotations that include both moderately salt-sensitive and salt-tolerant crops. Typically, the non-saline water is also used before planting and during initial growth stages of the salt-tolerant crop, while saline water is usually used after seedling establishment.

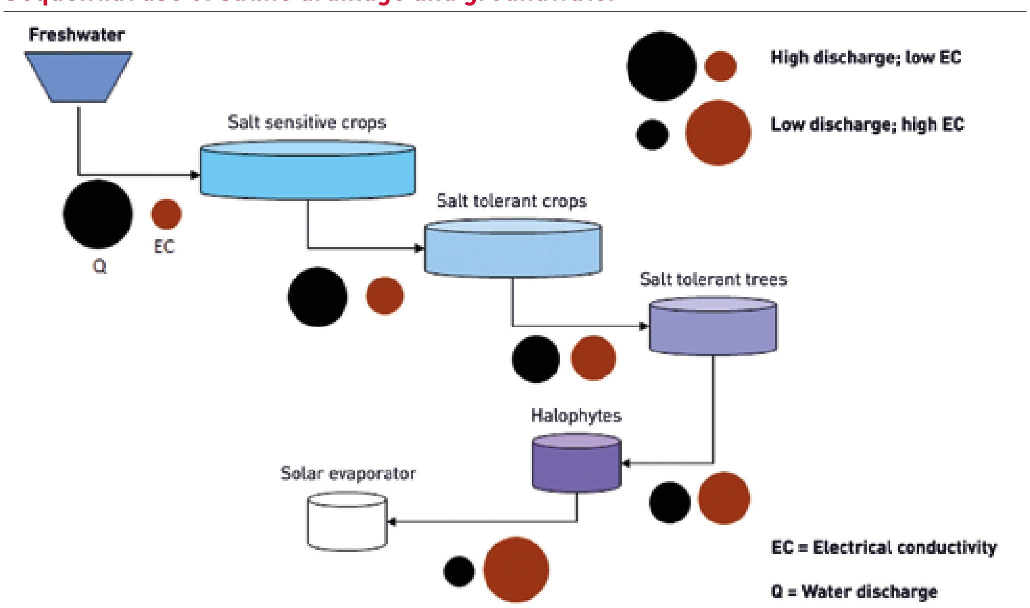
Blending consists of mixing non-saline and saline water supplies before or during irrigation. Drainage water from a drainage sump can be pumped directly into the nearest irrigation canal, or drainage water from a sump on a regional collector, which serves several drainage systems, can be conveyed to a single location and then pumped into a main irrigation canal. In both cases, the amount of drainage water pumped into the canal can be regulated so that target salinity in the blended water can be achieved. Different water qualities are altered according to the availability of individual irrigation water qualities and quantities, between or within an irrigation event.

The **sequential option** (see Figure) involves applying the relatively good-quality water to the crop with the lowest salt tolerance and then using the drainage water from that field – obtained from the subsurface drainage system – to irrigate crops with greater salt tolerance. The simplest management method is to use drainage water on fields located down-slope from those where the drainage water is collected. There is no fixed number of times the cycle can be repeated. It depends on the salinity of drainage water, the volume of water available, and the economic value and the acceptable yield of the crop to be grown.

Saline drainage and groundwater resources are used by the farmers in several river basins in a range of countries such as USA, Spain, India, China, Pakistan, Iraq, Iran, Egypt and most countries in the Central Asian region. For example, in India, saline drainage water has been used to irrigate different crops such as wheat, pearl millet and sorghum in Karnal, Haryana. The salts accumulated in the soil by saline irrigation water were leached by the monsoon rains. At times, pre-sowing irrigation with low-salinity canal water was applied to support the initial, salt-sensitive stage of crop growth.

There is a need for a paradigm shift towards reuse of saline water until it becomes unusable for any economic activity rather than its disposal. In doing so, there are additional gains in the form of mitigating climate change impacts through enhanced soil carbon sequestration. Therefore, saline drainage and groundwater cannot be considered redundant and consequently neglected, especially in areas that are heavily dependent on irrigated agriculture where significant investments have already been made in infrastructure such as water conveyance and delivery systems to supply water for irrigation and food security. There is a need to revisit policies and practices around water resources management in water-scarce countries and place saline waters as a priority in the public policy arena while promoting supportive action plans.

Sequential use of saline drainage and groundwater



Source: Manzoor Qadir

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Many developing countries lack proper regulations for the safe management of pesticides and chemical fertilisers. Farmers are often unaware of the environmental – and health – hazards that these active agents represent. Photo: Jörg Böthling

Tackling agricultural water pollution – a 21st-century challenge

Agriculture is critical to the economies of developing countries. It is the basic source of food supply and a major contributor to economic development. But there is a cost. Today, agricultural water pollution undermines economic growth and threatens the environmental and physical health of millions of people around the world. The annual social and economic costs of agricultural water pollution could reach trillions of dollars. Yet the issue receives scant attention in global research and debate.

By Javier Mateo-Sagasta

Agriculture is the main source of food, income and employment for rural populations and plays a key role in supporting food and nutrition security, economic development and health. Unfortunately, it is also the leading cause of water pollution in many countries, outstripping city living and industry. Rapid population growth, combined with changing diets, has led to unsustainable agricultural intensification.

A multi-faceted problem

Agriculture, including livestock, uses much more land today than it did 50 years ago, often at the expense of forests or grasslands. Agricultural expansion onto marginal lands, as well as changes in land use from forestry to agriculture, have accelerated runoff and erosion, with heavier sediment loads affecting river quality, aquatic life and the operations of water storage reservoirs.

The growth in crop production over the past five decades owes much to the intensive use of pesticides and chemical fertilisers. The overuse and misuse of these inputs can poison flora and fauna, as well as threatening water resources and drinking water supplies. Many developing countries lack proper regulations for the safe management of such chemicals, and farmers are often unaware of the hazards they pose.

The area used for irrigation grew from 139 million hectares in 1961 to 320 million hectares in 2012. While it remains an essential element of any strategy for increasing food production, irrigation agriculture can cause the loss of water quality through pesticide and fertiliser runoff and leaching. Irrigation also increases the seepage of saline groundwater into water courses: every year, drainage from irrigation transports billions of tons of salts to freshwater bodies.

The growing desire for milk and meat products, stimulated by population growth, rising affluence and urbanisation, caused livestock production to surge from 7.3 billion units in 1970 to 24.2 billion units in 2011. Livestock are probably the single largest source of water pollution today. In many parts of the world, particularly in drylands, overgrazing has caused land degradation and erosion, which has in turn increased sediment loads in water. Animal manure and slurries contain pathogens, ammonia and phosphate and, increasingly, large amounts of antibiotics, vaccines and growth hormones.

For its part, aquaculture, especially inland aquaculture, has grown 20-fold since the 1980s, particularly in Asia; this has led to a greater use of antibiotics, fungicides and anti-fouling agents. All of these contaminants can easily reach downstream water ecosystems and drinking water sources by leaching and runoff from livestock and aquaculture farms, as well as through the application of manure and slurries to agricultural land.

Today, nearly 40 per cent of the water bodies in the European Union are affected by agricultural water pollution, while in China, agriculture is the main activity responsible for groundwater pollution by nitrogen. And water pollution from agriculture poses a growing threat to human health and the environment in many developing countries.

Mitigating agricultural water pollution

The unsustainable intensification of agriculture will continue to contaminate rivers, lakes, aquifers and coastal waters until we develop interventions that increase food production and farm income with minimum or no pollutions loads. Admittedly, this is a major undertaking. Finding a solution will require policies that influence changes in farming practices, as well as significant investments in research and development.

Policies and incentives are needed to limit pollutants at their source or to prevent them from reaching vulnerable ecosystems. Regulatory instruments could include water quality standards, mandatory best environmental practices, and restrictions on agricultural practices or the location of farms. As the case of Denmark shows, taxing hazardous agrochemicals, such as pesticides, can promote a switch to safer pest control options and more efficient use.

A new approach allocates maximum tolerable pollution loads (often called caps) to landowners, based on the maximum tolerable concentration of a given pollutant in a water body. This requires farmers to focus on practices to minimise pollution outputs, rather than restricting farm inputs. Such an approach has been adopted, for example, in the Chesapeake Bay area in the United States and at Lake Taupo in New Zealand, with promising results.

Economic and other incentives can be used to encourage farmers to adopt good farming practices; these might include providing free advisory services and compensating farmers for improving the management of animal feed, additives and pharmaceuticals. Education and awareness-raising create behavioural change and help convince people to adopt more sustainable diets and farming practices. Enforcement remains a challenge, however, as does assessing the effectiveness of anti-pollution measures, particularly when they come from a variety of sources. A combination of agricultural water policy approaches tends to be most successful; these should ideally be part of comprehensive national policy frameworks and strategies around pollution.

A range of cost-effective management measures is also available to mitigate agricultural water pollution. For example, the integrated management of crops, livestock, trees and fish can optimise the use of resources by using waste from one activity as an input to another. At the same time, an effort to limit postharvest food losses and waste can reduce the loss of productive resources and associated environmental impacts. Practical measures can improve the efficiency of irrigation schemes and enhance the type, amount and timing of fertiliser applications to crops. More effectively managing animal diets, feed additives and medicines to minimise the use of drugs, nutrients and hormones can help control water pollution from livestock. Ensuring that aquaculture production does not exceed the carrying capacity of the fishpond can improve its sustainability as will standardising feed inputs to avoid excess, using fish drugs correctly and removing excessive nutrients in the water. Applying protection zones around surface watercourses and buffer strips at the margins of farms and along rivers can decrease the concentration of pollutants entering water bodies. Industrial livestock production can be decentralised, so that waste can be recycled without overloading the soils.

Addressing knowledge gaps

Although there have been considerable advances in our knowledge around agricultural water pollution, significant research gaps remain. We need to understand when and why pollutants enter farming systems, and where they end up. This requires the development of water quality models and chemical and microbial markers to identify and track pollution sources, pathways and attenuation processes. Tracking pollution sources can help optimise agricultural management strategies, while modelling can simulate cause-effect relationships and thus enable predictions under various mitigation scenarios. Comprehensive, high-quality data is needed to ensure accurate water quality models and effective water policies. The International Water Management Institute (IWMI) collaborates with different research groups to fill local data gaps and model sources as well as the transport and fate of water pollutants and contributes to global initiatives such as the World Water Quality Alliance which work to address knowledge gaps on water quality.

In addition to tracking the usual suspects, such as pesticides and agricultural wastewater, we need to refine our understanding of the source, composition and abundance of so-called ‘contaminants of emerging concern’ in farming systems. These include pharmaceuticals, antibiotics, hormones, personal care products, anti-microbial cleaning agents and microplastics. Although not commonly monitored or controlled, these agents can cause serious ecological and human health problems. We need to find more effective practices for reducing pollution, and determine how they can best be replicated and shared. We need to identify policies and incentives that motivate farmers to adopt these practices. We need practical studies to verify the environmental impact and costs of different interventions under different circumstances. Finally, we need to monitor the effectiveness of these interventions and determine how best to communicate their benefits to farmers.

Summing up

Tackling agricultural water pollution will require new policies and regulations, economic incentives, education and awareness initiatives, all backed by research and innovation. A clearer notion of the causes, effects, costs and impacts of pollution will be critical to increasing food production and farm income, while at the same time mitigating its negative impacts. The increasing environmental awareness and the new global sustainability agenda allow us to be optimistic. We are witnessing the emergence of effective solutions in many parts of the world with potential for replication in the Global South where water pollution from agriculture is emerging.

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References: **www.rural21.com**

On the way towards water stewardship – experience from Pakistan

Water Stewardship means that all water users within a catchment context work collaboratively for sustainable water management. The Water and Productivity Project (WAPRO) has been bringing together stakeholders from various countries for this purpose since 2015. Their engagement and motivation is crucial to the success of these projects, as our example from Pakistan demonstrates.

By Jawad Ali and Arjumand Nizami

For an agrarian country like Pakistan, water is a lifeline of the economy. Pakistan produces a variety of crops including cotton and rice, both with a high water demand. Rice, which is an important staple and revenue generation crop, places Pakistan among the top-ten rice exporting countries in the world. It is the third largest crop in terms of area sown and the second most important economic crop after cotton. All in all, 80 per cent of the country's exports depend on water. But with a growing population and increasing water shortage, competition for this resource among users and uses has increased over time.

Glaciers and snow, monsoon rains and groundwater are the main sources of water in Pakistan. Groundwater meets more than 40 per cent of irrigation water requirements. About 1.2 million tube wells are extracting groundwater. However, this is done without any scientific planning, keeping this natural resource under severe stress. At the same time, the government manages a huge irrigation system stretching to 1.6 million kilometres irrigating about 14.2 million acres. But despite significant investment in irrigation and agriculture sectors, water productivity – the amount of food produced in comparison to the water consumed – is still reported to be very low (see Table). In addition to poor agronomic practices, this is above all because of insufficient irrigation practice: an outdated and deteriorated irrigation infrastructure, a centuries-old supply-driven irrigation water distribution system (*warabandi* in Urdu: turn system in English) which is based on allocation to land size and not on the type of crop being cultivated, elite capture depriving poor users especially at the tail of channels, lack of user participation, including the private sector, in decision-making related to water governance, and lack of awareness on how much irrigation the crops actually need.

The irrigation revenue system is also fee-based, charged on land size and not on the type of crop being cultivated. Irrigation water is provided on highly subsidised rates. Even these fees are not systematically collected leaving room for irregularities and corruption. The water management and governance systems are highly centralised. Irrigation water is distributed to four provinces by the Indus River System Authority (IRSA). The Irrigation department is responsible for managing irrigation water and related infrastructure, whereas the On-farm Water Management department under the Agriculture Ministry observes improved irrigation at the farm level. Another actor is the Revenue department, dealing with irrigation theft cases and irregularities. The rest of the three departments have no role in mediating disputes and addressing theft at this level. Coordination among these actors is lacking. Climate change further complicates water availability for Pakistan's agriculture. According to Germanwatch ranking in 2019, Pakistan is the fifth most vulnerable country to climate change in the world.

Women transplanting rice in Sheikhupura, Punjab.
Photo: Tahir Salim

AGRICULTURE AND WATER AVAILABILITY IN PAKISTAN

- Pakistan's geographical area is 97.3 million hectares. Its irrigated and rainfed areas constitute 22.1 million hectares.
- Pakistan is one of the world's most water-stressed countries. In the last 70 years, per capita water availability has dropped from 5,260 cubic metres to 935 cubic metres. However, in comparison to many other countries in the world with far better economies, it is in a much better position (e.g. Netherlands: 642 m^3 water/capita; Israel: 282 m^3). So it is not physical water scarcity that Pakistan is predominantly suffering from but low water productivity.
- The water available at the farm gate for the farmers is about 144 billion cubic metres (BCM). The water that feeds into the canal system is about 125 BCM, whereas 5 BCM goes to urban and industry use. Nearly 31 BCM of water is reportedly lost during conveyance due to seepage and evaporation, and 49 BCM goes into the sea, whereas the losses from the rivers are 14 BCM. To augment surface water, Pakistan heavily relies on abstraction of groundwater for drinking and irrigation. This adds to another 59 BCM.
- Pakistan is the fourth largest user of groundwater after India, United States and China.

A multi-stakeholder approach for more water efficiency

With support from the Global Programme for Food Security of the Swiss Agency for Development and Cooperation (SDC), a multi-sectoral group of actors led by Helvetas Swiss Intercooperation is currently implementing a project to address inefficient irrigation practices in smallholder farming of cotton and rice in a number of countries, including Pakistan. The Water and Productivity Project (WAPRO) is based on a push, pull & policy approach. The push component refers to technological support for farmers to save water, and the pull component pertains to better conditions for marketing of high standard rice produced with water efficiency, while policy is about efforts to ensure up-scaling and sustainability of good practices. A crucial ingredient of good water governance is awareness of stakeholders on rights and obligations. The policy component contributes to this end through facilitating discussions among multi-stakeholders (push and pull actors as well as up-takers) in workshops and meetings and documenting success stories.

Punjab is the largest rice-producing province in the country. Here, more than 1.2 million farmers cultivate rice on over 1.76 million hectares. Out of the 23 rice districts in Punjab, nine top rice districts were chosen to participate in the project, which is being implemented by a multi-sectoral group of actors from the private sector, civil society and standard bodies (see Box on page 30). The project aligns with the water stewardship approach, which aims to bring water users and managers together to agree on negotiated and joint action and a water use plan. For this purpose, it uses the International Water Stewardship Standard of the Alliance for Water Stewardship (AWS), the goals of which contain good water governance and a sustainable water balance. The aims of water stewardship practices include advancing gender mainstreaming by encouraging assessment of the implication for women and men of any planned action in all areas and at all levels. For example, the project has conducted a study on the impact of alternative technology to replace manual transplanting, which is mainly done by women. The results of the study could be used to develop proposals to support the transplanters in acquiring new skills that could help them in finding alternative on- and off-farm jobs.

Comparison of water productivity in Pakistan with other countries

Country	Productivity (kg/m³)	Efficiency
Cereal commodities average		
EU	1.59	If EU=100
USA	1.26	79.2 %
China	0.78	49.1 %
India	0.39	24.5 %
Pakistan	**0.13**	**8.2 %**
World average	0.60	37.7 %

Achieving water security requires adopting inclusive and participatory approaches and a high degree of collaboration among all stakeholders. In the case of WAPRO, key private sector partners of the project are the Pakistani companies Rice Partners Limited (RPL) as well as Galaxy Rice Mills and national supply partners of food manufacturers Mars Food and Westmill (respectively). In addition to the rice farmers, other stakeholders include public sector departments (Agriculture and Irrigation), several companies engaged in rice milling and sourcing, service providers in rice sectors (including machinery providers, technology vendors) and researchers. The Sustainable Rice Platform (SRP) and the Alliance for Water Stewardship provide guidance to farmers and companies on sustainable production and water stewardship.

Rice Partners Limited and Galaxy Rice Mill procure their rice from two types of farmers: contract farmers who sign an agreement with the company to comply with the SRP Standard and source rice to the companies after due diligence, and farmers who are not contracted by the companies but participate in training programmes regardless of where they sell their rice. Together with the rice farmers in their area of operation the two companies have prepared Water Stewardship Plans to improve water productivity.

So far, 1,150 master trainers and 4,140 farmers in 50 villages have been trained to promote water productivity in line with the principle set by SRP, and 175 demonstration plots of 250 acres were established to demonstrate technologies with which water efficiency can be improved: laser land levelling, alternate wetting and drying und direct seeding of rice. Furthermore, the farmers were trained in using reduced amounts of agro-chemicals. Land levelling of 9,000 acres was completed with the farmers and the rice millers each sharing 50 per cent of the cost. 9,000 alternate wetting and drying (AWD) tubes were distributed among 861 famers for the area of 11,450 acres. Farmers used these tubes to determine if the crop needed irrigation so that over-irrigation could be avoided. Training is organised by the rice miller under the WAPRO project. It is provided by experts working with the millers and the public extension departments. There is no special focus on women since male representatives of the farming families represent their family in public and most of the farming work is also performed by male family members.

Overall, 20,000 famers were approached through different trainings, seminars, field days and IT-based awareness campaigns. A total of 1,650 contracts have been signed with farmers. Over 35,000 tons of paddy produced in 2019 following SRP principles was procured from contract farmers. The good news is that more millers are willing to participate in this endeavour. Five new millers have applied for the registration of SRP.

Promising results at all levels

Compared to conventional rice growing methods, the technologies employed, when combined with better agronomic practices, resulted in saving 30 per cent of irrigation water. A study conducted by Helvetas in 2019 based on a comparative cost-return analysis with 21 sampled farmers to compare the impact of change of practices showed promising results. The study assessed net revenue gain per acre (1 acre = 0.405 hectares) for all three categories of farmers – head, middle and tail of the channels. The average per acre increase in net revenue recorded in comparison from the baseline was 122 per cent at the head, 154 per cent at the middle and 190 per cent at the tail of the channel. The increase in revenue is mainly attributed to irrigation-efficient techniques and improved agronomic practices, e.g. the use of mechanical transplanters. In the past, the farmers, especially those at the tail of the channel who were receiving less irrigation water used more money to run tube wells for longer durations. Alternate wetting and drying tubes and laser land levelling technologies have proved to be very useful for improving irrigation efficiency. However, the results of direct sowing were mixed, with most farmers complaining of more weeds and inconsistent results in yield. Flood irrigation suppresses weeds. What also became apparent was that in comparison to selling to middle-men, increases in revenue and in time payments to the farmers improved in contractual farming, where millers and international buyers approach farmers directly.

Coincidently a number of developments took place since the start of the WAPRO project. The most crucial change in the context of the project has been the approval of National Water Policy 2018 in Pakistan. In connection with the Charter, the Government of Pakistan has launched a number of projects on water efficiency. For example, the Punjab Irrigated Agriculture Productivity Improvement project in Punjab province is now ongoing. And the KP Irrigated Agriculture Improvement Project is to be initiated in Khyber Pakhtunkhwa province in 2020. Both projects are financed by the Government of Punjab and the World Bank. Moreover, the Supreme Court of Pakistan has asked the bottled water industry to pay for abstracting groundwater. This indicates an overall shift and realisation in the country on the importance of sustainable water management as opposed to the highly-subsidised, supply-driven model operational for the last seven decades. The National Water Policy is highly supportive to promoting the concept of "more crop per drop". There is also more awareness at grassroots level among farmers regarding the roles of different agencies in water management. And they have learnt that, in contrast with the traditional view that more irrigation is beneficial for yield, more can be produced using efficient irrigation and improved agronomic practices.

THE WATER AND PRODUCTIVITY PROJECT IN PAKISTAN – SOME LESSONS LEARNT

The following conclusions can be drawn for successful water stewardship from the experiences gained in Pakistan's rice sector with regard to the individual stakeholders:

- Water productivity has to be promoted as a business case. Farmers will participate in sustainable rice production if they see benefits in water saving.
- As farmers have a low risk-taking ability and willingness, it is important that techniques are thoroughly studied and analysed for their relevance in various contexts. Moreover, it is easier to motivate farmers if the technology is locally available and economical.
- The use of mechanical transplanters as an alternative to manual transplanting proved to be very useful and should be promoted for water efficiency. However, the introduction of mechanical transplanters will result in women transplanters losing jobs. Support in finding alternative employment opportunities for this community is crucial.
- Participation of the relevant public sector players in the project activities is instrumental in achieving interest to upscale WAPRO practices.
- A motivated private sector is absolutely essential to achieve the water efficiency agenda by providing the much needed conditional pull to the farmers. This also holds for competence building of local service providers with regard to the push component.
- Local companies change their ways if they have export connections and related obligations. However, a strategic focus has to be on finding ways to motivate non-export companies to engage in sustainable production.

Challenges for up-scaling

However, several policy and organisational gaps are still hampering multi-stakeholder action towards water stewardship in the country:

- There has been no inclusion of farmers/ water users through their Water User Association in water management with clear duty bearing roles, and much of the irrigation network continues to be governed by primarily British era legislation. While the PIPIP projects referred to above are involving Water User Associations at the farm level in order to improve on-farm water efficiency, these associations do not have a role in the overall management of irrigation system.
- There is no policy to formally engage the private sector in water efficiency issues or invest in water use efficiency to positively reflect on water productivity or revenues.
- The huge irrigation system and water reservoir network provides highly subsidised irrigation water at the farm gate. In addition, the government subsidises electricity to pump groundwater and laser levelling equipment and provides low-interest loans and free extension services. Water is therefore seen as a free good by users. The government finds it hard to collect targeted revenues from users. The irrigation system stands deteriorated, and maintenance of the system is becoming increasingly expensive due to physical damages putting more financial burden on the government.
- Water stress in canals is often compensated by pumping out groundwater through tube wells. The provision of subsidies for the installation of tube wells will result in deterioration of the groundwater table.
- Public private partners and farmers are not working together on a commonly determined objective of water productivity. There are trust deficits on all sides. All the actors are working in silos.
- The equipment for improved water efficiency used in the WAPRO project is not readily available in the local market.

A brief outlook

The project partners will continue to participate in a learning process and assure that water productive techniques are used on a sustainable basis by the farmers. The main future outlook is towards high-level up-scaling by ensuring rice uptake by the private sector and the government. At a global level, efforts are ongoing to increase the market share of SRP rice by bringing more rice companies interested in SRP rice production and making these standards incrementally binding. This may only be achieved through a continuous dialogue with those who matter – and by disseminating a business model through different awareness raising mediums at local and national levels.

In the longer term, the partners will facilitate collaboration between actors in the rice supply chain to build a supportive infrastructure for rice growers, and to integrate rice growers into a more effective rice value chain by providing them with better access to technology, knowledge and training and linking them better to markets. This would drive positive change in the rice sector and develop an inclusive value chain, where rice farmers may supply quality rice, become stewards of the environment and increase the economic viability of their households. Partnerships are the basis for making a change – as stipulated in SDG 17.

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"The world we want tomorrow starts with how we do business today"

Five questions to Ian Knight, Global Sustainability Manager at Mars, Incorporated.

Mr Knight, you work in Pakistan and India with the WAPRO project. Why these countries, and why rice?
India and Pakistan are the largest producers of Basmati rice, and for us as the owner of the world's biggest rice brand, Uncle Ben's, Basmati rice is an important and growing part of our portfolio. Rice is a staple for half the global population, so it needs to be protected. We are working to create a sustainable rice supply that can help support business growth and the nutritional needs of a growing population.

What is the benefit evolving from such a kind of partnership for a company like yours?
Through collaboration and building partnerships, we believe that we are able to create mutual benefits for all involved. WAPRO serves to promote long-term relationships with our suppliers and the farmers who supply them. This encourages investment in training and deployment of more sustainable agricultural techniques that can improve yield and smallholder farmer income whilst reducing environmental impacts like water use.

What exactly is your role in this multi-stakeholder partnership?
Mars targets to ensure that all its rice farmers are working to implement the best practice techniques contained in the Sustainable Rice Platform (SRP) standard, such as alternate wetting and drying and laser levelling. Mars invests in agronomy to support and train farmers with implementation of the SRP. We also support the use of the Alliance for Water Stewardship's International standard as a framework for wider stakeholder consultation and engagement within the WAPRO project. Helvetas and its partners within WAPRO work to address the shared water challenges faced by communities in the areas we source rice from.

What has been reached so far? What are the lessons learnt?
In the first phase of WAPRO in Pakistan, we saw farm income and water productivity improve by 30 per cent. This encouraged us to extend our participation in WAPRO phase 2 to our Indian Basmati rice operations. A key learning has been the benefits of the Push Pull Policy approach and its suitability to be scaled, as WAPRO is now involved with projects in six countries.

What is next?
In terms of the partnership, we are keen to carefully assess the impact of WAPRO in Haryana state, India, and we are hopeful that the project will again be enabling significant water and economic productivity improvements.

As a business, we believe that the world we want tomorrow starts with how we do business today. We will be continuing to work to improve the sustainability of global rice supply and make sure that this crucial crop is around for generations to come.

The questions were asked by Silvia Richter.

Mars Sustainability Plan

In 2017, Mars announced they would invest a billion dollars in their 'Sustainable in a Generation Plan'. The plan addresses key areas of the Sustainable Development Goals. The company committed to ensure that their products are sustainably sourced and have a positive impact on the value chain – with a better yield and fairer pay. Regarding rice, the company's ambition is that by the end of 2020, 100 per cent of its rice is sourced from farmers working towards the Sustainable Rice Platform standard. By 2025, all farmers are to be on the path to sustainable income, and the gap to sustainable water use is to be reduced by 50 per cent. In addition, the company made a global commitment that 100 per cent of their packaging would be recycle-ready by 2025.

The water footprint – a practical tool for water-resilient value chains and catchments

Fifteen thousand litres of water for a kilogram of beef, and a thousand litres of water for a kilogram of avocados. Whenever there is mention of the water footprint, people usually associate it with water consumption for certain products. But the concept has a much bigger potential, as our authors show.

By Derk Kuiper and Erika Zarate


Photo: Jörg Böthling

According to the Water Footprint Network, producing 1 kg of cotton in India consumes 22,500 litres of water.

THE WATER FOOTPRINT

The water footprint is an indicator of freshwater use. Blue and green water footprints measure volumes of water consumed (evaporated or incorporated into a product), either from surface and ground sources (blue water footprint) or from rainwater (green water footprint). The water footprint is a geographically explicit indicator, showing not only volumes of water use, but also the location (Hoekstra et al., 2011).

In 2004, Arjen Hoekstra, a professor at the University of Twente, Netherlands, showed that a Dutchman drinking his nice cup of morning coffee actually consumed 140 litres of water. He had introduced the water footprint concept (see Box) in the scientific world back in 2002, but this time, the concept reached the public beyond the scientific community. The idea of consuming water while drinking a cup of coffee was powerful and contributed to increasing the understanding of water use in the value chains of commodities. Soon after, water footprints of commodities like sugar, cotton, beef, or energy started to appear beyond scientific papers in order to raise awareness and reach a wider public. Naturally, multinationals with agricultural value chains grew interested and also a bit anxious about the water footprint, which might potentially create a perhaps not so desired transparency on water consumption in commodity value chains. At the time, the water footprint contributed by increasing the understanding of the idea that the impacts on water consumption and water pollution of commodity production occurred in one place while consumption was mostly occurring at another place. This immediately brought up a notion of assuming responsibility for water use in production geographies and the need for value chains to take action.

Diverging opinions

While many embraced the concept, the water footprint was also strongly attacked by some research groups and industry bodies. They claimed that the 140 litres of water used for a cup of coffee did not say anything about the environmental and social impact of the water consumption. They were right about that, in the sense that the 140-litre number represented a global average and was used for awareness raising. However, they missed a key piece of knowledge embedded in the original concept as introduced by Hoekstra. The water footprint was never defined to show the impact of that water consumption, but rather as a measure of the volume of water consumed in a certain catchment in a specific period of time. Sadly, the water footprint suffered under these attacks and lost some of its appeal to the outer world. It did not however lose its conceptual strength or the interest of a group of people who continued to carry out research but also to develop practical applications using the water footprint as a solid tool to drive forward the sustainability of agricultural value chains. Today, we are witnessing a rebirth of the water footprint concept. It is becoming one of the key indicators to drive water sustainability in agricultural value chains.

Transparency on water consumption and engagement in water

Water footprints can nowadays be calculated by anybody in the world thanks to open access methodology and data. As a result, water footprint datasets have become more locally specific, and slowly, transparency on water consumption in many places around the world is increasing. Because of the open nature of the water footprint and the underlying data, water footprint data has the potential to become widely and transparently available to everybody engaging in water. This means that not only companies but also communities, civil society and governments can have access. The water footprint provides a solid information source supporting dialogues between stakeholders on shares of water consumption in specific places and time periods, and can inform the water allocation discussion as well as management arrangements for various uses.

Water footprints have the potential to align the water consumption of a commodity with the water situation in a locality. For example, the water footprint of coffee is nothing more than an estimation of the water consumed by the coffee plant and the subsequent processing in the production locality. This volume of water consumed by the coffee production and processing is connected directly to the local water situation and at the same time, indirectly, to a commodity value chain. It is this logic that helps companies with global value chains to understand their water consumption and their contribution to the water situation in their sourcing locations. While it is still early days, there are already companies that are starting to understand how this will help them to drive value chain water sustainability. For example, we are working with a global food processing company that sources raw materials from all over the world. Through our work they now understand the water use associated with the raw material they buy and how they can work with value chain partners to help improve or at least not worsen the local water situation.

In practical terms, how exactly?

Blue and green water footprints can be directly connected to the local water situation by linking blue and green farm water consumption with the water balance of the catchment, command area or administrative and hydrological unit for allocation of available water resources. The water footprint of several farms in a catchment forms the water footprint of a sector, and the water footprint of all sectors in a catchment forms the water footprint of that catchment. The water footprint of the catchment refers to the evaporative component in that catchment. If the catchment has an unsustainable water balance, there will be water flows being extracted from the catchment (i.e. the evaporative flow) faster than the renewal capacity of the same catchment, and therefore, there will be depletion and an unsustainable situation. This means an important water risk for the value chains sourcing a commodity – and its water in virtual form – from that place. A company can quantify its share of water footprint in the catchment, and moreover, can use the water footprint to conduct crop water use benchmarking across different catchments. Understanding the crop water footprint, the shares of crop water footprints in catchments and the benchmark of crop water footprints across catchments provides strong intelligence for water risk management in value chains and catchments.

The future

Taking the enormous growth in tech and data access into account will increase the efficiency of water footprint calculation. Satellite data will increasingly support the validation and verification of these calculations. The widespread access to more reliable and localised water footprint data will facilitate the drive of water sustainability in global value chains and the catchments these value chains depend on.

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References: **www.rural21.com**

A Village in Ciénaga Grande, Colombia.
Photo: Good Stuff International

Good Stuff International is a consultancy company specialised in supporting people and organisations to become sustainable water users. For example, we work for the World Wildlife Fund (WWF) to support the multi-stakeholder Water Stewardship Platform in Northern Colombia. The Platform was founded in 2015 by WWF and the private sector and is a space where stakeholders collaborate to design strategies and to carry out concrete projects for the sustainable use of freshwater in Frío and Sevilla Catchments to sustain water flow to the Ciénaga Grande Wetland (see image). We have used the water footprint as key information on water productivity and water efficiency of different stakeholders to drive collective action.

More information on the Water Stewardship Platform can be found in the brochure:

http://www.goodstuffinternational.com/images/PDF/WWF_Flyer_Kolumbien_WEB.pdf

Ismahane Elouafi is Director General of the International Center for Biosaline Agriculture (ICBA) in Dubai.

Photo: ICBA

"We must mobilise all available resources"

Freshwater deficits are affecting more and more people throughout the world. In order to counter this, our global food system will have to change, our author maintains. A case for more research on alternative crops and smart water solutions.

By Ismahane Elouafi

Our world today is in the grip of a climate crisis. So grave it is that it is listed as one of the several existential risks to humanity. Climate change is slowly taking a toll on communities, ecosystems and economies. And its costs are rising. The nations least prepared for climate-induced effects are, unfortunately, the most vulnerable.

Against this backdrop, population growth and resource depletion are worrying. As the global population is forecast to hit 9.7 billion by 2050, demand for food and water will soar. The problem here is that climate change will considerably impact agriculture, among many other sectors, putting the global food systems at serious risk. Several studies warn of future and in some cases current declines in yields of staple crops such as wheat, rice and maize due to climate change and other factors.

But climate change is not the only problem. Global food production is also threatened by water scarcity, as well as water and soil salinisation. Farming inconveniently accounts for around 70 per cent of the world's water withdrawals. Yet about four billion people face water shortages at least one month a year. And around half a billion do not have enough water all year round.

This problem is more pronounced in water-stressed regions like the Middle East and North Africa. To make up for the freshwater deficit, many countries depend on desalination, which leads to another problem: reject brine. Scientists reckon desalination plants around the world produce 95 million cubic metres of freshwater per day, often at a heavy environmental price. Some 142 million cubic metres of reject brine is discharged every day, mostly back into the environment.

Soil salinisation is a major constraint on agriculture, too. Every day since the early 1990s, an average of 2,000 hectares of irrigated land in arid and semi-arid areas in 75 countries has been degraded by salt. By one estimate, the global annual cost of salt-induced land degradation stands at 27.3 billion US dollars because of lost crop production only.

These problems raise questions about whether traditional agricultural approaches and crops are fit for purpose in marginal environments. As arable land and freshwater resources are in short supply, it is more important than ever before to make the most of every type of land and water to meet future food demand. Decades of research show that saline water, as well as other types of non-fresh water, can be efficiently used for food, feed and biofuel production. While alternative crops like quinoa, sorghum, pearl millet and Salicornia cope well with heat, salinity and drought, treated wastewater, saline water and seawater could be viable options for irrigated agriculture.

> Our research to date shows that alternative crops and water resources hold a lot of promise in marginal environments.

More diversity needed

Our global food system is currently too dependent on just a small number of major crops like rice, wheat and maize, which are neither resilient nor nutritious enough. As a result, our diets are not adequately rich. A mere 15 crops provide 90 per cent of our food energy intake, of which two-thirds comes from only rice, wheat and maize. This needs to change, as it is neither good for our health nor sustainable for our planet.

There are around 30,000 known edible plant species in the world. More than 6,000 crops have been cultivated for food throughout human history, but fewer than 200 species have any significant production levels globally. Our food systems and diets across the international market unfortunately do not reflect the diversity on our planet.

For more than two decades, the International Center for Biosaline Agriculture (ICBA) has been working on alternative crops and technologies that help to produce more food, save more resources and protect the environment.

Aerial view of the integrated agri-aquaculture system at ICBA.

Quinoa could have a huge potential in Central Asia, where the Aral Sea Basin has been especially hard-hit by salinisation.

Salicornia is a halophyte that can be used as a vegetable and as forage.
Photos: ICBA

Our centre has developed and tested a wide range of solutions suited to changing realities in different regions. Our scientists have introduced crops like quinoa, pearl millet, sorghum and Salicornia, among others, in countries in Central Asia, the Middle East and North Africa.

ICBA has also conducted applied research on treated wastewater, saline water and seawater irrigation. Our scientists have, for example, run long-term experiments on the effects of irrigating vegetables such as carrots, lettuce, eggplant and tomato, as well as landscaping plants and date palms, with treated wastewater. Results indicate that treated wastewater is a good alternative to freshwater resources when it comes to agriculture and landscaping under arid conditions.

Integrated approaches put to the test

Since 2013, our centre has operated inland and coastal modular farms to study the use of reject brine and seawater. The inland modular farm uses desalinated water for vegetables, reject brine for fish, and aquaculture effluents for halophytic plants, while the coastal modular farm uses seawater for fish and aquaculture effluents for halophytic plants.

We should consider options that have received little attention so far, especially in parts of the world that suffer from lack of water, poor soil and drought. First, alternative crops should come to the fore in areas where major crops produce little or fail. This will boost agricultural productivity and rural livelihoods. Second, it is important to make better use of brackish water, treated wastewater, reject brine and seawater for farming purposes in countries where freshwater resources are scarce. This will help to reduce pressure on freshwater resources. Third, it is crucial that research and development continues to identify and test crops and technologies best suited to marginal environments to ensure future food, nutrition and water security and to develop new food systems that are better adapted to today's and tomorrow's climates.

If we want to achieve the ambitious targets of the Sustainable Development Goals, we must mobilise all available resources.

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Saving water and energy with an intelligent subsurface irrigation system

A pitcher irrigation test field in Sanaa, Yemen.
Photo: Michael Klingler

An irrigation test site in Biskra, Algeria. Sensors monitor the soil water content.
Photo: Andrea Dührkoop

Investigations have been carried out by a research group at Kassel University aimed at adapting the auto-regulative potential of the old clay pot (pitcher) irrigation system to modern and up-to-date irrigated agriculture. Within the frame of several international projects the new irrigation technique was developed and tested. Various stakeholders were involved in spreading the innovation among a broader community.

By Andrea Dührkoop

It was a simple idea. A permeable pipe filled with water buried in the ground near your plants makes sure that they will not suffer from water shortage. And your only job is to make sure that your pipe is always filled with water. With that technical solution, you will save water and energy while providing an optimal soil water content for your plants (near field capacity). This simple approach was adopted from the old "pitcher" (clay pot) irrigation method.

A technology known for centuries

Clay pot irrigation is a type of subsurface irrigation which has been known in arid and semi-arid areas for thousands of years. The unglazed porous clay pot is embedded in the ground and filled with water which eventually drains through the porous pot wall. One special feature of this irrigation method is its auto regulation ability (Abu-Zreig et al. 2006, Stein 1997, van Sen et al. 2007), which arises from the close interaction between the pot and its environment, namely the plant, the soil and the soil water tension. Thanks to their specific material properties, the pots deliver water to the soil when it is dry, soil water tension is high, and the crop is suffering water stress. Once soil humidity rises, soil water tension will decrease and the water flow will eventually decrease or even stop. The decisive parameters for the efficient operation of pot irrigation are the porosity and the hydraulic conductivity of the pot material (Stein 1996, Dührkoop 2008, Dührkoop 2011, Abu-Zreig et al. 2006).

Clay pot irrigation is simple, low-cost, requires only a low pressure head, and can be manufactured from local materials (Stein 1994, Batchelor et al. 1996, Zarei et al. 2003, Klingler 2005). The disadvantages of pot irrigation are its mechanical sensitivity, leading to an exclusion of mechanised agriculture, and the high level of labour required (Lungu 1996). Moreover, longevity of the pots is often unsatisfactory (Klingler 2007).

Subsurface drip irrigation or SDI is another subsurface technique. The American Society of Agricultural Engineers (ASAE) defines SDI as the "application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation" (Camp 1998). The advantages of SDI are its suitability for mechanised installation, options for use at large scale, and a long life expectancy (Lamm et al. 2012). One drawback is that the system needs energy to provide pressure for water release through the emitters.

Combining the best of both systems

An optimised, highly efficient irrigation method may be achieved by combining the advantages of SDI and clay pot irrigation, while avoiding their disadvantages. Advantages that SDI and clay pot irrigation share are the water release in the plant rooting zone, a dry plant surface, a dry soil surface and, consequently, low losses through evaporation and deep percolation, with the latter depending on SDI proper management.

A research project (2011–2013) within the frame of the support programme "Sustainable Solutions for Sub-Saharan Africa" financed by the German Federal Ministry of Education and Research (BMBF) was conducted at the Department of Agricultural and Biosystems Engineering at Kassel University, Germany, in order to develop a new environment-friendly and water-saving irrigation technology. The innovation consists of a flexible porous pipe made of high-tech polymer membrane material. Laboratory and small-scale irrigation tests had led to the assumption that this irrigation pipe had auto-regulation properties. In the project, activities focused on field testing, research and development on the membrane pipe. The project partners involved comprised universities, research institutes and industry from Algeria, Kenya and Germany.

Four field test sites were selected to represent different climate, soil and operation conditions, which led to a broad scope of test conditions for the irrigation pipe. The climate varied between Mediterranean (Algiers, in the North of Algeria, mean precipitation 600 mm, annual evapotranspiration 1,200 mm), arid (Biskra and Touggourt, southeast of Algeria, annual precipitation 100 mm, annual evapotranspiration 2,000 mm) and temperate climate (Nakuru, central Kenya in the highlands, mean precipitation 1,000 mm). Soils ranged from clayey with a high content of gypsum through loamy textured (saline) to sandy soils in the desert regions.

Greenhouses were equipped with both the membrane pipes and common local drip irrigation techniques to compare in terms of water consumption, crop development (yield) and use of marginal water (high salt content, high load of suspended solids, wastewater). The installation depth of the membrane pipe was 25 to 30 cm, and the distance depended on the type of soil. In heavy soils (clayey, loamy), the distance was 50 to 70 cm, and in light soils (sandy) 30 to 40 cm. Wetting capillarity was a crucial factor. The crops cultivated were tomatoes, beans, pepper, cucumbers and egg plants.

Higher yield, no salt incrustrations

In all experimental fields, it was stated that the soil surface was dry, and no or significantly fewer weeds were observed in contrast to when surface drip irrigation was used. This is owing to the fact that water is only provided in the plant's root area and losses through evaporation are ruled out. The dry soil surface prevents weeds from growing.

One test site in Algeria was in Biskra (see right Photo on page 36), bordering on the Sahara in an arid region. Results showed a 60 per cent higher yield (tomatoes) with 48 per cent less irrigation water compared to drip irrigation when using low quality/ salty irrigation water (4.69 decisiemens per metre). The supply of water directly on the soil surface with the drip irrigation quickly led to salt incrustations. This was not observed on the membrane pipe plots.

The machine enables pipe installation with minimal disturbance of soil and vegetation.

Photo: Viermann Maschinen GmbH

When using water with a high content of suspended solids (e.g. dam water), the membrane pipes show a decrease of water flow through clogging (fouling) of the porous pipe. This needs to be monitored during operation, so that the system can be adjusted by introducing filters or by frequent flushing of the pipes.

The project showed promising results and led to more engagement in subsurface irrigation in order to promote this efficient system. A follow-up project, financed by Germany's Federal Office for Agriculture and Food (BLE, 2013–2016), was initiated to establish links between projects dealing with subsurface irrigation (SI) methods in Algeria, Kenya, Turkey, Germany and Namibia. The SI techniques concerned were: subsurface drip irrigation, porous hose and the newly-developed "auto-regulative" system. Each project conducted an analysis of various SI methods in field trials under local conditions in terms of water productivity, use of low-quality water, salinity effects in the soil and socio-economic aspects. Results were presented at farmer field days held during the individual projects. In addition, the combined results were summarised in guidelines for stakeholders, farmers, water managers, water authorities and ministries (Dührkoop & Hensel 2018).

Low-cost machinery for installation of irrigation pipes

Up to now, the labour-intensive installation procedure – digging thousands of metres of trenches – has been a major hindrance to the large-scale application of subsurface irrigation. Since 2018, a group of scientists from the above-mentioned institute have been developing efficient and low-cost installation machinery for mechanised installation of subsurface irrigation pipes. It enables pipes to be installed with minimal disturbance of soil and vegetation. The technology is being produced and marketed by a German start-up company, with first sales to clients from Southern Europe and Northern Africa. Expansive marketing activities are currently starting in close cooperation with major irrigation technology providers.

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References: **www.rural21.com**

Contrast between rangeland with regular bush control (front) and intense bush encroachment by woody species (back) in central Namibia. Photo: Otjiwa Safari Lodge

Namibia's bush business

Bush encroachment has negative effects on ecosystem services and reduces agricultural productivity. However, the bush biomass can be used for economic gain. In Namibia, farmers, entrepreneurs and technology companies are now buying into the enormous potential of this biomass. A joint project of the Namibian Ministry of Agriculture, Water and Forestry and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) is translating the problem of bush encroachment into an opportunity.

By Ina Wilkie and Asellah David

Namibia's national anthem tells a story of freedom fight, love and loyalty. It praises the "contrasting beautiful" country and the "beloved land of savannahs". Sadly, many areas in Namibia are not open expanses of grassland anymore. They have turned into thickets of thorny bush. The phenomenon is called bush encroachment and occurs across the savannah biome globally. Bushes, in Namibia predominantly indigenous acacia species, spread and form impenetrable thickets.

More than 30 million hectares are considered to be bush encroached in Namibia. This is a third of the country – an area roughly the size of Italy. Bush encroachment is largely anthropogenic. Inappropriate rangeland management practices such as overgrazing and the suppression of fires have been identified as the main causes. Further ones include the increase of CO_2 in the atmosphere and changes in precipitation patterns due to climate change.

Bush encroachment creates a number of environmental and economic challenges, and the quality and quantity of grass decreases. In extreme cases, the carrying capacity of farmland is reduced to one-tenth. Bush encroachment has resulted in a decline in Namibia's agricultural productivity by two-thirds in recent decades. The landscape looks monotonous, biodiversity decreases, and it becomes difficult to spot wildlife. This potentially has a negative impact on tourism, which is a very important industry for the country. Hydrological studies also show that bush encroachment has a negative effect on groundwater recharge as bushes evaporate significantly more water than grass.

Turning a challenge into an opportunity

Controlling bush on rangeland is a huge challenge. The vast lands are difficult to access, thorny bushes are hard to handle, and most species are known to coppice stubbornly after felling. However, today in Namibia, the tide is turning. Namibians are starting to see the land – and the bush – with new eyes: Encroacher bush can be high quality biomass for a number of value chains. Farmers, entrepreneurs, technology companies and financers are buying into the biomass opportunity. Academia and government are starting to realise the value of a bioeconomy for Namibia.

The Namibian government is in the process of creating an enabling policy environment for bush control and biomass utilisation. In the current National Development Plan (NDP5, 2017–2022), bush control is a national priority. The plan is part of the Namibian "Vision 2030" and identifies steps for economic progress, social transformation, environmental sustainability and good governance. Through sustainable land management practices, the

In-field training by the De-bushing Advisory Service on bush-based animal feed production from encroacher bush. Photo: DAS

country strives to achieve land degradation neutrality and optimal land productivity. Restoration of bush encroached lands and the sustainable management of rangelands are the main priority programmes under this strategy.

Owing to the multi-sectoral relevance of the topic, a project steering committee led by the National Planning Commission was convened already in 2014. The committee comprises government and private players, including the Ministry of Agriculture, Water and Forestry, the Ministry of Environment and Tourism, the Ministry of Mines and Energy, the Ministry of Industrialisation, Trade and SME Development, the national energy supplier NamPower, as well as the newly formed Namibia Biomass Industry Group (N-BiG).

To control bush in the long term, a sustainable approach to land management is critical. With its National Rangeland Management Policy and Strategy (2012), Namibia has introduced a policy based on principles of good rangeland management which provides for long-term sustainability. The policy has received international recognition for its holistic approach. Farmers were involved in the development and are at the core of implementation, through farmers' associations and under the umbrella of the Namibian Agricultural Union.

The promotion of bush control and of biomass value chains is also a central component of development cooperation between Namibia and Germany. A "Bush Control and Biomass Utilisation" project (BCBU, 2014–2021) of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in cooperation with the Namibian Ministry of Agriculture, Water and Forestry has been established. Within this cooperation, political framework conditions and approval processes for sustainable bush harvesting and utilisation are continuously being developed and implemented. Furthermore, support organisations for farmers and industry have been set up: The "De-bushing Advisory Service" is a knowledge centre for farmers and entrepreneurs; the above N-BiG is an industry association representing Namibian biomass producers.

Namibia has created regulations to ensure the sustainability of harvesting operations, including a set of approval processes for harvesting permits and environmental clearance. The Forestry Directorate of the Ministry of Agriculture, Water and Forestry and the Environmental Affairs Directorate of the Ministry of Environment and Tourism manage these approval processes.

Certified charcoal from high quality hardwood

To date, the largest demand for biomass is created by the oldest value chain, the charcoal sector. The Namibian government has identified charcoal as one of the ten strategic industries for Namibia's Growth at Home Strategy. The support is facilitated by the Ministry of Industrialisation, Trade and SME Development with various public and private sector stakeholders. Globally, Namibia ranks fifth in the export of charcoal and exported close to 200,000 tonnes in 2019. The charcoal is thriving on international markets as consumers are increasingly environmentally conscious. Charcoal made from Namibian hardwood is not only a high quality product, it is definitely not made from tropical wood and not connected to harmful deforestation. Rather, it contributes to rangeland restoration. In addition, there are positive social aspects as charcoal production also has an enormous employment potential for the country. The sector already employs more than 7,000 people, especially in rural areas where jobs are scarce. This adds up to at least six per cent of the total labour force of the agricultural sector.

Certification by the Forest Stewardship Council (FSC) is rapidly increasing in popularity in Namibia. The area certified by FSC has increased by a factor of three in the last three years. An FSC standard suited to Namibian conditions has been formalised. "The guidelines are now specifically adapted to the Namibian bush and environment. This will make it much easier for farmers to achieve FSC certification," says Michael Degé, manager of the Namibian Charcoal Association. "We are ready to upscale considerably".

Big biomass business

Upscaling is also one of the focus areas of the GIZ BCBU project. Currently, only 1.36 million tonnes per year of bush biomass are utilised. The annual spread of bush is estimated at 3 per cent which adds up to 9 million tonnes. This amount would have to be harvested annually to hold the status quo. For upscaling, an estimated minimum of 300 million tonnes of biomass is available for sustainable harvest within the scope of rangeland restoration. This calls for international cooperation and partnerships on technology, business and market development. In this context, N-BiG signed an agreement with the German National Association for Bio Energy on cooperation in


Photo: Ina Wilkie

Windhoek Lager is one of Africa's favourite beer brands. Two years ago, Namibia Breweries installed a biomass boiler and now utilises native encroacher bush for process heat production, subsidising imported heavy fuel oil. "For the brewing process, we heat water to 90 to 100 degrees," Bernd Esslinger (Photo, right), chief engineer of the brewery, explains. "Today, we use 90 per cent of the heat for brewing, pasteurisation and rinsing stems from biomass." This has a positive effect on the brewery's carbon footprint and reduced costs by 40 per cent. "Furthermore, we are now less dependent on the fluctuation of the oil price," Esslinger adds. "We are proud to utilise a local raw material, thereby investing into the local economy. That is also great for our image. We brew Namibian beer, and our energy stems from Namibian bushes."


Photo: GIZ/ Johannes Laufs


Photo: Ina Wilkie

"I have learned that we can actually use our bushes to produce animal feed," says Ndapunikwa Pahangwashimwe (Photo). She is a member of a farmers' cooperative and attended a training workshop of the De-bushing Advisory Service (DAS) in Okongo, in the north of Namibia. "We were shown which bushes to use and how to mix different supplements with the fibre so that we can feed it to our animals to survive the drought. As a cooperative, we are now planning to buy a machine so that we will be able to produce this type of feed."

mobilising know-how and resources as well as sharing networks and opportunities.

Utilising bush for energy production would be a big step forward for Namibia. Two industries, Namibia Breweries and Ohorongo Cement, are already using wood chips for heat production. NamPower, the national energy supplier, is in the process of planning a 40 megawatt (MW) biomass-fuelled power plant over the next four years as part of its strategic plan.

Ensuring sustainable supply structures for biomass, especially for large off-takers such as biomass power plants, is crucial for upscaling. The GIZ BCBU project has therefore launched a partnership with the Institute for Applied Material Flow Management (IfaS) of Trier University, Germany, to develop a strategy for a so-called Biomass Industry Park (BIP). Such a hub would bring together different bush-based industries at one location. The hub would move biomass in large quantities. It would trigger technological advancement in clean biomass production and synergies between different production processes. For the participating industries, economies of scale would lower costs for a number of reasons, including specialisation of labour, lower cost of capital, and spreading of internal function costs across more units sold. In addition, a BIP would be a leading player in the bush-to-value industry, and its trigger effect would attract other players such as logistics companies or independent energy producers.

Bush-based animal feed

Out on the farms, as Namibia is experiencing extreme drought, one bush-based product is booming particularly: animal feed. A range of scientific studies initiated by the project has shown that bush can be fed to cattle and small stock. However, bush-based animal feed must be produced and fed based on certain rules. Bushes need to be harvested in a specific way and at a specific time, the fibre needs to be milled, and supplements need to be added.

If produced correctly, bush-based animal feed can provide affordable fodder during emergency situations, such as droughts, but also as supplementary feed throughout the year. Bush-based animal feed can be an option for small-scale farmers who can start producing with a small set-up consisting of a panga (machete), axe and a hammer mill. On larger commercial farms, bigger set-ups including a chipper and a pelleting machine can be viable. Consequently, the demand for information and training is enormous, especially on bush-based animal feed, but also on harvesting techniques in general. The De-bushing Advisory Service (DAS) rolls out capacity development programmes for farmers, workers, contractors and SMEs. In addition, DAS is developing three career qualifications for technical and vocational education and training in line with the guidelines and frameworks of the Namibia Training Authority.

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Photo: Jörg Böthling

Empowering women through mechanisation: Where are the opportunities?

So far, development projects in rural mechanisation have mainly addressed the productivity and profitability of smallholder farmers, with little attention paid to the involvement of women in the mechanisation value chain, not just as beneficiaries, but also as controllers or owners of machinery. Here, this article aims to act as a conversation starter.

By Lungelo Cele, Ingeborg Adelfang-Hodgson, Michael Boateng and Eugene Moses Abio

While interest is growing in Africa in research on mechanisation and especially on farmers' access to mechanisation services, less attention is given to occupations and entrepreneurship opportunities, particularly for women. In 2017, 68 per cent of the people in developing countries were engaged in agricultural activities, with women comprising an average 43 per cent of the agricultural labour force. But at 16 per cent (as of 2018), the proportion of women in the plant and machine operator and assembler profession remains very low, resulting from barriers such as negative stereotypes about the profession, short-sightedness or lack of awareness on the part of the industry and training providers regarding the needs of women and cultural beliefs of what a women can or cannot do in society and in the economy. Hence there have never been projects or programmes aimed at training women in tractor operation, maintenance and management specifically to deal with this gap. Based on research done as part of a master's thesis looking at women tractor operators in Ghana, with this article, we would like to put more attention on agricultural mechanisation from a gender inclusive perspective, also looking at how women can help address some of the challenges faced by this industry.

First steps towards a mindset shift ...

Like in many other countries of the Global South, women constitute the bedrock of agriculture in Ghana. While forming just over half of the labour force in the sector, they produce 70 per cent of the country's food stock. In order to sustainably drive women participation and leadership in the operation of agricultural machinery, the Women in the Driving Seat (WiDS) project was established in 2018 (see Box on page 42). It provides five weeks of intensive training on both theory (20 %) and practice in field sessions (80 %). After the training, the trainees are placed with commercial farms to undergo four months of intensive workplace experience learning, which they would otherwise have found hard to acquire for gender reasons. And before the trainees exit the project, they are assisted in developing a business plan in tractor operation, a measure aimed at boosting their entrepreneurial drive so that they can start their own tractor business.

In 2018, the project had 60 places available and attracted 133 applications. A year later 120 young women were trained. It was surprising to have such a high number of applications, given that tractor operation is considered a male occupation. This was an indication that when the opportunities are created with intent and purpose, young women are willing to take them even if they are in the fields dominated by men or considered unattractive for youth. The women in tractor operation, maintenance and management training has been the first of its kind in terms of the training design and implementation approach tailored for women. The outcome of the project to date has challenged the existing status quo hindering women participation in this male dominated profession and created a new political awareness and commitment to/ for women in tractor operation and gender-sensitive trainings.

Out of the 180 participants in 2018 and 2019, 60 per cent have found employment in various commercial farms, training institutions and agricultural mechanisation service enterprise centres etc. The project revealed that most men who saw or heard about the women tractor operators had different views. Some believed that women were there to complement their efforts on the farms whilst others thought it was an approach to create competition between men and women in tractor operation.

What opportunities have not yet been explored?

Many African countries, including Ghana, Nigeria, Rwanda and Ethiopia, have developed Agricultural Mechanisation Service Enterprise Centres (AMSECs) to enable their farmers to acquire tractors and other machinery. However, these programmes have largely benefited commercial farmers. Consequently, as part of Ghana's accelerated Agricultural Modernization Policy to address the challenges of mechanising agricultural production in a timely and affordable manner, by 2017, the Ministry of Food and Agriculture (MoFA) had imported and sold on a hire-purchase basis about 6,200 agricultural tractors and other implements to Ghanaians keen to establish AMSECs. This also included imports of two-wheel tractors to address smallholder farmers' challenges regarding access to tractor services. AMSECs grew from 12 in 2008 to 201 in 2019. Yet, the involvement of women in such structures remains very low. Often, men conduct commercial transactions of agricultural mechanisation services addressing the use of farm machines and implements at farm level and make decisions and control the resources required to invest in mechanisation (especially capital).

Ghana's MoFA is expected to import about 3,000 tractors between 2018 and 2022 in line with the modernisation strategy to improve food security by reducing food imports from foreign countries. It is also aimed at enhancing agricultural production by reducing drudgery and minimising human labour. The number of women benefiting from the tractor programmes has once again remained very low in terms of employment and ownership. The traditional roles of women have restricted their participation in agriculture mainly to manual labour, which restrains them from using or managing farm machinery. In addition, lacking access and skills regarding farm machinery operation and management, women are often unable to make decisions on purchasing farm machinery for their family farms. Hopefully, however, increasing women capacity in tractor operation, which the WiDS project seeks to achieve, will result in more women operating and owning machinery and in training them in this area will lead to the creation of further encouraging role models.

Adam Fati (23) is currently undertaking her four-month internship programme at Chuchulga branch of Mango City Farms Ltd. She had her inspiration to attend the training programme from her sister who got trained from the first batch and is currently working as a tractor operator with a commercial farm in Daboya, northern Ghana.

Photo: Lungelo Cele

THE WOMEN IN THE DRIVING SEAT PROJECT

The Women in the Driving Seat (WiDS) project is being run by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in collaboration with Ghana's Ministry of Food and Agriculture (i.e. the Ministry Directorates of Agriculture Engineering Services and Women in Agriculture Development). It has three main objectives: improving skills and knowledge of beneficiaries regarding available modern agricultural machinery and its usage, strengthening local support networks in breaking the barrier and myths surrounding the usage of agricultural machinery by women, and improving the socio-economic status of beneficiary women. The first and second phases of the project took place in 2018 and 2019, when 180 women were trained in all. The intake number for its final phase, in 2020, is yet to be determined. The women are selected based on the following criteria: access to a tractor (not compulsory), aged between 18-40 years, basic literacy and numeracy skills, and a genuine interest in agricultural mechanisation. Training takes place in two Agricultural Mechanisation Training Centres (AMTCs) at Wenchi and Adidome Farm Institutes, where various agricultural machinery and equipment has been procured and stocked as training or learning materials.

There are different approaches to source funding for continuity, while plans are also underway to institutionalise the training at agricultural training centres where those interested can apply and be charged a fee to take part. In addition, measures are being put in place to sustain the training e.g. engagement with commercial farms to absorb some of the training cost and also engage the Ministry in allocating a budget to train more women and retrain past trainees. Moreover, the Ministry has already been taking best practices from the project which are leveraged on in terms of designing and implementing gender-sensitive trainings.

Where is the potential breakthrough for women empowerment in mechanisation?

Interventions and programmes by MoFA have been challenged greatly by the frequent breakdowns resulting from mishandling and improper use of agricultural machines, partly due to the low skill levels of the machine operators, mechanics and technicians. A survey by MoFA revealed that almost all the AMSECs were operated by tractor operators who lacked the knowledge in safety of agricultural machinery and proper handling of the various machinery and equipment. While machinery may pass the international standards under a particular environment, under the African environmental conditions, and with operators lacking sufficient technical knowhow, the same machinery may break down prematurely. This is a challenge that gives a window of opportunity for

OPEN RESEARCH QUESTIONS

Research on women and mechanisation is still in its infancy. Here are just of few of the as yet open questions:

- How could mechanisation be used to increase the number of young women in agriculture and encourage migration into rural areas?
- What would it take to achieve this? Could there be spill-over effects to smallholders as well as commercial farms if more women owned and operated tractors?
- What is the landscape of potential funders for such opportunities for women? What is important in addressing the need to find solutions for collateral issues for women who wish to take up these opportunities?
- Where else could the skills acquired for agricultural mechanisation be transferred to? For example, could women tractor operators in agriculture transfer their skills to other sectors like construction and operate machinery there?
- What diversification opportunities could exist for women as a result of being included in mechanisation?
- How could more women be involved in driving the ICT-enabled mechanisation services? What are the pros and cons for women in using the different types of tractors and other machinery in the 21st century?
- What kind of organisational forms exist that women could consider in pursuing these opportunities? How could women be embedded in mechanisation institutions such as AMSECs? Are there rules and regulations that act as a barrier for women?

Four-wheel tractors imported from Brazil to strengthen AMSECs in Ghana.

Photo: Eugene Moses Abio/ MoFA

the development of the industry and the inclusion of women.

The involvement of women in mechanisation could help create a mindset-shift not only for women, but also for practitioners, employers and society. Involving women in this field could help them acquire a new dual self-identity as professionals and homemakers. It would enable them to contribute to the security of a stable home environment and make critical decisions in the household about resources and income, changing how they view themselves and the perceptions they have about what is possible in the future, and thus promoting gender equality at home and in the workplace.

Through developing women empowerment projects in mechanisation, practitioners are challenged to think with, not for, the people they are helping. In addition, they gain direct experience of what is possible, which helps them perceive situations with a new awareness that leads to the discovery of newly-found actions. This could include looking at the challenges women face beyond the training, such as cultural beliefs and gaining trust from employers as capable operators, and helping them deal with those challenges.

Hiring women as operators means that employers have to take into account the fact that women go through menstruation and pregnancy, unlike their male counterparts. Therefore, employers have to change the way they operate in order to be more inclusive of women in the workplace. Society is also challenged to reimagine what the role of women is at home, at the workplace and in society itself. Myths held at different levels of the social structure are dispelled, inspiring the younger generation of women to test new opportunities.

Still a long way to go

While the agricultural sector provides a critical source of employment for about 300,000 to 350,000 new workers who enter the Ghanaian labour force each year, there is still lack of knowledge about how women can capitalise on the opportunities this sector presents. Along with this trend, the number of tractors continues to rise in Ghana with a deficit reported in 2017 of more than 10,000 tractors needed to mechanise land preparation of about 2.4 million hectares. More research on women empowerment programmes in mechanisation is needed, especially with the changing nature of the future of work and given the need to provide women with decent work (see Box).

The need to push for mechanisation in Africa calls for the need to investigate opportunities for women by doing things differently when it comes to gender equity in agriculture, zooming in on gender-transformative skills development opportunities for women in agriculture, especially young women. Mechanisation is one of the few fields that can change not just the economic status but also the social status of women in rural communities, where gender stereotypes are often a challenge. The inclusion of the gender and women empowerment dimension in the world of agricultural mechanisation is a potential game changer. It can open this industry to new customers, create new awareness and new possibilities of broadening occupations – provided it is undertaken with enabling support, giving new perceptions and perspectives about women for women.

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