Food and Agriculture Organization of the United Nations

Policy guide to improve water use efficiency in small-scale agriculture

The case of Burkina Faso, Morocco and Uganda

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By

Maher Salman,
Senior Land and Water Officer, FAO

Eva Pek,
FAO Consultant

Nicola Lamaddalena,
Head of Land and Water Resources Management Department, CIHEAM IAMB

With contributions from:

Fethi Lebdi, FAO Consultant

Stefania Giusti, FAO Consultant

Abdelouahid Fouial, Research Fellow, CIHEAM IAMB

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Foreword

Agriculture is still the engine of growth in the overall economic well-being in an increasingly globalized world. Therefore, many countries aspire the economic development through agriculture, thus making it the most important driver in water exploitation. While the demand is rapidly growing, water resources are becoming limited that leads to overall imbalance between demand and supply. A more efficient use of water in agriculture would certainly help. In response to this, considerable number of policy initiatives came into force that promoted irrigation development to keep up with the growing demand. However, many of them have not been brought to the ground yet due to their little-explored effect on the economic, agronomic and environmental conditions. The pathways of irrigation development – almost certainly essential for combating food security and poverty – need new approaches to close the gap between the conceptual frameworks and pragmatic approaches.

Creating policy instruments have received broad attention over the last decades to ensure the sustainability of the resources. In many cases, water policies were introduced as integrated parts of natural resource policy, energy policy or climate policy. The emerging concern of decreasing water resources set the scope to improve governance in water sector to create more enabling environment for policy and regulation. As the World Water Council, 2012 articulated "To improve governance in the water sector, we need to balance social dimensions with economic demands and environmental needs".

Increasing potential output of water use is particularly important in countries where the majority of the population is reliant on agriculture, and agriculture accounts a high share of water consumption. Based on AQUASTAT statistics, agriculture shares the 69 per cent of the total water withdrawal, but the ratio varies much between regions. Meanwhile, agricultural water withdrawal makes up only 21 per cent in Europe; it takes 82 per cent in Africa. As available water resources have direct impact on the livelihood, the effective use of water is at the core of development and pro-poor strategies. One of the striking constraints to achieve this goal is the fragmented size of lands, whereas small farms create a high temporal- and spatial variability of water demand. Small-scale irrigation schemes often present high degree of heterogeneity and disparity among the farmers and are less resourced to increase efficiency. However, 80 per cent of the farms in sub-Saharan Africa are still cultivated by smallholders, for whom enabling environment in increasingly needed. The objective of this guide is to overcome these challenges and provide support to enhance water use efficiency in small-scale schemes through policy recommendations (Bhattarai, Sakthivadivel, Hussain, 2002).

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The authors of this policy guide are Maher Salman and Eva Pek from FAO; and Nicola Lamaddalena from CIHEAM – IAM Bari.

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Acronyms

AWM – Agricultural Water Management

AU – African Union

CAADP – Comprehensive Africa Agriculture Development Programme

CEN-SAD – Community of Sahel Saharan States

CFE – Financial and Material Contribution of Water

COMESA – Common Market for Eastern and Southern Africa

DSIP – Development Strategy and Investment Plan

ECOWAP – Politique Agricole Commune de la CEDEAO

ECOWAS – Economic Community of West African States

FAO – Food and Agriculture Organization

FWS – Flexible Water Service

GDP – Gross Domestic Product

IGAD – Intergovernmental Authority on Development

IWM – Integrated Water Management

MASSCOTE – Mapping System and Services for Canal. Operation Techniques

NAP – National Agriculture Policy

NDP – National Development Plan

NEPAD – New Partnership for Africa's Development

O&M – Operation and Maintenance

ONEE – National Organization of Electricity and Drinking Water (Morocco)

ORMVA – Regional Organization of Agricultural Development

PAGIRE – Action Plan for Integrated Water Resource Management

PNDD – National Sustainable Development Programme

PNGIRE - National Programme for Integrated Water Resource Management

PNIA – Programme National d'Investissement Agricole

PNSR – Programme National du Secteur Rural

RBO – River Basin Organisation

SCADD – Stratégie de croissance accélérée et de développement durable

SD – Sustainable Development

SDG – Sustainable Development Goal

SDR – Stratégie de Développement Rural

SNIEau – National Information System on Water

SO – Strategic Objectives

SP – Strategic Programmes

SSA – Sub-Saharan Africa

SSI – Small-scale irrigation

UGGDS – Uganda Green Growth Development Strategy

UN – United Nations

WUA – Water User Associations

WUE – Water Use Efficiency

WUEi – Water Use Efficiency instruments

Introduction

It is well demonstrated that agriculture has poverty-reducing impact, and well-designed agricultural programmes have multiple effect on livelihoods, such as increasing household food security, enhanced incomes, rural employment and resource efficiency. Irrigation is the core to further increase the agricultural productivity and to gradually transform subsistence-driven farming (Nechifor and Winning, 2018). Its pro-poor impact is particularly significant in the case of smallholder irrigation schemes, where farmers have limited size of lands and resources to increase their production. Appropriate policy response is required to support smallholders' efforts that is consistent with sustainability and economic objectives (Pingali, 2016; Moyo et al. 2017).

Drawing lessons from the results and impacts of Green Revolution have been brought to the fore again as well as the strongly differing effect amongst regions that is under investigation (Bonnis, Maestu., Gomez, 2011; Chronic Poverty Advisory Network, 2012). Identifying the underlying issues of successful implementation or eventual failure is particularly important in the sense that substantial investment will be required to cover about 172 million hectares of irrigation-equipped area by 2050 (FAO, 2019). Irrigation development needs careful review for success in reducing failures and maximizing benefits. The approach of designing irrigation policy has already witnessed shifting to increase effectiveness. Participatory management, responsibility transfers to farmers, equal distribution amongst users, environmentally sound technology and design and institutional development are vivid proof of the efforts to improve irrigated agriculture (Gohar, Amer, Ward, 2015).

Underperformance of traditional irrigation systems results in many adverse effects. Considerable water loss through conveyance, difficulties in controlling flow and distribution issues amongst users are the most common problems faced by both farmers and managers. Farmers hold responsibilities to improve the performance the irrigation systems, but sustaining the results and further progress requires flanking and supportive policy (Hamdy, 2013).

This policy guide is drawn from the results of the FAO Project "Strengthening Agricultural Water Efficiency and Productivity at the African and Global Level" funded by the Swiss Agency for Development and cooperation (SDC). The long term vision of the project was that the in-country findings and processes which are of common nature can be synthesized and scaled up to other countries in a regional cooperation process and globally. This will eventually lead to the increase of investment in Agricultural Water Management (AWM) in the targeted countries – and beyond – that is socially equitable, profitable at the farm level, economically viable, environmentally neutral or positive, and sustainable. The guide focuses on the specific component of enhancing water use efficiency at small scale irrigation as one of the major outputs of the project. While creating and implementing water use efficiency (WUE) measures at field level, existing policy frameworks were

mapped and analyzed, and recommendations were defined as scalable policy instruments with the aim to demonstrate case-specific experiences to the collectively agreed goal of using water resources efficiently.

Although the concept of adaptive water-management is not a newly introduced approach in policy-making, it has not been used frequently in practice (Bormann et al, 1993; Pahl-Wostl et al, 2008; Pahl-Wostl, 2007). This guide is built on the systematic process of adaptive management "learning to manage by managing to learn". The guide is designed to lead the readers through the policy-making process in various conditions of the pilot countries. It presents the key steps overarching the country-specific implementation of development programme, design of combined WUE Instruments (WUEi), and formulation of policy recommendations for small-scale irrigation (SSI) by illustrating ad-hoc examples and case studies-based explanations.

Whilst the concern of the decision-makers is primarily the resource use efficiency, there are numerous aspects of improving efficiency. Commonly, the potential objectives of water policies for enhanced efficiency are (FAO, 2006):

- Improving efficiency of water use: 1) technical efficiency referring to the conveyance and application efficiency of irrigation water; 2) financial efficiency describing the net return of water use, and 3) economic efficiency considering the value for the society such as externalities and alternative use of water.
- Equity amongst users: breaking through the evidence that locational advantage is difficult to overcome, water policies foster the creation of equal provision between users. Where there is equal access in water distribution, the impact of improved irrigation management on productivity is more likely poverty-reducing.
- Sustainability of water-management systems: conceptualized environmental, socio-economic and institutional sustainability in introduced policies.

The guide incorporates the implemented work, obtained data and processed information in three countries: Burkina Faso, Morocco and Uganda.

Country-case and project information	The light coloured boxes refer to the country-cases what the guidelines build on. As case study, they are intended to give information on the background that have been found relevant in terms of WUEi.
Findings and highlights to address by policies	The dark coloured boxes contain main findings and highlights, which ought to be addressed by policies. The messages tend to draw attention on the given facts and help to recognize the major shortcomings of existing policies.

What are the Water Use Efficiency instruments (WUEis)?

Defining the term "policy" is a complex task, which requires some flexibility for the permeability between the sectors. In simple term, the policy is a formal process or plan for an action to achieve a particular goal. The form of the policy varies on a wide range, for example, it can be economic or regulatory. However, the guide does not consider policy as a linear process consisting of series of steps ("policy cycle"), but rather an iterative process commuting between stakeholders.

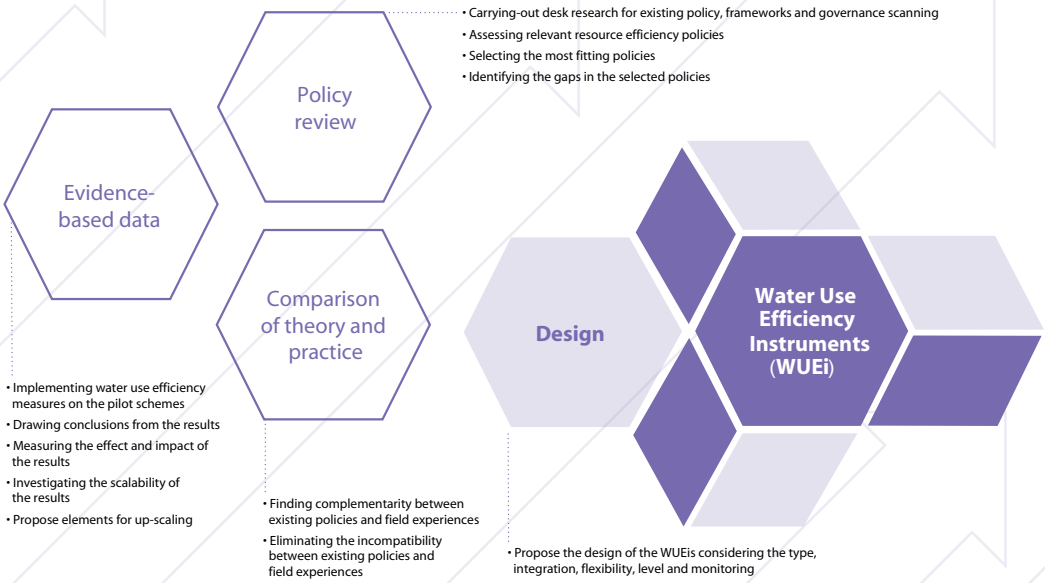
The policy formulation goes back and forth between decision-makers and end-users. Breaking down the process into particular means and tools to achieve the policy goals is called policy instruments. Policy instruments are usually combined then to create pathway to reach these goals. Five major types of policy instruments are differentiated: legislative and regulatory instruments, economic and fiscal instruments, agreement-based or co-operative instruments, information and communication instruments, and knowledge and innovation instruments. Instrument selection must consider generic criteria and summarize the impact of the instrument (Delacámara, 2013, Bouwma, 2015). The measured endorsement of instruments should be always inclusive, though, they also need to allow for externalities (interference with other sectors, out-of-system effects, necessary trade-offs, etc.).

The key characteristics of the instruments is that they create a bridge between legislation/framework and implementation. Therefore, WUEis were established on combined approaches throughout the project cycle: (1) review and process of existing policies, institutions and frameworks, and (2) experiences drawn from the field implementation. The combined approach helps not only to collect possible instruments, but also to design them to address the specific issues regarding to AWM**.** The complementary between existing policy frameworks and field experiences ensures the adaptability of the instruments then. The formulation of WUEi involves sequential steps presented on the flowchart of: policy review, evidence-based data collection, comparison between theory and practice, design, and recommendations (Figure 1).

Who should consider this guide?

Evidence-based studies proved that irrigation can lower the poverty by average 20 per cent compared to the adjacent rainfed areas, and that pro-poor management of water for farming resulted in considerable gains in poverty alleviation (Lipton, 2002). Therefore, irrigation can be an effective mean to address issues related to productivity, profitability and their direct effect on food security and economic growth. Endorsement of more efficient use of water resources is,

Figure 1: The flowchart of designing WUEi through the project cycle



Source: This study

thus, universally accepted. Yet, at least 40 per cent of irrigation water does not reach the fields in surface irrigation schemes due to their poor maintenance, runoff, seepage, and other inefficiencies of the infrastructure. Still 88 per cent of the irrigated areas in Sub-Saharan Africa is equipped with surface irrigation systems due to its relatively low requirement of initial investment and operating expenses. Since surface irrigation schemes have the lowest efficiency sharing the largest part of irrigated areas, special attention should be paid to improve their performance. The current guide sets a scope on surface irrigation schemes accordingly.

This guide is recommended particularly for decision-makers who attempt to overcome the limited approach of end-of-pipe solutions, which can handle individual problems only temporary, and those who recognize the importance of improving WUE to tackle the water-related issues.

How to consider WUEi?

Integrated approach for AWM combines the social, economic, environmental and political circumstances, but this broad approach also embraces a large number of uncertainties. Each irrigation scheme presents a combination of these conditions, which should be addressed by different WUE measures. Before introducing the WUEi, it is important to recognize the different types of uncertainties that act as key drivers of the instruments' adaptability in local conditions.

Uncertainties in water use efficiency

The most widely known uncertainty is the lack of information or the access to reliable data. Data means any type of information influencing the water use such as hydrological, agronomic, climatic, social or economic data. The data gap does not necessarily reflect on historical data, but real-time data, which allow taking immediate action. The fact that majority of irrigation schemes are not appraised regularly, and no baseline assessment supports the maintenance, rehabilitation and modernization works, translates into declining efficiency.

> "Good policy requires good data". One of the main finding of the project while establishing the baseline assessments is the lack of data at scheme level. None of the piloted irrigation schemes invested in obtaining data in order to improve the management either at scheme or at farm level. The project provided different means of data acquisition to ensure the measurability and the sustainability of the results.

The same important but often less admitted uncertainty is the one of knowledge about the system. Mismanagement of the system might derive from poor knowledge about the operated infrastructure, required water service or environmental impact. However, the system users still often work from insufficient information and they rely mostly on their own experiences. Farmers hardly find access to training, information sharing or capacity-building events.

Each system has different levels and layers - both in infrastructural and management terms. While the system-in-whole is often managed by institutionalized organizations such as Water User Associations or governmental bodies, the lower levels are operated and maintained by social institutions such as informal farmer groups. However, each level of an irrigation system is greatly dependent on the other levels. Unlike in large-scale systems, the design of small-scale systems is often influenced by farmers, thus, having asymmetries in system design. Enabling farmers to understand contingency of cause-effect relationships in SSI contributes to the overall goal to create reliable, flexible and equal access to water services.

Further uncertainties are the institutional and organizational uncertainties. In fragile systems, institutional failures have even multiplier effects to exacerbate the situation. The complex system of water governance consists of series of political, social, economic and administrative elements that influence water management. It determines the water use, distribution, allocation, while balances between the environmental and socio-economic constraints. However, the instruments of governance are often not in place to manage this complex task, or often the sustainability of existing policies are not supported by successive actions.

Wetland degradation is an emerging issue worldwide, and Uganda is not an exception. In total, about 10 per cent of Uganda's land is occupied by wetlands. Wetlands are severely exploited in the country, and the situation is particularly difficult in the western part where 80 per cent of the population is dependent on wetlands. After Canada, Uganda was the second country worldwide who passed a wetland policy and allowed farmers to obtain licences to access wetlands.

Despite the vast number of laws and policies for environment and natural resource conservation, the rapid depletion of catchment areas exceeds their renewal rate. Amongst the many factors of degrading environment, the lack of incentives for more efficient water resource use, the limited understanding of the importance of environment protection and the complete absence of data on natural resources are the leading ones.

WUEis come into practice

Many instruments – directly or indirectly related to water – already exist in national and regional frameworks, strategies, plans or policies. Nevertheless, most of them remains only theory due to lack of effective mechanism bringing them to the ground. Tariffs, charges, agriculture-related researches and subsidies are the most common instruments in Africa where access to water is a critical factor of agricultural productivity. Through the project cycle, many cases proved that even if the instruments are in force, their implementation has many shortcomings.

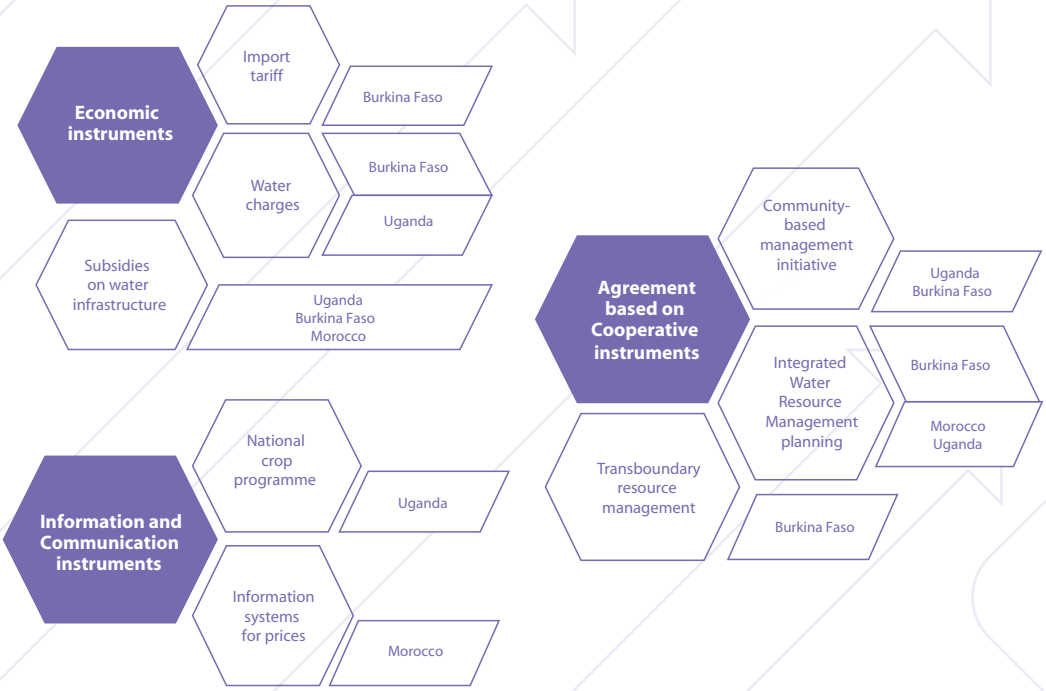
As the national diet in Burkina Faso has been significantly changing for 20 years, and rice is replacing maize and millet as staple food, the food markets are under pressure to match the increasing demand of rice to the less flexible supply side. Import tariffs are well-known instrument to protect local producers from import markets. The question is that how fast farmers can react on the increasingly rapid change in household consumption. Rice production has been supported by a vast number of governmental programs in order to increase productivity thus meeting domestic demand. The target of many irrigation development program was to reach such increased productivity (Pingali, 2012). But, the overall yields of irrigated rice have remained low in the last 20 years thus making the further investment in irrigation infeasible. This low productivity together with low profitability pose a risk in household food security in Burkina Faso (Barbier and Loncili, 2008).

As paddy rice is one of the most water consuming crops, the further improvement of irrigation management is unavoidable to secure the situation of both farmers and consumers. This requires harmonized policies to create enabling technical and economic environment.

WUEis are not only market instruments, which should affect through economic mechanisms. Well-design interventions to increase understanding and knowledge, technology-support and voluntary approaches such as participatory irrigation management (PIM) have the same importance though. As well, many market-related situations, such as responsiveness to market changes, can be influenced through information-based instruments that provide alternatives for decision-making.

Some examples from the project cycle:

Figure 2: Examples of different types of WUEis



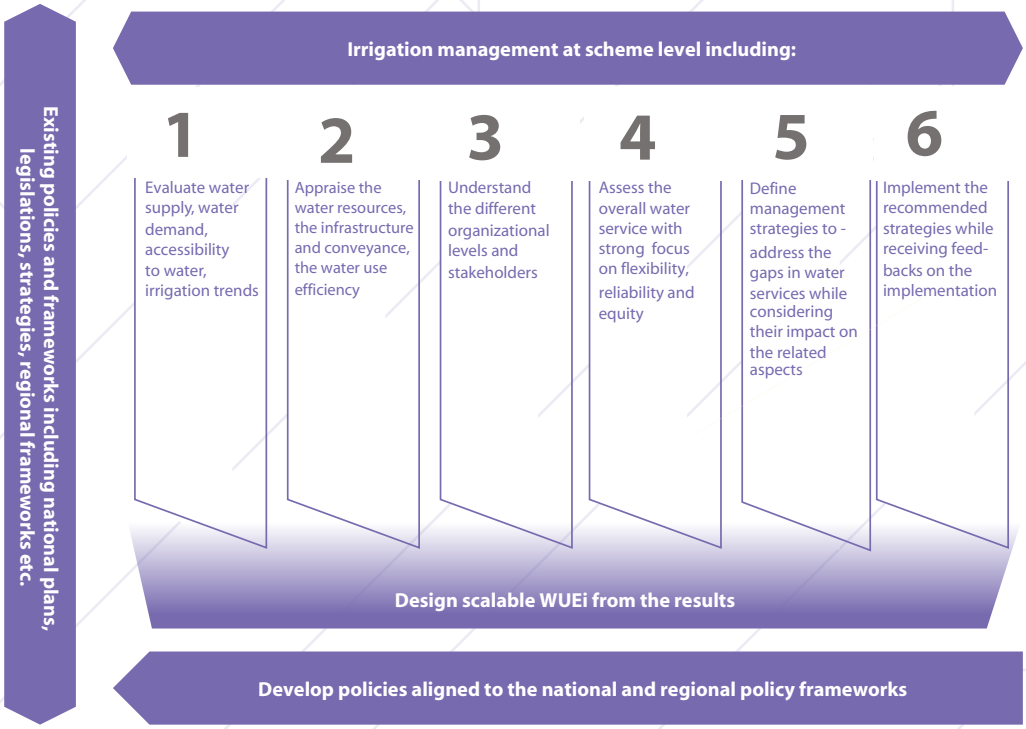
Source: This study

Many instruments are already introduced in many countries; considerable efforts were taken from governments' side to ensure efficient use of water. However, their adaptation in the practice is still often in its infancy. In order to reinforce these instruments, field experiences must be aligned and incorporated into their design.

How WUEis evolved through the project

The guide was constructed in a bottom-up approach integrating both field experience and existing policies. Pilot schemes, which represent the common characteristics of typical small-scale schemes, were selected and analyzed through comprehensive appraisals. The irrigation management of the schemes was appraised through six successive steps, meanwhile, national policies were investigated through extensive reviews and stakeholder consultations. The tried-and-tested strategies are converted into WUEIs, and plugged into existing policy frameworks in order to fill their gaps or increase their effectiveness.

Figure 3: Process of mainstreaming WUEis into national and regional policies through adaptive approach



Source: This study

1. Water supply, water demand, accessibility to water, irrigation trends

In first step, the project evaluated the applied water supply, water demand, farmers' accessibility to water and future projections on irrigation trends at national and scheme levels through MASSCOTE approach.[1] After investigating the national diet and cropping pattern, the most common crops were selected to analyze farming practices. Water supply was estimated at scheme level, and discharge monitoring protocol was set-up for each scheme to build-up discharge history. Overall trends of irrigation water use were determined through establishing water balance in the schemes.

2. Water resources, the infrastructure and conveyance, the water use efficiency

Through the monitoring of water supply, the factors influencing the water resources, hydraulic water balance, water use and distribution efficiency were defined. The step involved appraisal of conveyance infrastructure from intake to final deliveries. The discharge monitoring revealed hotspots of water losses and potentials of the better use of hydraulic structures. The WUE was estimated through the conveyance system and the water balance at scheme and farm levels.

[1] MASSCOTE – Mapping System and Services for Canal. Operation Techniques, FAO-developed methodology for irrigation modernization

3. Organizational levels and stakeholders

Each scheme is governed by public bodies, water user associations (WUA) and the farmers (PIM). The organizational levels were mapped and evaluated according to their responsibilities in irrigation management. Disclosing the financial conditions and budgets of the WUAs helped understanding the shortcomings in operation and maintenance (O&M), and the impact of management on the profitability of farming.

4. Overall water service with strong focus on flexibility, reliability and equity

Overall water service was assessed through three major indicators: flexibility, reliability and within-system equity. Flexibility of the water service investigated the responsiveness of scheme management to changing water demand, varying conditions and farmers' additional requirement. Reliability of water services compared the effective operation of the system to farmers' expectation. Equity amongst farmers aimed at minimizing the inferiority of downstream farmers, and creating in-system equity.

5. Management strategies addressing the gaps in water services

The project cycle included the development of guidelines on management rules to increase WUE. The so-called Flexible Water Services (FWS) are scheme-specific guides to increase WUE while outgrowing the irrigation requirements in both frequency/duration and amount terms. Meanwhile management strategies were defined at scheme level, and WUE guidelines on farm level were elaborated to support irrigation practitioners in enhancing irrigation practices.

6. Implementation of strategies while receiving feedbacks

The defined management strategies were trialed in the pilot schemes in order to prove their feasibility in local conditions. While involving a wide range of stakeholders from irrigation practitioners to decision-makers, dissemination activities to measure the willingness of adaptability were included. The activities involved the surveying of farmers, discussion with the local authorities and two regional workshops and a conference with decision-makers[2]

WUEis

The successive steps of establishing management practices, rules and strategies lead to the final design of recommended instruments of WUE. The instruments can be evaluated then and scaled-up to national and regional level.

[2] The thematic agenda and the discussion materials of the regional events can be found in the following links: August 2018, Saskatoon, Canada, International Conference and 69th IEC Meeting of the ICID: http://www.fao.org/agwa/news-events/events/saskatoon2018/en/ August 2017, Bari, Italy, Emerging Practices from Agricultural Water Management in Africa and the Near East – Thematic workshop: http://www.fao.org/agwa/news-events/details/en/c/1039086/

Policy guide for improving water use efficiency (WUE) in Burkina Faso, Morocco and Uganda

As first step of the screening, the guide provides an insight into the most relevant international, regional and national frameworks, strategies and policies in order to understand the possibilities of mainstreaming WUE through WUEi and how it contributes to the development visions of the countries. The chapter also underpins the link between international and the national policies. Drawing from the national policies, the chapter looks for complementarity between the evidence-based recommendations and the existing frameworks.

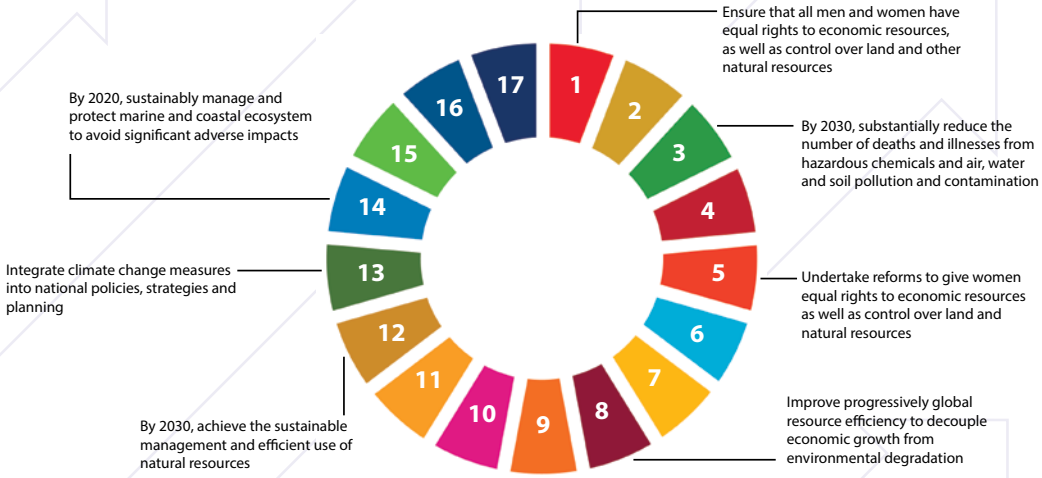
WUE to meet SDGs, strategic objectives and the global water policy objectives

The 2030 Agenda for Sustainable Development (SD) is adopted by the members of United Nations in 2015. At the core of a consistent plan for sustainable development, 17 Sustainable Development Goals (SDGs) are designed to embrace all aspects of SD while recognizing that ending poverty and other deprivations can be achieved through improving health, education, reduced inequality and spur economic growth. As access to water is a key issue of SD, it appears directly and indirectly in many SDGs. Figure 5 gives an example on how water use and water use efficiency are mainstreamed into the different specific targets.

Water related SDGs: Clean water and sanitation

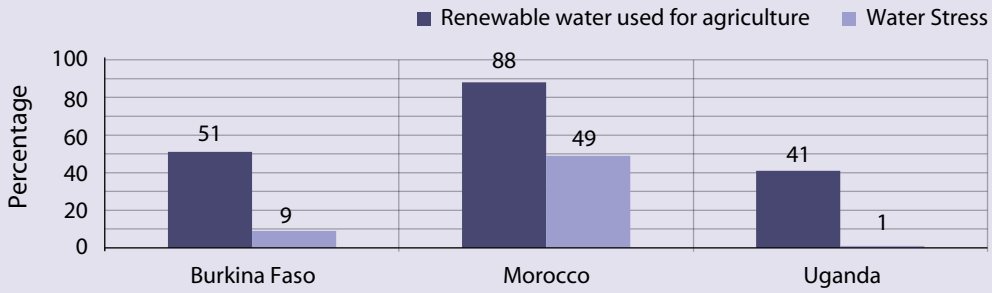
The project focused on improving WUE in irrigation, which can reduce water loss, improve farmers' income, and reduces the pressure on the ecosystem. This is in line with the Target 4 of the SDGs that aims to increase, by 2030, substantially WUE across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity. Two indicators were developed to track the progress for this target: 6.4.1 Change in water-use efficiency over time; and 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources. Decision makers can combine the information from these indicators to understand how increasing water use affects the availability of water resources and to define a tipping-point target for decoupling water use from economic growth. Such information would enable countries to adequately follow-up on target 6.4. Improving

Figure 4: Water resource management mainstreamed into the specific SDGs



Source: This study

The importance of the improvement of WUE increases with the **level of water stress** that countries face. Improving the WUE in agriculture can increase the availability of water for other productive uses, and may minimize impacts on ecosystems. This can be achieved by technical (physical and institutional) improvements, appropriate policies and economic incentives.



WUE in agriculture can also be related to the other targets of SDG 6, when considering the decline in water quality of streams and groundwater due to uncontrolled drainage, capacity-building, participatory water-management etc.

Water related SDGs: Contribution to environmental objectives

In the light of the SDGs 6 and 15, the main pathways for enhancing WUE in irrigated agriculture are to increase the output per unit of water (engineering and agronomic management aspects), reduce losses of water to drainage canals, water streams, and groundwater, reduce water degradation (environmental aspects), and reallocate water to higher priority uses (societal

aspects). Unsustainable national water policy that does not consider the interrelations between these three aspects will produce misleading objectives and eventually leads to environmental degradation. Throughout the project, the interrelation between unsustainable water management and environmental impacts were clearly defined. Soil degradation, drainage water pollution and energy use due to over-pumping are some examples of the WUE and environmental impacts.

The project focused on improving WUE in irrigation, which can significantly decrease the pressure on the environment by reducing water pollution and reducing water abstraction from streams and groundwater. This is in line especially with the Target 1 of the SDG 15 that aims to conserve freshwater ecosystems.

Water related SDGs: Contribution to agriculture as poverty reduction measure

In African countries, a large percentage of the population relies on agriculture, and many of them live in extreme poverty. There is a positive, though complex link between good water-management that increase WUE in irrigation and other farm use, poverty alleviation and food security. Many of the rural poor work directly in agriculture, as smallholders or farm laborers. Their income can be significantly boosted by appropriate WUE measures that contribute to reducing poverty, such as ensuring fair access to water and land, as well as good governance. Relevant reforms of agricultural policy and practices can strengthen these measures. The availability of water opens various opportunities to individuals and communities to boost food production, to satisfy their own needs and to generate income for improving their livelihood. Good irrigation practices have a positive effect on crop production, meaning the difference between extreme poverty and the satisfaction of the household's basic needs.

Increasing WUE in agriculture can improve farmers' income as well as the livelihood of rural communities. This is in line with the SDG 1 that refers to the ending of poverty in all its forms everywhere and the target 1.1 stating that by 2030, extreme poverty must be eradicated for all people everywhere.

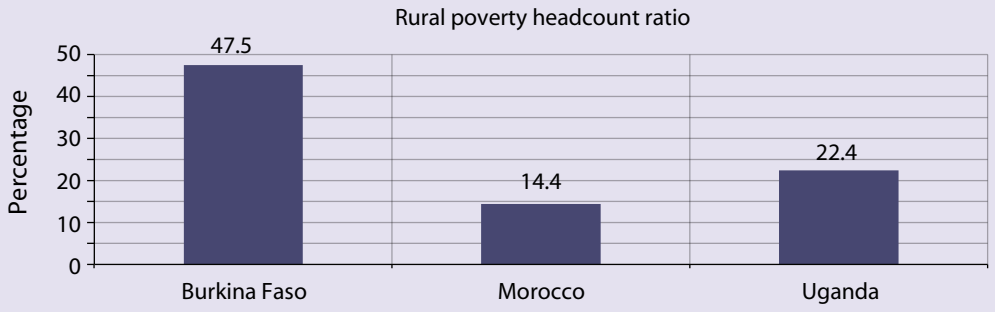
Water related SDGs: Contribution to socio-economic objectives as hunger eradication measure

Globally, one of nine people in the world today (815 million) are undernourished. The majority of these people live in developing countries, where 12.9 per cent of the population is undernourished. Poor nutrition causes nearly half (45 per cent) of deaths in children under five – 3.1 million children each year. One in four of the world's children suffers stunted growth. In developing countries, the proportion can rise to one in three. 66 million primary school-age children attend classes hungry across the developing world, with 23 million in Africa alone. On the other hand, agriculture is the single largest employer in the world, providing livelihoods for 40 per cent of today's global population. It is the largest source of income and jobs for poor rural households. 500 million small farms worldwide, most still rainfed, provide up to 80 per cent of food consumed in a large part of the developing world. Improving WUE in agriculture improves food production and farmers income.

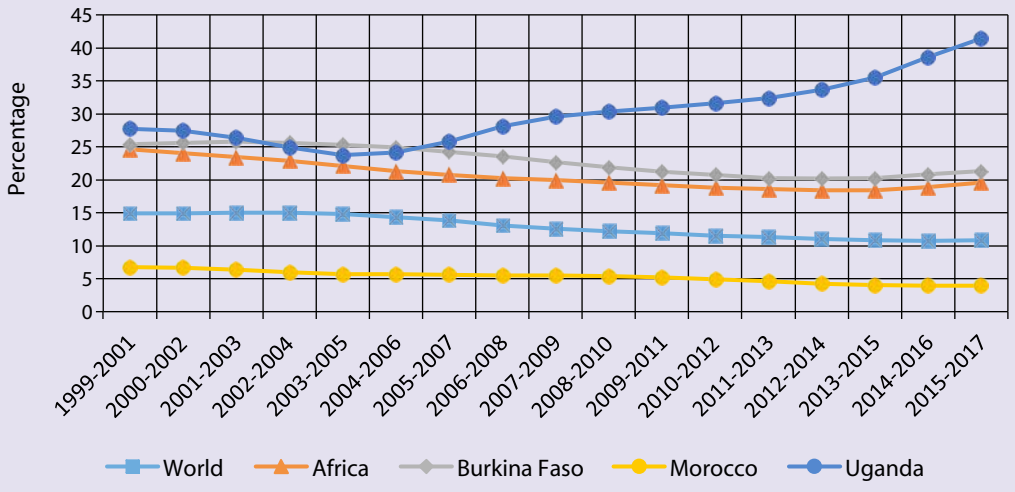
Concentrating the investing in smallholder women and men is an important way to increase food security and nutrition for the poorest, as well as food production for the local and national levels.

The pro-poor effect of irrigation has a great importance in SSI which provides income for rural labour, increases household food security and creates workplace. As Lipton et al. (2002) together with FAO reported "small-scale, low-cost and labour-intensive irrigation techniques that can be accessed by small, capital and/or credit-constrained farms are more likely to be of benefit to the poor than large scale, capital-intensive technologies". As the indicator of **rural poverty headcount ratio at national poverty lines** shows, the high degree of rural poverty is present in each country.

Irrigation development can be considered as potential strategy for the governments and their agencies to combat poverty.



Undernourishment rate in Burkina Faso and Uganda is above both the world and Africa average. Even though Uganda has enough water compared to Burkina Faso and Morocco, the percentage of undernourishment in three-year-average kept rising reaching over 40 per cent.



The overall picture in Africa

FAO predicts that the world population is expected to grow by over a third between 2009 and 2050, and half of the growth will occur in Africa. This entails the need to increase the global food production by 70 per cent in this period. Also, agriculture sector must be prepared to absorb the increasingly growing rural labour as in Africa alone, annual 11 million young people will enter the labour market in the next decade. On the other side, irrigation potential is higher than the recently exploited. In Sub-Saharan Africa (SSA), only 4 per cent of the arable land is irrigated, and 2 million of the 7 million hectares of the equipped land are not under production. The large ratio of rural population triggers the increase of productivity of the agriculture through public programmes thus creating many public schemes assigned to smallholders (FAO, 2011; FAO, 2016; FAO, 2017; OECD-FAO, 2018).

Many schemes suffer from shortcomings, which undermine their profitability. They are often fragmented into simply too small plots to provide economic threshold for the minimum subsistence. In addition, these schemes are often designed as part of the national food security measures and farmers are suggested to select staple-crops, which are less profitable than other cash crops. The lack of profitability is then translated into shortfalls of operation and maintenance works (O&M), under-resourced reinvestment and other management failures (World Bank, 2008). Farmers, who consider themselves as transitioning from subsistence-based production to commercial farmers, turn the irrigation schemes into multi-cropping systems with a large variety of staple and cash crops (Bjornlund and Pittock, 2017). The investment in flexible irrigation systems allows the intensification and diversification of agricultural production with multiple high value crops per year to lead farmers out of the low-yielding rain fed agriculture (Grace, 1997).

SSI are in the scope of the project, none of the pilot scheme exceeds the 1 000 hectares, and the average land size per farmers varies between 1 and 3.5 hectare. While investigating the pathways for development, the interventions must consider the economic feasibility. As farmers are resourced low and their capacity is limited to deploy new practices and technologies, therefore, the WUEis design must adopt gradual approach.

Considerable number of policy initiatives came to force to promote irrigation development in SSA and to keep up with growing population. In 2002, African Ministers' Council on Water was established to provide institutional framework for water-management, and in the same time, Maputo Declaration was established to adopt the overall objectives of Comprehensive African Agriculture Development Programme. From the institutional cooperation, regional policies were elaborated to declare the shared vision of SSA countries on joint water-management. Such instruments were the regional water strategy adopted in 2006 and regional water policy in 2005 to support the common planning and construction of water storages (Mwamakamba, 2017). According to the Investment Sourcebook of World Bank (2005), the challenges facing AWM

are distinguished into six major categories: 1.) incomplete policy and institutional reforms, 2.) economic and financial constraints, 3.) lack of initial investment sources, 4.) unexploited pro-poor impacts, 5.) access to technologies, and 6.) sustainability issues.

Incomplete policy and institutional reforms: Historically, governments have managed the irrigation schemes in the region, and this fact certainly led to the failure of efficient water service delivery. The top-down solutions often led to poor services and technology choices, slow adaptation to changes or long reaction time. These occurring difficulties uncovered the potential in shifting to public-private approaches, in which the roles and responsibilities are distributed amongst the public bodies and water users, and the market plays an active role to finance the irrigation development. However, some governments have to ensure that the effect of irrigation on food security will never shortfall due to the transition. The countries suffering from severe food insecurity are in the difficult position to seek the best trade-off between the support to social function of the agriculture and the economically feasible food policy. This goal necessary requires the integration of AWM policies into the national agricultural policies. Yet, policy and institutional reforms of agriculture and irrigation development are developed in silos.

Economic and financial constraints: The described phenomenon that established structure of irrigated agriculture in small-scale is often too fragmented to reach economic threshold of production leads to continuously re-formulating farming. Farmers are often incapable to gain profit from production of staple crops recommended by governmental programmes, while, cash crop production entails considerable field and market risks. Water pricing has numerous implications around the globe, but the cost recovery of water use remains a challenge. Alternative pricing strategies, which hold the farmers' ability to pay in evidence while covering all necessary O&M works, have not provided widely agreed good practices yet. Moreover, the experiences show that collection efficiency of water fees is adversely affected by the low profitability of farming.

Lack of investment sources: Most of the irrigation schemes are established within governmental programmes and financed either from public budget or donor sources. Despite their role in agricultural growth and the received huge investment, several irrigation projects and schemes

Both schemes in Uganda and Burkina Faso applies flat water fees collected by the WUAs. The difference is the share of the water fees in the cost structures of farming. Meanwhile, farmers in Burkina are required to pay the energy costs of the pumping system, the Ugandan farmers supplied by gravity-fed water withdrawal have significantly lower expenses. The increased water fees in Burkina Faso led to low fee collection efficiency whereas only 60-65 per cent of the farmers are able to pay the fees; the rest of the farmers simply do not have sufficient profit to comply their liabilities.

In conclusion, the WUA in Uganda is able to finance the necessary maintenance of the system, which shares the 80 per cent of the total budget. On the other side, 70 per cent of the WUA's total budget in Burkina Faso is paid for energy costs thus allowing insufficient budget for the maintenance. The case studies highlight the impact of different system designs on the financial sustainability of the system and production costs of the farmers.

are underperforming in delivering reliable irrigation services. The decline in investment can be explained by the falling economic rate of return both at new and existing irrigation systems. This falling rate is largely ascribed to the unpredictable agricultural prices and some technical reasons. Still, a large amount of green field investment is ahead, furthermore, as the irrigation schemes created during the Green Revolution reach their useful life span, there is a need for rehabilitation of their initial investment value. Due to the low profitability of the traditional small-schemes, the farmers or farmers' associations are under-sourced to carry out large investments. Furthermore, even maintenance activities depend often on external sources. Another important shortcoming of the currently operating schemes is the lack of investing in alternative water uses such as re-use of wastewater, drainage use or desalinized water.

Unexploited pro-poor impacts: Irrigation has a great importance in poverty alleviation. While the empirical evidence on the poverty reducing impact of irrigation still holds, the degree of such impact is largely determined by the type of irrigation system. Irrigation improves the productivity of farming through two major ways: increased yields and intensified production. Another not negligible effect on poverty is via employment. The rural labour-force tendencies in Africa calls for rapid pace of creating job opportunities. Finally yet importantly, irrigation is a proxy to increase resilience against the devastating impacts of climate change, to which the poor are exceptionally exposed. However, the poverty-alleviating potential for small farmers may be limited if the schemes are not able to provide equity amongst the farmers.

The water withdrawal with large-pumps in Burkina Faso entails significant energy consumption, which is transmitted to the farmers' water fees then. The fragile access to markets does not always provide favourable condition to receive good prices; therefore, farmers are exposed to the fluctuating energy prices. The initial design of the irrigation system does not consider the cost of water withdrawal and since the scheme is not subsidized by external funding anymore, farmers must convert their farms into cash crop production with its underlying risks to pay the energy consumption.

Access to technologies: Technology has never been easier to access than in the 21st century. However, converting traditional cropping systems into modern schemes requires additional capacity-building, support and empowered extension services. Many of the technologies cannot exploit their initial potential due to poor understanding of their required operation and maintenance. According to FAO, 40 per cent of the water in surface irrigation systems does not reach the farms due to the low conveyance efficiency. Technologies partly replaced the expensive

In Uganda, both traditional and non-traditional discharge measurement methodologies were introduced to establish water monitoring system. The weirs as traditional hydraulic structures were constructed along the system to create water balance in the scheme; meanwhile, particle image velocimetry methodology (PIV) was trialled to create an easy-to-use alternative to the weir measurement. Although the PIV integrated into an online application is a promising and scalable technology for discharge measurement, multiple irrigation campaigns were required to fine-tune its application and decrease the relative error. Furthermore, capacity-building and established protocol were provided to the extension service to rule out the possible errors in measurement.

solutions of re-engineering the schemes, but many of them are stuck in the piloting phase. Efficient mechanisms should be established to lead the scaling-out process of the proven technologies.

Sustainability issues: As agriculture is the driver of freshwater exploitation, it is also the main polluter of it. The tension between the agricultural production and the sustainable resource use is growing. Far more ecosystem is threatened by agriculture than ever before, and in some cases, the effect is already irreversible. In-built sustainability measures are general requirement in irrigation project planning and implementation; however, they make only a marginal contribution to preserve natural resources. The need to increase resource use efficiency is critical for the ecosystems.

The issues above reflect on the experiences gained in the three countries, the improvements in AWM must contribute to all of them. Not all the gains can be achieved together, but creating a policy must find the trade-off amongst them.

The African-led initiative towards hunger and poverty reduction: the Comprehensive Africa Agriculture Development Programme

Endorsed by the leaders of the African Union (AU) during the summit held in Maputo in 2003, the CAADP represents the agricultural programme of the New Partnership for Africa's Development (NEPAD) Agency. As a commitment of African countries to pursue a higher path of economic growth through agriculture-led development in order to reduce poverty and hunger in the continent, CAADP focuses on improving food security and nutrition and increasing incomes in Africa's largely farming-based economies. The Programme's main objective is the promotion of reforms in the agro-forestry-pastoral sector and it serves as a guide for governments to respond to the demand for social welfare, while at the same time supporting growth and sustainable development. To this scope, CAADP marks two key intermediate targets, namely: i) pursuit of a 6 per cent average annual agricultural sector growth rate at national level; ii) allocation of 10 per cent of national budgets to the agricultural sector.

Currently, CAADP is acknowledged not only as an Africa conceived and agricultural-driven agenda, but it also emerged as a key entry point for both national and international development partners supporting the agricultural sector in Africa. CAADP is about bringing together diverse key players - relevant government ministers, representatives of farmers and private sector, commissioners of regional economic organizations, national development partners - to improve coordination, to share knowledge, successes and failures, to build partnerships, peer review and mutual accountability at all levels, and to promote, as a result, joint and separate efforts towards the CAADP goals. The Programme develops through four pillars:

- Extending the area under sustainable and land management and reliable water control system
- Improving rural infrastructure and trade-related capacities for market access
- Increasing food supply, reducing hunger and improving responses to food emergency crises

- Improving agriculture research, technology dissemination and adoption.

Operationalization of CAADP involves a series of steps to be undertaken at national, district and/or at local level:

CAADP Pillar 1 – Land and water management

Recognizing the key role of land and water as primary resources for agricultural development, CAADP's Pillar 1 aims at extending the area under Sustainable Land and Water Management (SLWM) in Sub-Sahara Africa as one of the four continent-wide entry points identified for investments and actions.

Long-term goal: Restoring, sustaining, and enhancing, the productive and protective functions of Africa's land and water resources by combating the interrelated problems of land degradation, food insecurity and rural poverty.

Short to medium term objectives:

Building capacity and strengthening the enabling institutional, policy, legislative, budgetary and strategic planning environment for SLWM;

Mainstreaming SLWM within country-driven programs, to remove the barriers and bottlenecks to financing and scaling-up successful SLWM technologies and field-approaches.

The CAADP Pillar 1 also recognizes the issues and uniqueness in the strong linkages between agricultural and natural resources-related objectives. It serves agriculture productivity interests as well as environmental resilience and bio-diversity protection goals, thus focus is accordingly placed on:

Addressing knowledge management and M&E barriers – through filling knowledge gaps and improved management of knowledge collection, storage, analysis and dissemination;

Addressing institutional and governance barriers – through: (i) multi-sectoral and inter-agency stakeholder partnerships at regional, country and local levels; (ii) awareness raising and consensus building on a common vision for SLWM with a recognition that agricultural water is an important cross-cutting element; (iii) building capacity amongst planning, research and advisory service providers at central and local levels; and (iv) decentralization to address area-specific problems and take advantage of local development opportunities;

Addressing financial resource bottlenecks – through increased and harmonized government, donor and private sector investments within a comprehensive strategic planning framework and portfolio of related priority projects and programmes.

Moving forward: from the CAADP Process to the Malabo Declaration and the CAADP Results Framework (2015-2025)

Between 2003 and 2013, CAADP implementation was instrumental in raising the profile of agriculture to the center of national, regional and continental development agendas, while at the same time facilitating the mobilization and alignment of multi-stakeholders partnerships and investments around National Agriculture and Investment Plans (NAIP) that were developed through the CAADP process. Nevertheless, demand of further elaboration, refinement of CAADP targets and clear assessment of technical efficacies and political feasibility for success, was deemed necessary by AU member States and stakeholders after a decade of implementation, together with a move from planning to effective implementation for long-term results. To this scope, 10 years later in June 2014, AU Heads of State and Government convened in Malabo, Equatorial Guinea, to sign the "Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods", a set of seven new goals outlining a more targeted approach to achieve the agricultural vision for the continent:

The AU Malabo Declaration (June 2014)
1. Recommitment to the Principles and Values of the CAADP Process
2. Recommitment to enhance investment finance in Agriculture • Uphold 10 per cent public spending target • Operationalization of Africa Investment Bank
3. Commitment to Zero hunger – Ending Hunger by 2025 • At least double productivity (focusing on inputs, irrigation, mechanization) • Reduce PHL at least by half • Nutrition: reduce stunting to 10 per cent
4. Commitment to Halving Poverty, by 2025, through inclusive Agricultural Growth and Transformation • Sustain Annual sector growth in Agricultural GDP at least 6 per cent • Establish and/or strengthen inclusive public-private partnerships for at least 5 priority agriculture commodity value chains with strong linkage to smallholder agriculture • Create job opportunities for at least 30 per cent of the youth in agricultural value chains • Preferential entry and participation by women and youth in gainful and attractive agribusinesses
5. Commitment to Boosting Intra-African Trade in Agricultural Commodities and Services • Triple intra-Africa trade in agricultural commodities • Fast track continental free trade area and transition to a continental Common External tariff scheme
6. Commitment to Enhancing Resilience of Livelihoods and Production Systems to Climate Variability and Other Shocks • Ensure that by 2025, at least 30 per cent of farm/pastoral households are resilient to shocks
7. Commitment to Mutual Accountability to actions and Results • Through the CAADP Result Framework – conduct a biennial Agricultural Review Process

The Malabo Declaration set the Africa 2025 Vision for agriculture to be implemented through CAADP as a vehicle to operate and achieve the First Ten Year Implementation Plan of Africa's Agenda 2063. Conveners thus reconfirmed the priority of the agricultural sector in the development agenda of the continent and recommitted to the principles and values included in the CAADP including, amongst others:

- The pursuit of agriculture-led growth as a main strategy to achieve targets on food and nutrition security and shared prosperity;
- The exploitation of regional complementarities and cooperation to boost growth;
- The application of principles of evidence-based planning, policy efficiency, dialogue, review, and accountability, shared by all NEPAD programs;
- The use of partnerships and alliances including farmers, agribusiness, and civil society;
- Support implementation at countries levels, and regional coordination and harmonization.

Women's role in water management

Most of the world's poorest people, of which two thirds are women, live in water-scarce countries. Recognition of women's role in poverty alleviation through increasing agricultural output is gaining ground in countries' development strategy. Women's role in agricultural production is particularly important in Sub-Saharan Africa, where women are the main producers of staple crops. Although women develop key competencies in agricultural value chain, their contribution is only concerned in water uses other than irrigation, such as sanitation and domestic use. Involving women in decision-making, from planning to implementation of irrigation development programmes, is a key strategy for gender mainstreaming. Taking into account these considerations, the guides reviews the recent development stages of PIM in each countries, and defines relevant WUEi in appropriate cases.

Understanding the country focus: key features and national policies affecting WUE

Burkina Faso

The availability of water is considered as one of the most important issues in West African countries and more particularly in the Sahel. The fast-growing population combined with the problems of urbanization, the predicted negative impacts of climate change will put more pressure on the finite resources thus constraining the sustainable development of these countries. Burkina Faso covers an area of 274 000 km^2. From a hydrological point of view, the territory of Burkina Faso has four basins, namely, the Comoé watershed, the Nakanbé and Mouhoun (Volta) watersheds and the Niger watershed. In the 1970s, the country was hit by a disastrous drought, which revealed the high vulnerability of the country with regards to the low and irregular rainfall and increased water

demand. From this turning point, the issue of water was prioritized and considered as a major focus of the development of national policy by the national policy of water by the Ministry of Agriculture, Water Resources and Food Security in 2015.

Irrigated agriculture in Burkina Faso remains poorly developed despite of the potential of 233 500 hectares of irrigable land and 500 000 hectares of accessible lowlands. Only 9 per cent of these irrigable areas are under production, which makes the irrigated agriculture represents only 0.6 per cent of cultivated land. For this reason, the goals of the National Rural Sector Program (PNSR) focuses mainly on water-management. The irrigation in 2011 occupied 54 275 hectare, or 0.6 per cent of the cultivated land and 23 per cent of irrigable land (estimated at 233 500 hectare). These 54 275 hectare are distributed as following: 16 030 hectare of large and medium-scale irrigation schemes; 13 700 hectare of small-scale irrigation scheme; and 24 545 hectare of lowlands.

Agriculture remains the largest consumer of water at the national level, exceeding 60 per cent. Over the last decade, water resources have faced major challenges: 1) the pollution resulting from the development of agricultural and mining activities; 2) overexploitation of water resources; 3) degradation and siltation of water bodies and watercourses; 4) the increasing degradation of existing hydraulic infrastructures; and 5) the urgent need to recover financial resources necessary for the sustainable management of the water resources.

The main problems of water and irrigated agriculture arise mainly in terms of continuity of investments, the sustainability of these investments and the efficiency of water use. The shortcomings of investments are similar to the identified problems in Africa generally: 1) the functioning of the farmers' organizations for development (such as WUA); 2) the responsibilities of the maintenance of infrastructure; and 3) the financial situation of these organizations.

Classified as a low-income country with more favorable conditions (LI-2), Burkina Faso is a member of both the Economic Community of West African States (ECOWAS) and the Community of Sahel Saharan States (CEN-SAD). The contribution of the agricultural sector to the overall GDP, between 2003 and 2008, amounted to an average of 48.8 per cent per year to the country's GDP, however, it fell to 40.6 per cent per year in the following five years.

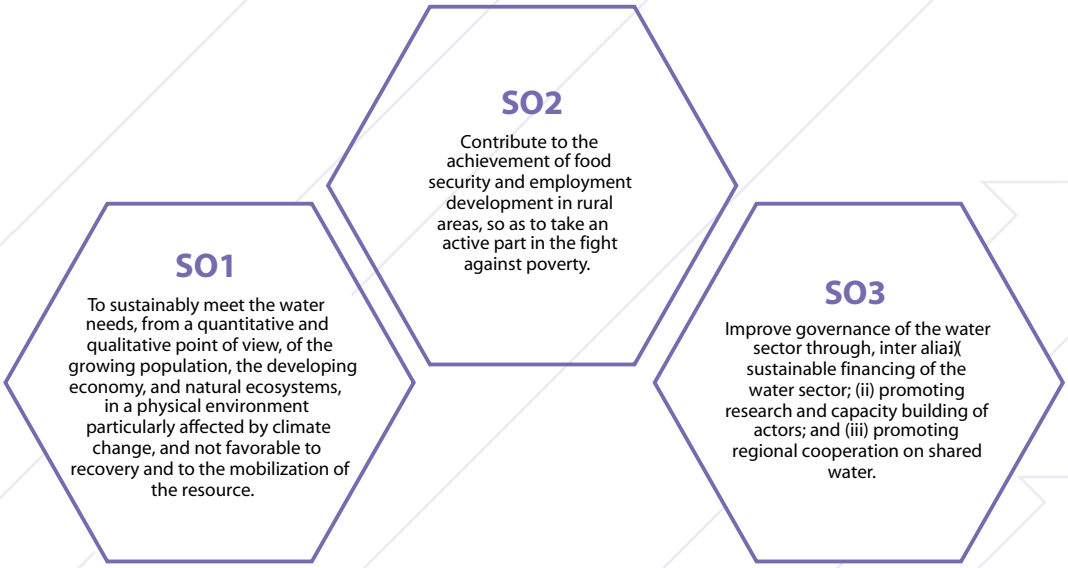
Within the framework of the CAADP COMPACT, signed in July 2010, a number of dedicated national policy instruments were developed:

- Politique Agricole Commune de la CEDEAO (ECOWAP), the regional policy that aims to 1) sustainably respond to the nutritional needs of the population; 2) enhance the economic and social development; 3) reduce poverty in member states.
- Stratégie de croissance accélérée et de développement durable (SCADD), whose objectives are 1) the improvement of agro-pastoral infrastructures; 2) the promotion of agro-forestry-pastoral and fishery processing units; 3) the modernization of agriculture and husbandry; 4) enhanced contribution of the sector to the environment, and in particular of the family households.

- Stratégie de Développement Rural (SDR), which focuses on 1) strengthening food security; 2) increasing income of rural population; 3) ensuring a sustainable management of natural resources; 4) empowering rural population as development agents.

CAADP is thus implemented at national level through the Programme National d'Investissement Agricole (PNIA), also known as Programme National du Secteur Rural (PNSR), the governmental unified planning and management tool for the rural sector, which translates the priorities indicated in the SDR into specific programmes aligned to CAADP objectives.

Water is a major factor in the sustainable development policy (PNDD) since national development greatly relies on water accessibility. The country set the target by 2030 that the national water resources are estimated and efficiently managed to realize the universal right of access to water and sanitation, in order to contribute to the sustainable development of the country. The specific objectives of the national policy related to WUE are:



Since 1990, Burkina Faso has been working on formulating an action plan to implement integrated water resource management. Through series of steps, the country created the Law No002-AN/2001 to create legislative framework for IWM. It included the directives of water resource management, the formulation and implementation of National Action Plan for Integrated Water Resource Management (PAGIRE), the establishment of National Council of Water, the Committee of Water, the financial and feasibility plans of implementation. Many objectives of the GIRE did not come to reality, therefore the government was forced to revise it and rearticulate the new National Programme for Integrated Water Resource Management (PNGIRE) in a time-horizon 2016-2030. In order to ensure the sustainable management of water resources while meeting the needs of users and protecting

Concerning the objectives of PNGIRE, increasing WUE is of great importance once more. Reducing the water loss through conveyance, tools for decision-support, improved capacities for effective implementation of IWM are all directly interrelated to the measures of WUE. To provide solid ground for WUEis, the Guide seeks for the complementarity of the experiences with these objectives.

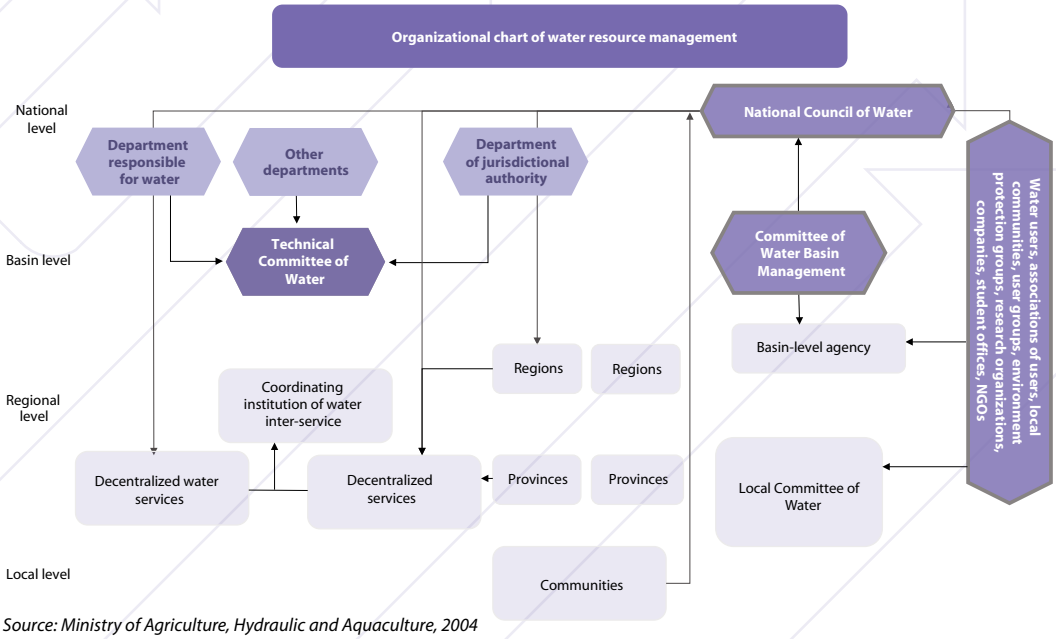
the ecosystem, the following ten actions were proposed: 1) Policy of the water, 2) Financial and material contribution of water (CFE), 3) Institutional organization and instruments of management, 4) Strengthening the capacities of the organizations of water, 5) National Information System on Water (SNIEau), 6) Research and development in water sector, 7) Protection of the surface- and groundwater from pollution, 8) Protection of water quality from contamination and aquatic plants, 9) Integrated and cross-sectoral water-management, 10) Communication and dissemination of water-management. Each action of the PNGIRE requires harmonized and integrated approach at national level, but some of the actions can be addressed only directly through field experiences. For example, roles of organization and instruments of management must be always tailored to local conditions considering financial and resource limitation, socio-economic circumstances, available information and cross-sectoral issues. On the other side, the establishment of National Information System on Water requires decentralized data collection and validation. Through the actions, the PNGIRE aims at achieving the following objectives:

- Reduce the contradictory regulations regarding water.
- Increase the financial resources for water resource protection.
- Improve the capacities for IWM.
- Increase the competences and effectiveness of organizations related to water-management.
- Identify reliable tools for decision-making support.
- Increase the knowledge on water resources and related domains.
- Preserve sustainably the water quality for different water users.
- Reduce the water loss through conveyance.
- Integrate the aspects of human rights in water resource management.
- Change the attitude of different stakeholders regarding to water resources.

Issues of participatory irrigation management

The current structure of water-related institutions still presents a top-down approach of management, where Local Committees of Water (Comités locaux de l'eau) are the only link between end-users and top-level political institutions. Emphasis on extended participation of water users in operation of irrigation scheme is already on the policy agenda. National Policy of Hydro-agricultural development (2004) declared the need of involving water users and their organisations in the investment of small, medium and large-scale development programmes. Reinforcement of their

Figure 5: Organizational structure of water management in Burkina Faso



Source: Ministry of Agriculture, Hydraulic and Aquaculture, 2004

management is envisaged through Water User Associations (L'associations d'usagers de l'eau). The most recent changes in institutions involve the role of decentralized management that might provide blank cheque to link between users and governmental agencies.

Morocco

The scarcity of water resources in Morocco has placed water sector in top priorities for the Moroccan government. Morocco's natural water resources are among the lowest in the world. In fact, the water potential is estimated at 22 billion m3 per year equivalent to 730 m3 per capita per year. The country relies mostly on surface water, while the groundwater represents around 20 per cent of the available water resources. The more frequent and acute droughts have been forcing the country to give high priority to improved WUE.

Although the 'Plan Maroc Vert' was developed outside the CAADP Framework, its effective implementation consistently enhanced the country performance in the implementation of the Malabo Declaration Commitments on Accelerated Agricultural Growth and Transformation for Shared prosperity and improved Livelihoods. 'Plan Maroc Vert' represents the comprehensive National Agricultural Investment Plan. Thanks to a new wave of private investments, the objective of the Plan is to develop high-performing agriculture, adapted to market rules. Its approach, geared towards the fight against poverty, aims at increasing the agricultural income of most vulnerable farmers and it develops through two main pillars:

- Added value modern agriculture, which will target 400 000 farmers and will generate 150 billion Dirhams of investments through 900 project.
- Solidarity farming for small-scale agriculture, which will target 600 000 – 800 000 farmers and up to 2 million of rural people, with foreseen investments for around 15 billion Dirhams.

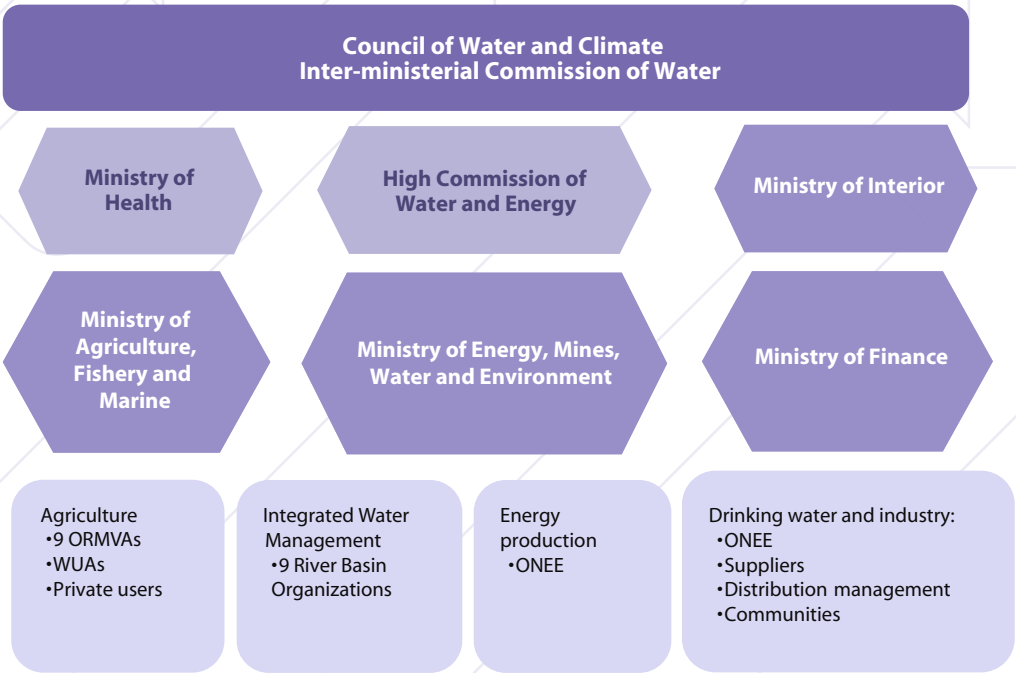
Since 1980, institutional, technical, pricing and advisory programmes were designed to ensure better use of water. The first Integrated Plan for Watersheds was launched in the 80s, then the country created its first law regarding water management (Law 10-95), which included the integrated management and planning, decentralized and participatory management of water resources. Also, it included the polluter-pays and cost recovery principles for effective protection. The large potential in modern irrigation techniques, such as drip irrigation, was targeted through trade allowances. For example, the irrigation related equipment and materials (sprinklers, pivots, drips, etc.) were exempted from import taxes to support their expansion. Furthermore, financial incentives were introduced for hydro-agricultural and land improvement. By today, 10 per cent of the total irrigated lands (141 800 hectare) is irrigated by drip and 9 per cent is irrigated by sprinkler irrigation. While the 95 per cent of the total irrigated areas in Africa is irrigated by surfaced irrigation, Morocco developed its irrigation systems successfully and decreased the surface irrigation to 81 per cent of the total irrigated area. Furthermore, the recent chronic water shortages forced the country to set its ambitious goal to equip 700 000 hectare (50 per cent of the total irrigated area) with drip irrigation by 2022. As drip irrigation is the most efficient type of irrigation, the government supports the installation of drips by covering the 60 per cent of total investment cost. As result, the country expects to conserve irrigation water while enhancing the agricultural productivity. The excessive effort to use water in the most efficient way is evident, but further policy formulation is needed to provide sustainable results of the achievements.

Table 1: Irrigation types per system scale in Morocco (AQUASTAT, 2019)

Type of irrigation	Surface	Sprinkler	Localized	Total	Per cent
Large-scale	533 900	113 800	34 900	682 600	47
Medium or small-scale	327 200	6 900		334 100	23
Private	317 600	16 950	106 900	441 450	30
Total	**1 178 700**	**137 650**	**141 800**	**1 458 150**	**100**

The institutionalization of water management has an exemplary path in the country. The framework of water governance is based on the Law 10-95, which enabled the creation of National Water Strategy with the horizon 2030. Furthermore, the elaboration of National Water Plan is currently on-going. The institutional and organizational background consists of three layers: consultation and coordination, planning and sectoral decision-making, organizations of water users.

Figure 6: Institutional structure of water-management in Morocco



Source: This study

Indeed, the country has built an efficient Water Management Strategy, specific to the country, and recognized at the international scale. This success is due to:

- the mechanism of control and mobilization of water resources through the construction of large dams and water transfer structures.
- the development of technical skills and applied scientific research.
- a long-term policy plan launched at the beginning of the 80s that allows decision makers to anticipate the shortages of water supply by providing public authorities with long-term vision (20 to 30 years).
- a regulatory and institutional development, focusing on an integrated, participatory and decentralized management of water resources through the creation of local agencies.
- the introduction of financial mechanisms for the protection of water resources.

This policy endorsed the development of important hydraulic infrastructures including around 330 large dams totaling a capacity of nearly 17.5 billion cubic meters and several thousands of wells for the use of groundwater. The main action plans of the National Water Strategy can be represented in six main actions: 1.) Water demand management and valorization of water resources, 2.) Preservation and protection of water resources, natural habitats and fragile areas, 3.) Continuation

of the legislative and institutional reforms, 4.) Management and development of water offer, 5.) Reduce vulnerability to natural water risk and adaptation to climate change, 6.) Upgrading information systems and capacity building and skills. From all, water demand management and adding value related to AWM is the action associated with water demand management and the economic value of water:

- In the context of scarcity, moving towards the water demand management and valuation of water, through the development and implementation of technical, regulatory and financial instruments, is urgent. Indeed, in the agricultural sector, the potential for saving irrigation water is estimated at around 2.5 billion m^3 per year, based on:
  - Conversion to localized irrigation: the potential of 2 billion m^3 per year with a conversion rate of 44 000 hectare per year.
  - Improving WUE of the networks supplying water to irrigated schemes: the potential of about 400 million m^3 per year.
  - Adoption of water pricing based on volumetric metering.
  - Awareness and guidance of farmers for water saving techniques.
- Preservation and protection of water resources, ecosystems:
  - Protection and reconstitution of aquifers.
  - Protection of the quality of water resources and fight against pollution.
  - Protection of watersheds and oases.
- The pursuit of regulatory and institutional reforms.

Despite the increasing frequency and duration of droughts, the country lacks national drought management strategy. Institutional mechanisms are already in place though, so, further elaboration of preparedness measures should be taken beforehand through consultative process between stakeholders. Some of the possible applications are already piloted such as drought monitoring through remote sensing, seasonal forecasting of National Meteorological Department or agricultural and hydrological monitoring by river basin authorities. However, agreed indices have not been defined yet to develop drought monitoring and early warning systems. Moreover, end-users are the lasts to receive information on upcoming climatic events.

Morocco has already established a solid ground for introducing and implementing policies of water-management. Most of the policies combats water scarcity through different instruments such as financial subsidies on water saving technologies as economic instrument, limiting the water use as regulator instrument or balancing water distribution across the sectors as agreement-based instrument. WUE is an integral part of each instruments in order to minimize the water losses and maximize the benefit per crop. Therefore, the project-based recommendations are in line with any of the national policies. The sustainability of these policies are often neglected though, the commitment to implement and maintain policies and achievements is of great importance, and needs further considerations.

Issues of participatory irrigation management

The national policy of WUAs enable the voluntary creation of associations, as well as government-led establishment. Their functions must be declared in the agreement between WUA and Government by indicating: area of jurisdiction, works to carry out, funds to implement maintenance and repair works, resources for financing works, shared contribution of WUA and Government, responsibility of WUA to carry out the works and to cover all costs related to water delivery and O&M. While WUAs are entitled to collect fees, they can apply for governmental subsidies. In order to ensure effective link between the members and Government, a representative of the Government must be a member of Council.

Uganda

Agriculture is the mainstay of Uganda's economy as a source of livelihood for over 80 per cent of the population. It has contributed between 24.7 per cent and 22.2 per cent of Gross Domestic Product (GDP) between 2011-2012 and 2015-2016. Ugandan agriculture has progressively been constrained by frequent droughts and floods, which heavily affect efforts for increased production and the fight against hunger and poverty. Although agriculture is one of the pillars of the Ugandan economy, food security and financial benefit to the farmers are still major issues. The country is still reliant mostly on rainfed agriculture since the infrastructure to exploit water resources are not in place yet. The dependence of most of smallholders on rainfed agriculture without adequate water-management is especially concerning in light of increasing climate variability and soil degradation that reduces water retention of fields.

Since the late 1980s, the policy and legislative framework for the management of the water and sanitation sectors in Uganda has evolved tremendously. The first step-stone of sustainable water-management was the Water Act in 1997. The Act is in force for use, protection and management of water resources and supply, for constitution of water and sewerage authorities, and for devolution of water supply and sewerage undertakings. Uganda has created its national water policy to promote the strategy of Integrated Water Resources Management (IWRM) in ways that are sustainable and most beneficial to the people of Uganda. The policy has been developed under two distinct categories: Water Resources Management and Water Development and Use. Some of the key policy directives from this policy that are related to WUE are:

- Development and efficient use of water in agriculture in order to increase productivity and mitigate effects of adverse climatic variations on rainfed agriculture, with full participation, ownership and management responsibility of users.
- Promotion of awareness of water-management and development issues, and the creation of the necessary capacity for the sector players at different levels.
- Promotion of the collecting and maintaining reliable water resources information and databases.

A member of the Common Market for Eastern and Southern Africa (COMESA), the Intergovernmental Authority on Development (IGAD), and the East African Community, Uganda is classified as a low-income country with more favorable agricultural conditions (LI-2). The contribution of the agricultural sector to national GDP raised from 24.6 per cent, between 2003 and 2008, to 26.7 between 2008 and 2015.

The government signed the CAADP Compact in March 2010 and thus organized its independent technical review of the NAIP in September. The process is well aligned with the National Agriculture Policy (NAP) and the National Development Plan (NDP) and it is implemented through the national Development Strategy and Investment Plan (DSIP), whose main priority areas for public sector investments in agriculture include: (i) Enhancing production and productivity; (ii) Improving access to markets and value addition; (iii) Creating and enabling environment; (iv) Institutional strengthening in the sector.

The Vision 2040 under the Comprehensive National Development Planning Framework is in line with Uganda's international commitments. The Vision focuses on agricultural transformation through irrigation development with the mission to "Promote irrigation development and management to enhance water use efficiency for increased and sustainable agricultural production and productivity and profitability to ensure food security and wealth creation". Its goal is to ensure sustainable availability of water for irrigation and its efficient use for enhanced crop production, productivity, and profitability that will contribute to food security and wealth creation. Regarding the interlinkages between the WUE and Uganda's water policy, a number of recognized guidelines are adopted in the Water Action plan that is directly related to WUE:

- freshwater as a finite and vulnerable resource, essential to sustain life, development and the environment.
- the role of Government as an enabler in a participatory, demand-driven approach to development.
- the recognition of water as a social and economic good.
- the integration of water and land use management.
- the important role of the private sector in water-management.

Uganda Green Growth Development Strategy (UGGDS 2017/18 –2029/30) aims to ensure that the goals of the Uganda Vision 2040 and the NDPII 2015/16-2019/20 are accomplished in sustainable manner. Green growth is defined as "an inclusive low emissions economic growth process that emphasizes effective and efficient use of the country's natural, human, and physical capital while ensuring that natural assets continue to provide for present and future generations". Highlighted importance of efficient use of natural resources is in the core of Uganda's development plans. From the five focus areas, the first focus is the "Sustainable agriculture production through upgrading the value chain of strategic commodities and enterprises with a focus on irrigation and integrated soil fertility management", which articulates the need of increasing irrigation in sustainable manner.

The national target for irrigation potential is a set at 567 000 hectare, based on two types: irrigated areas close to surface water resources where irrigation water can be withdrawn from, and the other type of areas lie further from surface water systems and require investment in bulk storage and in transfer from bulk storage. The National Irrigation Master Plan for Uganda recognizes the multiple potential in irrigation development, which addresses both sustainability and poverty reducing impacts of irrigated agriculture. Overall Objective of the Master Plan in Uganda, in line with the NDP is therefore: "Poverty Alleviation and Economic Growth as a result of the sustainable realization of the country's irrigation potential mitigating the effects of climate change and contributing to the transformation of Uganda society from a peasant to a modern and prosperous country". According to the Plan, irrigation can bring numerous benefits: 1.) Reducing the risk of climate shocks (drought and flood) and allowing adaptation against climate change to contribute to the investment in seasonal inputs, longer term productivity and sustainability measures; furthermore, it also reduces the perceived risks of farming system diversification. 2.) Increasing productivity and quality of crops. 3.) Contributing to publicly funded irrigation to exploit poverty alleviation potential. 4.) Reducing the unit cost of input, extension and post-harvest services through appropriate irrigation development planning and facilitating intensified production.

Issues of participatory irrigation management

Ugandan National Water Policy (1999) regulates the establishment of User Associations for irrigation and livestock water supply to act as contracted service providers through performance contract. WUAs must organize the O&M activities related to Irrigation and livestock water supply. The monitoring and evaluation, as well as necessary back-up and supervision of irrigation activities remain the responsibilities of the Government. The policy emphasizes the importance of farmers' participation in planning, decision-making and operation, but it allows for flexibility in sharing responsibility between WUAs and farmers. While Government ensures gradual transfer of ownership of the irrigation facilities, associations are required to collect funds in order to cover the O&M.

Key achievements in water use efficiency for designing policy instruments

In each country strategy, efficient and sustainable use of water resources receive top priority amongst the development issues. Nevertheless, each country sets its strategy having different perspectives and reasons. Burkina Faso and Uganda put emphasis on the cross-cutting issue of poverty reduction through irrigation development. On the other side, Morocco shifts irrigation development as mean of resilience to the effects of climate change. The tradeoffs between the national development goals and efficiency goals are increasingly in the policy-making agenda of each country, but designing the policy mix yet requires long consultation process.

Burkina Faso: the case of pumped irrigation system

Burkina Faso is paying attention to sustainable water use and is addressing countrywide water scarcity problem to increase food security and lower the 20.7 per cent undernourishment rate. Sourou is one of the so-called food basket of Burkina Faso. The Government converted Sourou Valley to the production and distribution center of rice supply. Close to the Sahel, Sourou is threatened by the desertification, land degradation, decreasing rainfall, and eroding soil. Agriculture is the single sector in the region due to the lack of industrial activities and service sector. Currently, there is no competition between water needs; irrigation and livestock have a priority amongst the water users. Ben Nafa Kacha small-scale irrigation scheme occupies 275 hectares area cultivated by 247 farmers. Agriculture is the only sector to provide work and income for the rural population in the area. Close to the border with Mali, the farmers produce for both commercial and subsistence purposes. Market conditions are unfavourable for farmers as they are price-takers in most of the cases. Prices follow the paying willingness of both individual consumers and retail companies. Whenever farmers must cope to unfavourable market conditions, they are exposed to turn into loss-making. Since half of the production is subsistence-driven and their total income is based on agriculture, unprofitable production results social hardship. Yet, farmers often fail to receive payment for their products - especially in export deals. Furthermore, input market has bad influence also on the farmers' financial liquidity, because they have to use their lands for seed growing. This decreases the efficiency of production particularly in the case of rice, whereas farmers must sacrifice their lands for nursery. Most of the farmers do not have access to fertilizers, while others have little knowledge about the recommended application. Organic manure and high-quality fertilizers are still the major bottlenecks of productivity in economic and environmental perspective. The yield remains under its potential, and the inadequate use of organic manures and fertilizers adversely affect the soil fertility.

The water resources provide sufficient conditions for irrigated agriculture; therefore, the region became one of the country's strategic area for agricultural production. The scheme has tropical dry climate distinguishing two agricultural seasons. In fact, double-cropping is one of the most common practice to intensify the agricultural production in the scheme. The irrigation campaign lasts from October to April, otherwise, the system is off in the rest of the year. The water amount is sufficient, but not appropriately distributed. Although the bulk water supply is sufficient to meet the overall crop water requirement at scheme level, the current fixed irrigation schedule does not allow for flexibility to distribute water according to the actual requirement of the crops at farm level. Despite of the high energy cost of pumping, large amount of the water ends up in the drains. The drain water in these systems is not reused, drainage water management needs to be developed and introduced.

Water-energy nexus in paddy rice system

The issue that farmers are price-takers is important while considering the poverty alleviating effect of irrigation. Farmers depend on external factor such as timing of wholesale and export market conditions. On the other hand, farmers must face the market risk of changing input costs. If the

energy price spreads, the WUA transmits it to the water fees, while farmers cannot increase their market prices accordingly. This asymmetric price transmission makes farmers more vulnerable to input markets such as energy supplier. The lack of interaction between prices drives to political and social tensions. Furthermore, the current consumption pattern does not consider the energy tariff system since the pumping hours are set in the peak hours. In critical years, the tariffs in peak period can reach the 200 per cent of the off-peak period.

Rice is the basis of the diet, thus the most important crop of nutrition. Therefore, the sufficient supply is crucial to strengthen food security in the region. Rice is produced both in the dry and in the humid season. The production cost is the same regardless of the season. Notwithstanding its importance, rice production is critical in term of productivity and profitability. Fertilizer, organic manure and water use share 40 per cent of the total production cost. In case of rice production, water use represents the highest cost in the total cost of production. It also means that if farmers do not reach a medium-level yield, the production has negative cash flow. Rice production is the bottleneck of the cropping pattern since it consumes most of the water, represents the lowest profitability, and provides the basis of local diet. Maximizing its pro-poor effect is critical in the scheme. Hence, obtaining high yields by increasing water productivity and decreasing production cost are desirable to ensure food security. The profitability of the production depends mostly on three inputs: seeds, fertilizer and adequate water service, which enables the altering water level through the development stages. Improved WUE to decrease energy costs and transmit the saving into farmers' fee becomes an important proxy of management rules for pro-poor policy.

Water User Association (WUA): issues of water tariff in glance

'Autorite de Mise en Valeur de la Vallee du Sourou' set its priorities in 2017 to strengthen institutional background of agriculture in Sourou. Its strategic plan aimed to set-up ten new 'Organisations d'Usagers de l'Eau Agricole' (OUEA). Ben Nafa Ka Cha OUEA was established in 2014. The WUA is responsible to operate and maintain the irrigation infrastructure in the scheme. The WUA has a single irrigation water service for the farmers; it does not provide any additional service. Even though, farmers often require microloans and financial subsidies to finance their production, the WUA has not created any financial instrument for them (non-returnable subsidies, in-kind subsidies, guarantees for credit etc.). The water service includes the maintenance of the structures, the operation of the pumping station, the arrangement of the irrigation turns, and the communication with farmers.

Survey showed that farmers require multiple services from the WUA to improve their productivity and profitability. Beyond the water service, the most requested services were the collective purchase of agronomic inputs (e.g. fertilizers, seeds, organic manure), and the farmers advisory system focusing on fertilizer use. The medium requested services were the available machinery service, access to sale markets and collective representation for enforcement of their rights, and post-harvest technology to decrease the food loss due technology shortages. Human resource and related works are clearly the least requested services of the farmers - meaning that their human capacity is enough to cultivate their lands.

As part of developing strategies for the local WUA, scenario analysis on energy saving was carried out. The scenario proposes 25 per cent of saving on energy bills by re-scheduling the irrigation to off-peak periods, while it includes the investment in electric pumps to increase pump efficiency. The strategy has strong multiplication effect since it builds solid ground for further investments and had a direct impact on farm economics through saving on water tariffs.

Net Present Value (NPV of the saving on the energy use scenario)

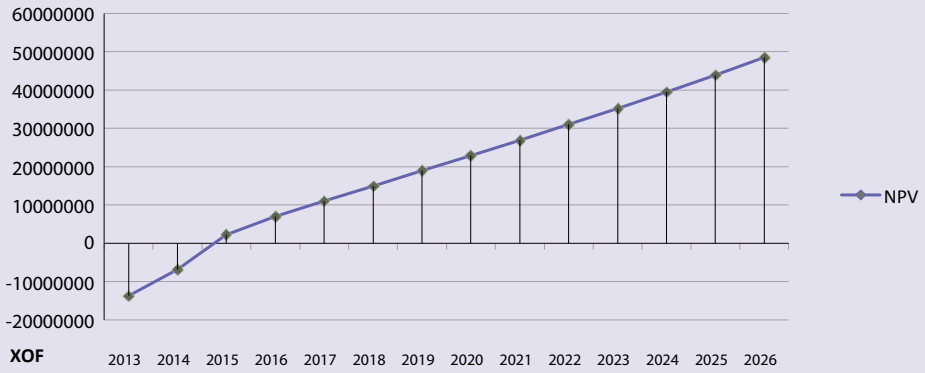
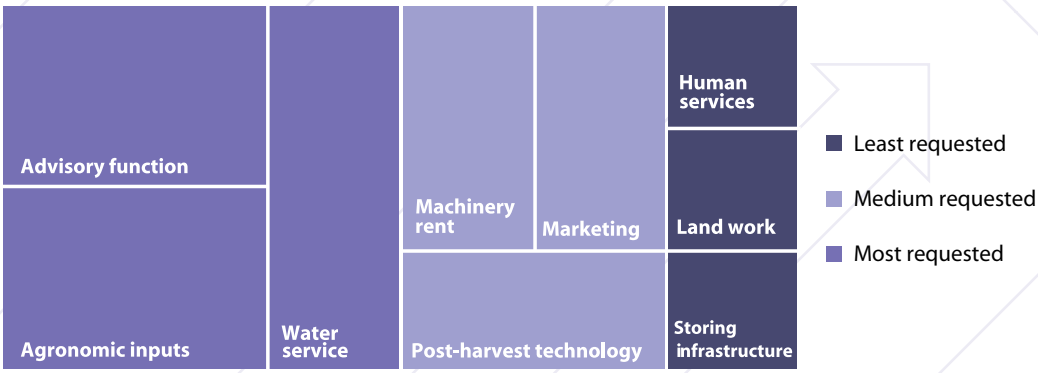


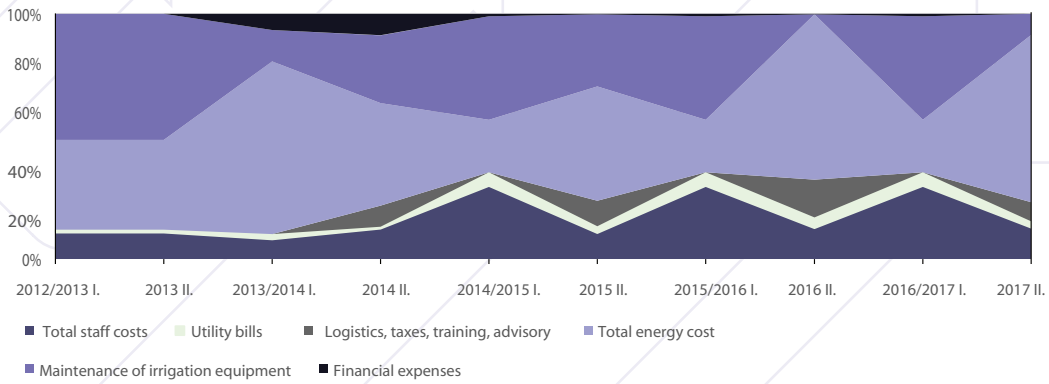
Figure 7: Farmers' service requirement to improve farming



Source: This study

The WUA plans its budget in advance, and sets the annual water tariff according to the projected expenses. The energy cost is the most critical expense of the WUA representing around 30-60 per cent of the total operating costs. The accounting of the water service is difficult as the energy consumption is estimated and pre-financed, and the farmers with ex-post financing should cover the compensation for additional consumption. The contribution of farmers is also not included in the budget as in-kind revenue. Due to the lack of prudent accounting, the budget planning becomes reactive instead of forward-looking approach. Elaborating strategies on cost recovery remains a pressing issue.

Figure 8: Seasonal cost structure of the Ben Nafa Kacha WUA



Source: This study

The income of the WUA consist of the farmer's contribution. Notwithstanding its importance, the fee collection efficiency is low at 60 per cent, and the enforcement of financial contribution remains weak. The annual liquidity plan still keeps positive balance due to the public and donor start-up funding, but the annual financial result[3] and corrected result[4] indicate financial mismanagement. If the WUA is not able to increase the fee collection efficiency, the annual results turn to deficit. In long-term, this financial mismanagement can drive to liquidity shortfalls.

As the WUA is water service specialized, the only income source is the contribution of the farmers. The fee covers exclusively the operating expenses of water service while leaving maintenance backlog. The fee combines different methods of pricing; namely area-based, crop-based and time-based irrigation – described in Table 2. The basis of the fee does not reflect on the volume of applied water even if farmers use far less water than the water supply. The fee varies amongst the crops[5]:

- fee of rice per campaign: 65 000 XOF/hectare
- fee of onion: 75 000 XOF/hectare
- fee of tomato: 75 000 XOF/hectare

[3] Annual financial result: the net profit as the difference of incomes/revenue and costs

[4] Corrected result: annual financial result multiplied by the fee collection

[5] The prices are from the financial year 2017/2018

Table 2: Water pricing methods (Bowen and Young, 1983; Cornish et al 2004, World Bank, 2016)

Basis of water fee	Definition	Applied (Yes/ No)	Potential (High, Moderate, Low)
Area-based	Fixed rate per size of area, unrelated to the applied water per area	Yes	Moderate
Crop-based	Rate is differentiated by the type of crop per a unit of area	Yes	Moderate
Volume-based	Rate is differentiated by the volume of applied water per a unit of area	No	High
Time-based	Fixed rate per time of irrigation in a unit of area, unrelated to the amount of water and crop	Yes	High
Flat rate	Fixed rate per membership of the WUA, unrelated to the irrigation	No	Moderate
Tradable rights	Quota-based price which gives opportunity to trade with	No	Low
Moving price	Ex post pricing based on the expenses of the service provider	No	Low
Block tariff	Progressive unit price of water based on consumption blocks	No	High

Due to the high energy cost of pumping, the current pricing policy is rigid, and it is often beyond the farmers' ability of paying. Although paddy rice production requires the largest amount of water, fee of rice is the lowest due to pro-poor considerations. Even if farmers apply different amount of water for growing other crops (onion, tomato, other vegetables), the flat fee does not vary according to the increased water amount. The lack of providing incentives for reduced or more efficient water use results in disinterest of farmers and downplayed significance of water resources. Furthermore, some of the pricing methods are currently infeasible due to the lack of appropriate equipment. For example, volume-based or block tariffs can be applied only in schemes where water supply is metered. One of the main shortcomings of the scheme is the lack of protocol to operate discharge monitoring system, although the modules a masques[6] are specialized hydraulic structures for discharge measurement.

Participatory irrigation management

WUA has responsibility to manage the irrigation up to the secondary canal level. Farmers adjust the water rate, duration and frequency based on their agreement among themselves at tertiary level. This type of distinguished responsibility is frequent in small-scale multi-cropping systems, and a well-known type of PIM; but also, if farmers have insufficient information about the crop

[6] Modules à masques are free surface water intake structures used to ensure and control constant flow. The discharge can be adjusted by fully opening or closing small gates of different widths.

water requirement, it might lead to inequity in the scheme. The inferiority of downstream farmers becomes apparent through received water discharge compared to upstream discharge. Since upstream farmers often use syphons, the conveyed discharge to downstream farmers is reduced. Strengthening and institutionalizing PIM helps improving farmers' understanding of AWM, thus eliminating in-system inequity.

Although the WUA and the farmers share the O&M responsibilities, the potential in PIM is not yet fully exploited. The WUA is responsible for the O&M activities down to secondary level, and farmers carry out O&M from tertiary level and arrange the irrigation turns. While the canals are lined at main and secondary levels, the tertiary canals and drains are small earthen canals. This difference between the canals' conditions poses significant decline in WUE from tertiary level. Many activities, such as manual maintenance works (weeding, de-silting, etc.) can be delegated to farmers' groups in order to increase the efficiency of the WUA. Moreover, saving on maintenance through allowance of in-kind services from farmers would enable the WUA to invest in the scheme. Farmers' contribution – both in monetary and in-kind terms – is at the core of irrigation management, e.g. relative good performance of a scheme at headworks can be completely undermined at farmer-operated levels.

Although 48 farmers out of 205 are women, their role in operating the system is currently not emphasized. Women are also informal users of the irrigation systems since the canal used to be the water source for domestic purposes as well. The emerging risk of using contaminated water for household consumptions (washing, cleaning, etc.) severely affects also the overall WUE. For example, women often divert water to downstream canals to avoid the long walking to the upstream part of the canals. Improving their understandings and providing alternative water source for other water uses are effective mean to keep water for irrigation purposes.

WUEi and policy mix in Burkina Faso

1. Informed decision on irrigation scheduling	
Type of instrument	Knowledge and innovation instrument
Achievement by the project	The inflexibility of water supply in terms of frequency and duration is addressed through the guidelines of the Flexible Water Service. Real-time crop water requirement was defined through crop growth simulation model developed by FAO (AquaCrop). Recommended water requirements per development stages of the crops were adjusted to local conditions. In order to avoid excessive runoff and temporal water stress, new irrigation schedule was proposed for the furrow-irrigated crops. The shorter but more frequent irrigation turns were proposed according to the crop water requirements.
Lessons learned	WUE can be improved through adjusted irrigation schedule to the crop water requirements. Hence, information about crop water requirements per crop development stages is a crucial criterion for enhancing WUE.
Plug into existing policy frameworks	According to the defined requirement in the national policy (PNGIRE), capacity-building was organized for the local river basin authority and the WUA, where stakeholders learned about the link between crop water requirements and WUE. Furthermore, the project introduced crop growth simulation tool to establish management rules, thus increasing capacity and supporting decision-making related to irrigation and agronomic practices.

Definition of the WUEi	*Informed decision on irrigation scheduling* is defined as agreed tool or toolbox to support increasingly efficient irrigation management. Although irrigation scheduling is tailored to local conditions in every case, facilitated access to tools/methodologies allows stakeholders to improve their management practices. Design and development of simple and practical tools for scheduling is key to improving WUE. However, as not every irrigation scheme can adopt technology based scheduling (precision agriculture) due to the lack of equipment or rigid design, the scheduling must allow for some flexibility.
Addressed AWM issues	Improved irrigation scheduling is particularly relevant in water-scarce countries where water resources are not sufficient to meet the crop requirements that turns into production failing. Countries with high evapotranspiration or changing weather pattern are more likely exposed to water stress or other water-related events. Irrigation scheduling is an efficient mean to increase resilience and preparedness. Schemes with abundant water resources often over-apply irrigation water and the water flows out of the irrigation system as runoff. During conveyance, water quality is often reduced due to agrochemical leaching and poses danger to the ecosystem. Consequently, irrigation scheduling gains positive environmental externalities. The information-based decision helps avoid both water stress and over-irrigation.
Potential stakeholders	Toolbox for Informed decision on irrigation scheduling should be designed and operated in a centralized manner. Once the recommended tools/methodologies are agreed by decision-makers, the following stakeholders are considered as users: • WUAs • River Basin Organizations • Farmers associations • Institutions of higher educations • Governmental bodies • Institutions and organizations related to water-management
2. Energy-cost optimized irrigation	
Type of instrument	Economic and fiscal instruments
Achievement by the project	The new irrigation schedule considered the peak periods of energy tariffs and shifted the pumping to off-peak period. Taking advantage of the storage capacity of the canal, the timing of the pump operation was proposed to morning and evening hours. Furthermore, consultation with farmers facilitated farmers' acceptance to introduce night irrigation. Incentives of decreased water fee were offered to farmers to re-schedule their irrigation turns into off-peak energy periods. From supplier side, negotiation process with the energy service provider resulted in decreased lump sum rate of energy.
Lessons learned	The pro-poor policy effect of irrigation can be undermined by the financial strain of energy prices in pumped irrigation systems. Therefore, the irrigation schedule must consider the economic return of irrigation at different level of time-variant energy tariffs.
Plug into existing policy frameworks	The Strategic Objectives of the national development policy declare that agriculture and irrigation must take the leading role in poverty alleviation and improved food security. Actions on increasing WUE can, thus be explored from economic point of view in order to find optimal tradeoff between hydrological and economic aspects.

Definition of the WUEi	*Energy-cost optimized irrigation* defines operating conditions and rules which ensures optimized energy cost in resource-poor schemes. The WUEi builds on the time-variant electricity pricing of the supplier. The incentive of cheaper prices during off-peak times help gaining farmers' agreement to re-schedule their irrigation turns, thus reducing the electricity bills. The WUEi does not necessary decrease the consumption since the pumping is only re-scheduled. Metering water – through calculating the operating hours and pump efficiencies – helps not only meeting the initially defined water demand, but also lowering the costs by shifting to off-peak tariffs.
Addressed AWM issues	In systems, where the design is not flexible and water can be withdrawn only by pumping, energy costs should be controlled. Energy takes normally major share of operating expenses, furthermore, it affects both WUA liquidity and on-farm profitability. Optimizing energy cost helps maximizing the pro-poor effect of irrigation in pumped irrigation systems. In energy-water nexus, reliability and flexibility of irrigation depend on energy service. Through operating rules, system failures can be avoided. For example, overloading the existing system leads to power failure. Irrigation systems connected to fragile energy system are particularly encouraged to schedule irrigation into off-peak periods. The irrigation systems with low fee collection efficiencies are jeopardized by budgetary deficits. Optimized energy costs can help to decrease the financial burdens, through which the saving can be translated into the farmers' fees or the cost can be allocated to other necessary expenses.
Potential stakeholders	Optimized energy cost brings benefits directly to the water users and their associations (WUAs). The indirect stakeholder group of the instrument is the competing energy-using sectors such as domestic users and industrial sectors.
3. Food security by irrigation prioritization	
Type of instrument	Legislative and regulatory instruments
Achievement in the project	The large water requirement to fill rice basins is counterbalanced by optimized water use in furrow irrigation. Established guidelines on Flexible Water Service provides water saving without reducing the water supply for paddy rice. Based on the fact that paddy rice is staple crop and rapid change would expose the families to food insecurity, the basin irrigation is not re-scheduled.
Lessons learned	Rice production must be prioritized to ensure local household food security. However, inserting paddy rice production in multi-cropping systems needs careful planning since sufficient amount of water for basin filling must be ensured.
Plug into existing policy frameworks	The national development policy's main objective is the complete elimination of hunger. Rice production is currently emerging into national food security policies as staple crop in national diet.
Definition of the WUEi	Food security is critically dependent on irrigation, irrigation prioritization ensures the sufficient production of staple crops. Prioritization is particularly important in multi-cropping systems which present a large degree of spatial and temporal variability of crop water requirement. Those crops are prior to others, which are staples in the national diet. Rice constitutes the daily food intake country-wide. Allocating sufficient amount of irrigation water to meet crop water requirement ensures household food security.

Addressed AWM issues	Countries with scarce water resources are forced to distribute irrigation water based on certain criteria, therefore the instrument primarily targets these countries. Irrigation water distribution and scheduling are difficult in multi-cropping systems, and often requires tradeoffs amongst water users and crops. Making tradeoff is even more complicated in irrigation systems with large number of water users as each user's interest must be taken into account. Commonly agreed priorities in favor of food security helps eliminating risk. Prioritizing irrigation increases the countries' resilience to the negative consequences of climate changes such as varying rainfall pattern or drought.
Potential stakeholders	Irrigation prioritization is a viable proxy to reach food security even if the potential water resources are scarce. The following stakeholders are considered: • Farmers • Farmers associations • WUAs • River Basin Organizations • Governmental bodies • Food security authorities • Institutions and organizations related to agriculture and food
4. Sustainable finance of irrigation services	
Type of instrument	Knowledge and innovation instruments
Achievement in the project	Investment analysis was prepared to recommend management strategies for the WUA in order to reach financial stability and sustainability. Although the WUA prepares annual accounting about expected incomes and costs, tools and methodologies for business planning are missing. Liquidity indicator (corrected profit) were introduced to give realistic picture about the financial conditions. Since energy cost takes the highest share of the total cost, the irrigation rescheduling eases the budgetary burdens also. Furthermore, the investment analysis included scenario assessment on empowering the WUA with extended agronomic services (machinery rent). Providing broader services enables the diversification of incomes, financial stability and create jobs.
Lessons learned	"Manage scarcity" – of water, capital and institutions should be interpreted broadly. Efficiency of irrigation scheme management can shortfalls from many reasons, of which budget deficit and lack of investments are likewise corrupting. The irrigation management strategy has to be reconciled with the strategies and business plans of the water users (organizations, governmental bodies, farmers etc.).
Plug into existing policy frameworks	According to the PNGIRE action plan, institutional reform should be introduced to empower and capitalize the water management related institutions. There is no public financial scheme in force which covers either the capital or operating expenses of the WUAs. Hence, the WUA must find individual mechanisms for self-financing. However, the WUAs and other management organizations have little access to methodologies on business planning and financial strategies.
Definition of the WUEi	The instruments provide improved capacity on investment and financial planning in water resources. Collected toolbox/methodology on managing irrigation systems provides knowledge for managers. Benefits of irrigation must be offset against costs, which include either investment or operation expenses. Sustainable finance of irrigation services means the positive balance of the operating an irrigation system. Nevertheless, positive balance of accounting is often obscuring the normal financing mechanism of irrigation systems. Finance is sustainable if gains cover the necessary expenses of operating and maintaining the irrigation system in order to keep up the system performance and it can fund the necessary investments.

Addressed AWM issues	Smallholder irrigation schemes are normally resource-poor in terms of financial, human and institutional capacities. Sustainable finance is an issue if the scheme is self-financing and dependent on farmers' contribution. Business planning and liquidity management have to involve scenarios for the lack of external funding, which is not yet in widespread use though. Schemes requiring expensive and regular operation and maintenance works are more exposed to financial shortfall. The most apparent evidences of lacking resources are the poor or deferred maintenance and rehabilitation. Schemes characterized by these failures need to develop more sustainable financial mechanisms.
Potential stakeholders	Sustainable finance of irrigation services applies to the institutions and organizations responsible for the management: • WUAs • River Basin Organizations • Governmental bodies
5. Improved arrangement for shared responsibilities in O&M	
Type of instrument	Agreement-based or co-operative instruments
Achievement in the project	Scheme inception on WUE discovered the apparent differences in conditions between the main-, secondary canals and the tertiary canals. The main and secondary canals are the responsibilities of the local WUA, while, tertiary canals are operated and maintained by farmers. The poor condition of tertiary canals undermines the schemes' conveyance efficiency. The conditions are due to the lack of farmers' effective means for maintenance or rehabilitation. On the other hand, the income of WUA is sufficient to maintain only the main and secondary canals, but insufficient for rehabilitation. Through the project, the main and secondary canals were rehabilitated. Furthermore, field guidance on the operation and maintenance of the hydraulic structures was compiled in order to enhance the WUE capacity. These practical measures provide inexpensive methods to maintain the conditions and share responsibilities between farmers and scheme management. Through capacity-building, different business models were prepared for the WUA to increase farmers' in-kind contribution to the scheme maintenance, thus decreasing the expenses of WUA.
Lessons learned	Despite of relatively good conditions at headworks, WUE can be completely undermined if the lower levels are poorly maintained. Therefore, WUE capacity can be enhanced only through systematized efforts in all levels. To reach that, better arrangement is required between scheme management and water users. Also, all stakeholder must learn and access the potential coupling elements for enhanced WUE.
Plug into existing policy frameworks	The PNGIRE defines a set of actions to reach its objectives through improve capacities on IWM, increased efficiency of water-related organizations, increased knowledge on water resources or reduced water loss through conveyance. Agreed responsibilities between stakeholders contribute to all actions, but mostly to the increased efficiency of water-related organizations. PIM has emerged as governmental strategies to share responsibilities between stakeholders. Tackling the O&M through PIM has multiple purpose of strengthening water-related institutions and enhancing WUE in the same time.

Definition of the WUEi	Improved arrangement for shared responsibilities in O&M as form of PIM defines the optimal share of O&M works between scheme management and end-users. Instead of distinction by different levels of scheme, O&M works should be shared by their types. For example, farmers are capable to carry-out manual works at main canal level which do not require mechanical work, while WUA can contribute with mechanical works at tertiary canal level. Improved arrangement for shared responsibilities enable cooperation and working mechanisms between stakeholders that are more efficient. It also exploits the potential of in-kind contribution of smallholders, which is often more feasible than financial contribution. Emphasis on in-kind contribution of smallholders can become mean to reinvent O&M works via crowdsourcing.
Addressed AWM issues	Water delivery systems are usually costly assets under a fragile cost-recovery policy, which strains the governmental fiscal capacities. As a result, the deterioration of the system is rarely tackled which is eventually translated into declining performance. The vicious circle of deterioration, low performance and unwillingness to pay fees is difficult to break then. Improved negotiation on responsibilities can help preventing the deterioration and lowering the financial burdens of public bodies. Beyond the financial objectives, O&M is the direct mean of delivering water efficiently. Increasing WUE through minimized water loss is particularly important in water-scarce countries. In pumped systems, energy use normally increases the operating costs. Depending on the generated water loss, poor O&M depresses economic return of irrigation. The issue of financing and investing in irrigation systems has higher magnitude in pro-poor context since farmers are not only reliable to finance the system but are also reliant on the efficiency of the system.
Potential stakeholders	Arrangement between management and water users is considered at local level since each responsibility sharing must be drawn on local conditions: • Farmers • Farmers associations • WUAs • River Basin Organizations
6. Increased contributions of women to WUE	
Type of instrument	Agreement-based or co-operative instruments
Achievement in the project	Multiple use of water is a common problem in irrigation scheme where access to other source of water is limited. In Ben Nafa Kacha, the irrigation water was also used for industrial and domestic purposes. Beyond the proved decline in water quality, it created in-system inequity between farmers. Water withdrawal for domestic purposes was done mostly be women, who used water for washing and cleaning. Although the scheme has a deep well for household consumption, the access to water is difficult (manual pumping) and the design supply is lower than demand. The project constructed extension of the scheme allocating water for other purposes than irrigation. The pond stores water for multiple purposes except potable water. Also, capacity-building for women was organized on sanitation issues.
Lessons learned	Women's involvement in irrigation management and building their capacity on water use is critical to achieve proper water management.

Plug into existing policy frameworks	As National Development Policy declares, women's involvement is cross-sectoral issue, and their empowering by capacity-building and facilitated access to information should be a priority in each sectoral strategy.
Definition of the WUEi	*Increased contributions of women to WUE* aims at improving women's capacity in water management. Empowering women is horizontal policy which is required to appear in sectoral policies. However, water-management issues appear locally, therefore, women should be involved accordingly. In current case, increased contribution of women to WUE is realized through more equitable distribution of water and separating multiple users.
Addressed AWM issues	In smallholder systems, irrigated agriculture is the key to improve household food security and generate household income. Accordingly, families are primary stakeholders of agriculture. Women's understanding on water management has multiplication effect on many sectors such as water resource management, food production, health and sanitation, education, etc. Multiple use of water is a source of conflict in many schemes. Smallholder system consists of many users, thus making equitable distribution more difficult. Women's involvement in arranging water distribution helps settling issues between water users.
Potential stakeholders	Women's empowering is cross-cutting issue : • Farmers • Farmers associations • WUAs • River Basin Organizations
7. Data-driven policymaking	
Type of instrument	Information and communication instruments
Achievement in the project	Despite of the high energy prices, the pumps were operated without business model. Due to the long irrigation turns, large amount of water ended up in the drain, hydraulic structures are tertiary level were damaged and soil was over-saturated in time of irrigation. After establishing demand-based schedule, pump operation was optimized through FWS. Despite the offtakes are calibrated modules a masques, and overall water supply can be calculated through pump parameters and operation, the scheme did not have discharge monitoring activity. In order to make monitoring feasible, discharge history was established. Time-series was validated by the design capacity of modules a masques. After establishing monitoring activity, capacity-building for WUA was organized in order to carry-out data acquisition.
Lessons learned	Irrigation is still based on farmers' observation and judgment, instead of proper data acquisition. Even schemes, which are equipped by monitoring facilities, are rarely able to collect, analyze and store discharge data, unless the management embraces the need of better data.
Plug into existing policy frameworks	Decision-making support is one of the widely defined mean of reaching the objectives of national water resource strategies. Although decision-support systems (DSS) are mostly data sensitive applications, the country has not started to establish solid system for data acquisition. SNIEau system for water accounting is currently under formulation, but its initial concept is rather providing information for management rules than scaling-down data for end-users. Obtaining data on the ground helps to operate the irrigation systems more efficiently.

Definition of the WUEi	*Data-driven policymaking* aims at building solid information based for rigorous evidence-based decision making. Water data is essential for establishing strategies and realizing investment. Improvements in WUA and cost effective design of water infrastructure are both intertwined with reliable data. Water data, more closely discharge data are used in the following principle working fields: water assessment, water evaluation, water operation, water accounting and planning, design, allocation based cooperation and improved understanding of water resources. Mainstreaming data into policymaking helps creating measurable, accountable policies, which create equity between different users. Data acquisition can be bottom-up (users' direct measurement) or up-to-down (remote sensing acquisition) process depending on the local conditions.
Addressed AWM issues	Management rules to increase efficiency require water data. Nevertheless, small-scale schemes often lack the means and systems for data acquisition. Irrigation turns are scheduled according to estimated data, water resources are not quantified and farmers are reliant on available water source. Poor information and the lack of water data can lead to numerous failures in managing the system and also in on-farm irrigation. Discharge data can help understanding the flow behavior, thus the potential management rules. Scheme management should allocate water according to scheme-level demand. Water excess can be extra expense for the scheme, or water shortage can lead to production failure. In order to create overall balance in the scheme, the data on available water sources is crucial to create optimal rules for water allocation. If farmers do not quantify their water demand and supplied water, either they suffer from water stress or large amount of water will be lost as runoff. Accurate water balance gives them opportunity to increase their irrigation practices, thus their productivity. Water allocation is often a source of conflict between water users. Water data can help creating equity between users and finding optimal tradeoff between sectors.
Potential stakeholders	Data acquisition is cross-cutting sector since its use has multiple purposes at farm, scheme and national level equally. The number of stakeholders is wide though: • WUAs • River Basin Organizations • Farmers associations • Farmers • Institutions of higher educations • Governmental bodies • Institutions and organizations related to water-management

Morocco: improved production and drought preparedness

Agriculture in Morocco accounts for 15 per cent of the GDP and is a source of employment for 24 per cent of the economically active population. Undernourishment is not an issue in the country, since only approximately 5 per cent of the population is considered to be undernourished. Morocco is, however, a highly water-stressed country, and it is imperative that its increasingly scarce water resources be managed as efficiently and as economically as possible. Such management necessarily entails sustainable use of irrigation water, which accounts for more than 80 per cent of allocated water resources with losses often exceeding 50 per cent of withdrawn water.

The considered area Haouz-Sector 3 irrigation scheme located in Haouz, Morocco. El Haouz region is one of the three large olive producing regions in Morocco. The climate in the area is semi-arid with a low and irregular yearly rainfall of 240 mm. The considered area is about 150 hectare, where water is delivered by gravity through the secondary canal S2P1R3. Water is diverted from Hassan I-Sidi Driss Dam for the irrigation of the main cultivated crops in the area, which are cereals and olives. At farm level, water is applied by surface irrigation.

Drought preparedness

Droughts in Morocco are increasing in terms of frequency and intensity. Irrigation is the key strategy for drought resilience, for example, shallow aquifers are utilized by small farmers to maintain water supply. However, the excessive abstraction and decreased recharge led to severely stressed conditions in south and central part of the country. The three pillars of Morocco's long-term drought management strategy are 1) integrated approach to water resource management, 2) improved access to water and sanitation and increased wastewater treatment capacity, 3) improved productivity, cost-effectiveness, water conservation and efficiency, and irrigated agriculture sustainability. Although the country made great progress in developing strategies to combat drought and dry periods, further interventions should be taken to the ground to tackle all possible effect of changing climate.

Following the market trends, olive and citrus sector has been increasingly growing, both production area and production output have positive tendencies. Olive is more stress-tolerant than citrus production, so less vulnerable to decreasing rainfall, hot winds in early summer has negative effect on flowering. Extreme temperature variation affects both fruit formation and blossoming. Despite its tolerance, water stress can results in decreased oil amount or lower quality. El Haouz has unfavorable climate with low effective precipitation (around 300 mm). The 300 mm difference between rainfall and irrigation requirement should be covered by irrigation in order to ensure regular production.

Inception of hydraulic structures

The surface irrigated system consists of suspended main, secondary and tertiary canals to create sufficient slope for water conveyance. Canals convey large amount of water on daily base that puts continuous pressure on the joints. Therefore, suspended (mounted) canals are more exposed to damage and deterioration than excavated canals. Though, their conveyance efficiency is much higher. However, since 90 per cent of olive lands in the command area is irrigated with recession, WUE remains low; the high WUE down to tertiary level is lowered by the final deliveries and flood irrigation method.

Since conveyance structures are fragile, their regular inception is desirable. However, ORMVAH has no human capacities to carry-out frequent inception due to the lengths of canal systems. Broken joints accounts large water loss and worsens the fragility of the system. Moreover, maintenance works are more reactive than preventive; pre-treatment of the canal system is not in place.

Performance assessment tools and methodologies came onto the scene to maximize the benefits of the systems in many perspectives such as engineering, environmental and socio-economic. FAO-developed Mapping System and Services for Canal Operation Techniques (MASSCOTE) methodology plugs a gap in achieving efficiency, equity and sustainability in irrigation systems. MASSCOTE consists in a comprehensive set of determined indicators to establish a diagnosis and performance assessment of the irrigation system. The methodology primarily targets to identify and prioritize modernization improvements, and to set a baseline assessment, against which progress can be measured. While a cause-effect relationship of the current undesired condition is established, the Rapid Appraisal Procedure (RAP) – as first step of MASSOCTE – represents a stocktaking exercise of what essential functions are missing to operate the irrigation scheme efficiently. Canal systems, such as El Haouz irrigation scheme, have generally low WUE, which forces management to improve performance with the most possible measures.

Discharge monitoring as tool for drought preparedness

The Government of Morocco heavily subsidizes agriculture modernization in the country and promotes water-efficient technologies to reduce water loss. Farmers are subsidized to turn their surface irrigation into localized irrigation (mostly drip irrigation), and a vast number of public measures are introduced to support farmers, such as micro loans, tax exemption and other fiscal instruments. Still, olive production deems to be difficult to transform since the majority of the lands are irrigated with recession. Deploying drip irrigation would require large investment, moreover, sediment load of conveyed surface water is a potential risk for pressurized system.

Although main, secondary and tertiary canals have modules a masques as offtakes, they are not used for discharge measurement. However, equity and flexibility of water distribution require discharge monitoring. With upcoming droughts, measuring water supply becomes necessary to reduce water loss through runoff.

WUEi and policy mix in Morocco

1. Discharge monitoring for drought resilience	
Type of instrument	Information and communication instrument
Achievement in the project	Despite of the modules a masques offtakes, discharge was not monitored, so compliance of irrigation schedule, equity in water distribution and water control were not ensured. During the project implementation, The Government of Morocco ceased irrigation due to heavy drought. Although the rainfall was not sufficient for production, total amount of stored water was allocated for domestic purposes. The event raised attention on the urgent need of water use planning. As first step of the project, the conveyance structures were calibrated to enable monitoring in the Scheme. In second step, training was organized to local WUA on discharge measurement, data logging and analysis, and water monitoring. The discharge monitoring helps reducing runoff and creating equity between water users.
Lessons learned	Water-stressed countries are forced to introduce water resource planning to minimize their water loss. Yet, many countries have not established systems for discharge data acquisition, which could provide evidence for more efficient distribution.
Plug into existing policy frameworks	Morocco drought strategies define efficient and productive use of water as tools to increase resilience. Data acquisition is the first step to generate information for decision-makers.
Definition of the WUEi	Discharge monitoring for drought resilience is a strategic approach to increase preparedness and decrease the negative effects of the natural hazard. In surface irrigation systems, large amount of water does not reach the fields yet due to excessive runoff, percolation etc. Creating database of available water sources both at local and national levels helps reducing water loss and establishing preparedness strategies of water allocation for drought periods.
Addressed AWM issues	Drought is viewed in different terms such as agricultural, social, hydrological and environmental perspectives. On each issue, drought has severe effect on the ecosystem as it alters freshwater availability and other ecosystem services. Droughts have impact on hydrological cycle, which induces a series of environmental changes. Discharge monitoring is the first step to draw information on natural, particularly hydrological features. Based on this information, trends and forecasts can be envisaged and interventions can be defined. Water availability has several socioeconomic impacts including food security, food markets and rural employment. As such, drought correlates with decreased yield and food access, thus affects livelihood. Discharge monitoring creates a baseline for better provision of water services, more equal in-system distribution and irrigation strategies.
Potential stakeholders	Water monitoring system with a specific purpose for drought preparedness has direct social, economic and environmental impacts. It has wide range of stakeholders including water management and food-related institutions: • Governmental bodies • River Basin Organizations • WUAs • Farmers associations • Farmers • Institutions and organizations related to water-management • Institutions and organizations related to agriculture

2. Preventive measures for O&M	
Type of instrument	Legislative and regulatory instruments
Achievement in the project	The lack of regular inception for maintenance works decreased WUE. Water losses which could be prevented by WUE measures were inspected and estimated. The project conducted surveying and performance assessment – applying MASSCOTE approach – over the conveyance system to diagnose and eliminate water losses, thus increasing WUE.
Lessons learned	Despite of the highly efficient design of the irrigation system, the lack of maintenance works significantly decreases the system performance.
Plug into existing policy frameworks	Required cost-effectiveness and efficiency of irrigation systems are defined as strategies for drought preparedness. In surface irrigation systems, which have low WUE by their design, appraising system performance regularly is particularly important. Such preventive measures on O&M help then improving the lifespan of the systems.
Definition of the WUEi	Preventive measures for O&M are set of practical management and maintenance measures which help increasing WUE in the scheme. Preventive measures are based on system diagnosis, performance assessment and prioritized planning of interventions for WUE.
Addressed AWM issues	Despite their role in agriculture and the received huge investment, several irrigation projects are underperforming in delivering reliable irrigation services. Technical and management design to reduce the inefficiencies in the irrigation systems – as it relates to the flexibility, reliability and equity of the services – needs careful review. Performance assessment tools and methodologies came onto the scene to maximize the benefits of the systems with many perspectives such as engineering, environmental and socio-economic. Maximizing the benefits of irrigation is particularly important in water-stressed countries requiring higher investments to exploit potentials. Water loss due to system inefficiencies (leakage, overtopping, etc.) often starts in small, and water loss enlarges over time. Furthermore, this mechanism leads to deterioration of the system. Both socioeconomic and environmental impacts can be encountered by declined WUE then.
Potential stakeholders	General inception liability should be instructed by governmental authorities to increase overall preparedness, but inception must be carried out at local level. Therefore, stakeholders are the following: • Governmental bodies • River Basin Organizations • WUAs • Farmers associations

Uganda: the case of abundant water source

Mubuku irrigation scheme was established as governmental program in 60s to better exploit the agricultural potential. Mubuku is one of the schemes which were designed based on societal need to provide employment and income for rural people. Due to the high unemployment rate in the region, Mubuku was dedicated to reintegrate people back into work. Consequently, farmers in

Mubuku scheme have little experience in agricultural production. The scheme is approximately 540 hectare cultivated by 167 farmers. Farmers are awarded with an average field size of 8 acres (around 3.2 hectare) under a long-term lease contract. The typical cropping pattern includes rice, maize, onion primarily, then tomato, beans and mango production. Although the scheme management does not restrict the selection and change of cropping pattern, farmers limit their production mostly on three crops: rice (upland), onion and maize making up 84 per cent of the total cultivated area. The production is exclusively market oriented, although the market conditions are often unpredictable. Farmers have typically little market power to influence farm gate prices; in other words, farmers are price takers. The sale is physically limited to Kasese district due to the lack of transportation, sufficient post-harvest technologies or warehouses. This market price uncertainty is strong incentive for farmers to produce low-profitability, but fixed-price maize, and to follow the recommendations of the farmers' cooperative.

The River Sebwe provides sufficient water for irrigation; therefore, the Scheme does not rely on groundwater resources; the scheme design applies surface irrigation with gravity conveyance. Two irrigation seasons are distinguished through the year; moreover, the annual precipitation is abundant. The peak period of water demand is April, May and July in the first season, and November and December in the second season.

Water User Association: integrated water services

Abasaija Kweyamba Mubuku farming cooperative integrates the function of WUA. Beyond the agronomic services, the cooperative operates and maintains the irrigation system; it is responsible to maintain the irrigation system until secondary canal level including the canals, regulating structures, measurement structures, fishponds and adjacent roads. Until secondary canal level, the overall conveyance efficiency is around 90-95 per cent including evaporation losses. On the other side, the irrigation management on farm level, the general conditions of tertiary and quaternary canals significantly decrease the WUE.

Table 3: Difference between provided and requested services in the Scheme (authors' own edition)

Cooperative services	Provided service	Basis of entitlement	Farmers' request
Advisory function	Yes	Personal application	High demand
Agronomic input function	Yes	Personal application (for maize producers)	High demand
Water service	Yes	Total cultivated area	High demand
Machinery rent	Yes	Personal application	Middle request
Human service	No	-	Low demand
Land work	No	-	High demand
Marketing	No	-	No demand
Post-harvest technology	Yes	Total area and crop cultivated	Low demand
Storing infrastructure	Yes	Total area and crop cultivated	No demand

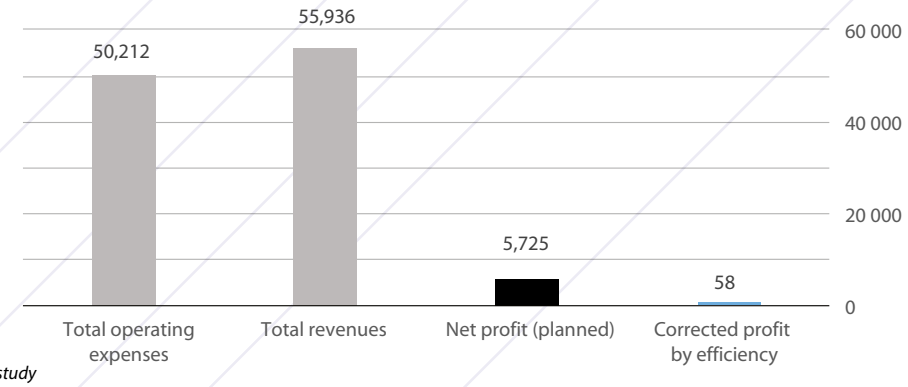
The cooperative provides multiple service for farmers including advisory function, agronomic inputs for maize, water service, machinery rent, post-harvest technology for rice and maize, and silos for maize. The only missing service, which is highly request by farmers, is the land works. This includes also excavators to maintain canal shapes and fix levelling, which could help to improve WUE at tertiary and final delivery level.

The cooperative allocates 20 per cent of its budget to the maintenance of irrigation infrastructures, although, only 10 per cent of its total revenue comes from the water fees. Farmers are obliged to pay water fee of 240 000 UGX (around 63 USD7) per year for 8 acres annually, which is recovered at 84 per cent. This high fee collection efficiency is due to the large water supply. Despite of this collection efficiency, the planned contribution (10 303 USD) is not sufficient to cover the maintenance costs. However, the budgetary issues of water services do not affect the liquidity since other provided services generate sufficient income. The cooperative has four full-time employees, of whom one person is employed to provide water services.

Table 4: Planned budget of cooperative, Uganda (authors' own edition)

Planned budget composition of the cooperative (in USD, 2017)			
Costs		**Incomes**	
Salaries and allowances	8.23%	Income of water service (water tariff)	18.42%
Third-party services	0.53%	Income of agronomic service (farmers fee)	79.69%
Utility bills	6.81%	Income of services provided to third party	1.90%
Supplies	2.64%	Public subsidies	0.00%
Maintenance of irrigation equipment	22.60%	Donor subsidies	0.00%
Maintenance of other equipment	59.20%	NGO subsidies	0.00%
Financial expenses	0.00%	Other incomes	0.00%

Figure 9: Cost-benefit analysis of the cooperative



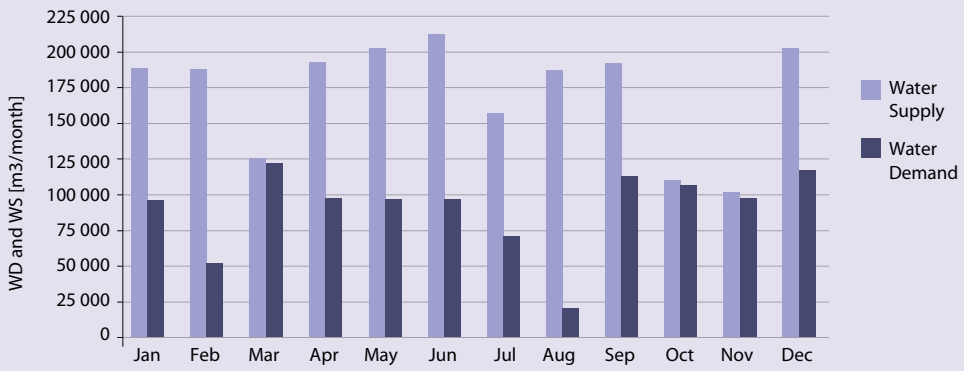
Source: This study

[7] Calculated at the exchange rate (2017) 1 UGX = 0.000265899 USD

Water imbalance and in-system equity

Mubuku scheme has single source of irrigation water. However, Sebwe River provides sufficient water for double-cropping in Mubuku. The lack of discharge measuring leads to massive amount of excess water entering the scheme. Depending on the varying discharge of Sebwe, water is not controlled at headworks and diverted into the canals. Due to the low design discharge of main canal, high velocity of River and steep slope of the lands, over-supply became one of the constraining factors of productivity. Another issue of the system design is the lack of exit and canal tails, which forces farmers to lead excess water through their tertiary canals into the drains. Large discharge is not only a concern for the environment, but it potentially decreases productivity. It leads to excessive agrochemical load in water bodies, oversaturated soils, decreased application uniformity and declining water quality. Controlling water based on precise measuring is necessary to prevent such consequences.

After several discharge measurement campaigns throughout the project cycle, modelling resulted in massive imbalance between water supply and water demand. Water demand simulation applied AquaCrop crop growth model, which indicated the need of reducing irrigation discharge. The largest over-supply was measured at early crop growth stages (from February to April) when supply exceeded demand by 89 per cent. While considering the current cropping pattern and climatic conditions, water supply prevails throughout the year.



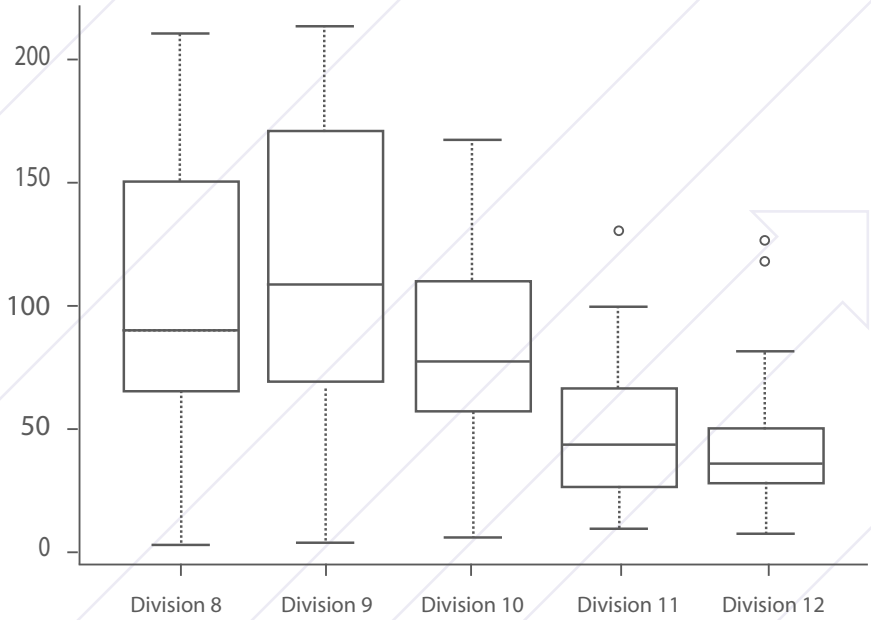
Drainage water is reused in downstream irrigation schemes, so ensuring marginal-quality water is crucial to avoid adverse effects on human health. Since large over-supply occurs in initial crop growth periods and farmers do not split fertilizer and input use to different periods, nutrient overload in water bodies is potential threat. Beyond economic loss, agrochemicals, which are soluble in water, are transported to downstream schemes then. From contaminated water to declining soil fertility (soil erosion), agrochemicals have many negative effects which makes the reuse of drain water unsafe.

So-called “fish-pond” is operated in Mubuku for environmental and storage purposes. Storage capacity can ensure sufficient water in peak irrigation periods, and control the flow. The pond was

created as original part of irrigation design, but its potential is not exploited yet. Its operation is limited to environmental purposes and returning flow from the pond is not controlled. The only management rule applied on the pond is one scheduled day per week for basin filling.

The introduction discussed the issue of equity in smallholder schemes, where magnitude of in-equity corresponds with degree of resource scarcity. Although water supply is far more than sufficient, upstream-downstream conflict is still present in the Scheme. Due to lack of information on water discharge, farmers often choose the strategy to apply as much water as they can to avoid production failure. Inferiority of downstream farmers leads to inequity, the discharge of downstream canals are significantly lower than the discharge in upstream canals. Boxplots show the evidence of difference in water service between upstream and downstream Divisions. Although farmers appoint division leaders to represent them and negotiate on water distribution, the arrangement between division leaders cannot improve within-system equity. In many cases, reduced discharge in downstream divisions leads to water stress in downstream farms.

Figure 10: Boxplots of the discharge time-series of divisions



Source: This study

Participatory irrigation management

Farmers are responsible to operate and maintain the irrigation system at tertiary level and final delivery level. Furthermore, farmers' community arranges the irrigation turn within the Divisions; division leaders are appointed to distribute water amongst farmers in the same Division. Although farmers operate the irrigation turns at Division level, maintenance is the responsibility of the cooperative until tertiary level. Since farmers are under-resourced, and most of them does not have

an extensive experience in agriculture, O&M works are poorly managed. Conveyance structures are well-maintained until the secondary level, the canals are lined and regular maintenance works are carried-out. Despite of high conveyance efficiency, WUE declines from tertiary level. Neither regular maintenance is followed by farmers nor is canal operation appropriate. The most frequent WUE measures that farmers apply are the cooperation with other farmers in re-arranging water distribution, and weeding and bushing around hydraulic structures. Quantitative analysis was carried out to investigate farmers' contribution to WUE. Results showed that the two driving factors of more active participation in increasing WUE are education level and access to capacity-building. Those farmers who have higher education and/or attended in trainings related to irrigation are more likely engaged in voluntary O&M works to increase WUE.

Based on the multistage surveying from management to field level, water-efficiency activities were well identified which contribute to improving agricultural water management at field level. The Farmer Participatory Index survey aimed at measuring farmers' participatory behavior through 14 water-efficiency activities. Standard weights were assigned to all activities corresponding to their potential impact on WUE at system level. The farmers achieving higher scores than FPI=0.5 were considered as Participating farmers, otherwise Non-participating farmers. The survey aimed at identifying socio-economic status as observed variables of the Participating and Non-participating farmers. Results showed that the difference between groups in Education-level and Attendance in irrigation training/course variables are statistically significant.

Table 5: Descriptive statistics of socio-economic variables of participatory irrigation management

		Participating Farmers (%)	Non-participating Farmers (%)	P-value
Education-level	primary	68.33	83.87	=0.0118*
	secondary	18.33	12.90	
	advanced	5.00	3.23	
	university	8.33	0.00	
Gender	female	26.67	27.42	=0.92
	male	73.33	72.58	
Age	below 15	0.00	0.00	=0.81
	15-25	0.00	0.00	
	25-35	1.67	1.61	
	35-45	10.00	8.06	
	45-55	18.33	19.35	
	above 55	70.00	70.97	
Membership of cooperative/WUA/extension service provider	60 %	100.00	100.00	
Attended in irrigation training/course	75 %	75.00	54.84	=0.019*
Frequent experience of water shortage or waterlogging	90 %	35.00	43.55	=0.338
Frequent experience of failing production	60 %	46.67	50.00	=0.71
Access to information system on production and water use	75 %	83.33	79.03	=0.54

Note: H0=there is no significant difference between the two samples

Capacity-building is one of the effective means to improve WUE in smallholder scheme, though, 85 per cent of the farmers have only elementary and secondary education. From Non-Participatory group, the rate is worse off (95 per cent). The Lack of advanced or specialized education is a limiting factor of improving AWM and agricultural production in Mubuku. Despite its ample water resources, irrigation is not widely practiced and developed in Uganda. Therefore, good practices in irrigation have not been established yet, irrigated agriculture sector requires development.

Potential of technology

Introducing technology and innovation into smallholder systems is a viable pathway to increase productivity and efficiency. However, not all technology pays back due to their initial investment costs, operation errors, malfunctions, inappropriate use, etc. Successful piloting of discharge measurement application in Scheme underlined the necessary conditions to exploit its potential and scale-out. Farmers require cost-effective and user-friendly technologies which can demonstrate solid impact on profitability without interfering with other practices.

Mubuku irrigation scheme was established on societal needs, therefore, activities –such as extension service – are based on community-level. Like in many smallholder scheme, farmers are reliant on each other, they have common representation. This structure should be followed by applied technologies as well. Single-standing devices, which provide benefits individually, have low potential. Discharge application is designed as crowd-sourcing technology that draws on farmers' participation and contribution, which helps creating more efficient management rules on water distribution.

WUEi and policy mix in Uganda

1. Informed decision on irrigation scheduling	
Type of instrument	Knowledge and innovation instrument
Achievement in the project	Due to the over-irrigation, farmers could not maximize their yields; furthermore, they suffered from economic losses due to agrochemical leaching. Previously, the cooperative offered comprehensive production programme only for maize. Nevertheless, maize programme was launched as governmental initiative, and it was not tailored to local conditions. The project carried-out monitoring and piloting phases to collect and analyze ground-truth data. Aquacrop growth model was applied to obtain maximum yield and to establish optimal agronomic practices. Applied to three main crops, guidelines on good practices provides methodology to calculate water demand at farm-level and scheme-level. Beyond appropriate irrigation, the guidelines explains how different production factors interact at different level. Information on crop production – with a particular emphasis on water demand – must be obtained to establish irrigation schedule which maximizes benefits.
Lessons learned	Even in irrigation schemes with abundant water resources, poor irrigation management has productivity-reducing effect. Farmers, who do not respect the thresholds of optimal irrigation amount, suffer from production and economic losses. Irrigation scheduling should be based on evidence-based information which is drawn on local experiences.
Plug into existing policy frameworks	WUEi is strongly interlinked with the irrigation master plan, which taps on several unexploited potential of water management. It expects from irrigation to increase productivity and crop quality, reduce cost of input and other services, and intensify production.
Definition of the WUEi	*Informed decision on irrigation scheduling* refers to established irrigation and agronomic programmes to maximize yields and benefits. Complementing the governmental maize programme with locally-tailored guidelines and further tools to scale-out results contribute to systematized development of national irrigation sector.
Addressed AWM issues	Improved irrigation scheduling is equally important in countries with abundant water sources. Enhanced WUE enables the extension of irrigated areas, better distribution across sectors (allocation for industrial activities), preservation of ecosystems and water quality. Agriculture and irrigation are the driving water users, and also water polluter sectors. Irrigation adversely affects water quality if runoff is not treated. Applying appropriate amount of water help avoiding environmental and human health consequences of reduced water quality. Irrigation scheduling is an effective tool of climate change mitigation. Scheduling the water in right time, and utilize storage capacity within the schemes ensures sufficient water in water-stressed periods and helps controlling the flow. Increasing productivity does not necessary goes hand in hand with increased profitability. If productivity requires high operating costs, and farmers do not control their expenses on production inputs, poverty-reducing impact of irrigation cannot be achieved. Scheduling irrigation minimizes the risk of reducing effects of fertilizers or pesticides.

Potential stakeholders	The established programme on irrigation scheduling should be agreed on decision-makers' level, and scaled-down by experts at scheme level. The following stakeholders are considered as users: • Governmental bodies • River basin organizations • Farmers associations • Institutions of higher educations • WUAs • Institutions and organizations related to water-management
2. Water monitoring system for accounting	
Type of instrument	Information and communication instruments
Achievement in the project	Due to excessive water supply and limited knowledge about the required discharge, farmers over-irrigated their lands and a large amount of water was conveyed into the drains. The project installed monitoring system in the Scheme from headworks, through canals to drain level in order to set-up both on-farm and hydraulic water balance. Accordingly, the system has multi-objective purpose considering 1) the relation between water supply and demand, and 2) monitoring optimal water allocation to enhance water use efficiency. Canals were equipped with different types of discharge measurement methods (weirs and particle image velocimetry methods) to provide real-time data; furthermore, the members of extension service received training on discharge reading. As result, water supply could be significantly reduced and adjusted to on-farm requirement. Furthermore, discharge measurement proved the inequity between Divisions. Based on measured water supply, inequity could be improved.
Lessons learned	Imbalance between water supply and water demand can be improved only if evidence-based data is available. Small-scale water monitoring systems are established to quantify water resource, on which water management rules can be based on. However, local data should be extended on national level to develop national and regional water account database. Water resources are currently underutilized, although, irrigation could plug the gap between growing food demand and agricultural productivity.
Plug into existing policy frameworks	Uganda has not formulated its national framework for water resource accounting. Moreover, methodologies for quantification of water is still in its infancy. UGGSD sets clear target on reaching 60 per cent of smallholders equipped for irrigation by 2030 in sustainable manner. Although, System of Environmental Economic Accounts is still in experimental stage. Water monitoring, thus accounting allows for development of national development strategies based on reliable data. So, it contributes to prioritization of interventions in NDPII with the objectives of: i) increasing Uganda's resilience to the impacts of climate change, and ii) improving climate change legal & institutional framework.
Definition of the WUEi	*Water monitoring system for accounting WUEi* is defined as locally developed water monitoring system enabling the quantification of water resources. Water monitoring system has multiple purposes such as creating water balance between water demand and supply, and providing information on available water resources in the area. As part of water resource network, established water monitoring systems can be interconnected.

Addressed AWM issues	The most common root of water resource exploitation or underutilization is the lack of knowledge on available resources. Administering and accounting for water resource planning can bring the following benefits: • Equitable distribution between water users and sectors, thus eliminating the competition for water amongst sectors; • Prudent water allocation which does not harm ecosystem, but yields the maximum benefit to end-users; • Adjusted water supply to the demand, thus meeting changing demand and shortages; • Preparedness for unexpected consequences of climate change; • Foundation for water conservation and ecosystem protection. Proper irrigation practices require planning of distribution, more specifically, irrigation planning/scheduling must answer what, when and with how much water one should irrigate. Without having information on availability and amount of water, water delivery service becomes unreliable. Water discharge monitoring system provides answers for all the necessary questions to improve reliability.
Potential stakeholders	Water monitoring system has wide range of stakeholders as it provides information both for end-users and decision-makers. The following stakeholders are considered as users: • Interregional authorities • Governmental bodies • River Basin Organizations • WUAs • Farmers associations • Farmers • Institutions and organizations related to water-management
3. Improved drainage policy for increased water quality	
Type of instrument	Knowledge and innovation instruments
Achievement in the project	Large amount of water was conveyed into the drains due to excessive water supply. In lack of discharge measurement, farmers applied the total amount of delivered water on the fields, and runoff ended-up in the drains. The project defined the required discharge based on crop water requirements, and installed discharge measurement structures at final delivery level and in the drains. By matching water demand and water supply, excess water was conveyed into drains through tertiary canals – without distributing water on fields. As a result, drainage water is less contaminated, and can be reused more safely by downstream irrigation schemes.
Lessons learned	Drainage water management is emphasized mostly in water-stressed countries. Although, drainage water reuse can be useful in temporal water shortages, water re-distribution, creating more equity within the system or extending irrigated areas. However, sufficient quality of drainage water must be ensured through management options, for example, minimizing drainage water by conservation, safe disposal or water treatment. If equipment for drainage water management is not accessible, marginal-quality water should be ensured in drains.

Plug into existing policy frameworks	Uganda takes considerable efforts to protect ecosystem, particularly, to ensure sustainable management of wetlands. The main water quality problems derived from agriculture are salinization, nutrient and pesticide pollution. In case of surface water, high nutrient load is the driving problem. Still, Uganda does not report high level contamination due to industries and agriculture, and eutrophication from excessive quantities of nutrients is already present.
Definition of the WUEi	Improved drainage water policy is defined as practical strategies to preserve water quality, and ensure safe irrigation water. Controlling distributed water on the fields is a conservation strategy to minimize nutrient load in drains. Nevertheless, many strategies are available and feasible for drainage water management, which should be selected and implemented locally.
Addressed AWM issues	Agriculture and irrigation are driving causes of salinization and pollution. Increased use of fertilizers and pesticide are applied for higher crop productivity, which exposed land and water resources to degradation. Many countries in Africa still do not need to face agriculture-caused environment problems since the level of applied agrochemicals is low – compared to other continents. However, intensification of agriculture and agrochemicals-driven degradation go hand in hand; therefore, countries must be prepared through developing strategies. Drainage water use is a global concern in terms of water quality and safe use of water. Marginal quality water such as wastewater or drainage water is gaining some ground particularly in water-stressed countries. Minimizing risk and maximizing benefits is a global challenge, which should be addressed through setting international standards. Water quality analysis – particularly for irrigation water – is often expensive and many farmers have no means to access such analysis. Also, preventive measures are less costly than water treatment. Therefore, management options should be introduced to improve water quality. Safe water reuse allows for extending irrigated areas. Water scarcity is not only physical, but economic. Even in countries with abundant resources, access to water can be limited, thus indicating water scarcity. Reuse of drainage water can be applied in extended irrigated areas, or re-distributed to farmers receiving less water than required.
Potential stakeholders	Drainage water requires irrigation planning and management, therefore the consideration of WUEi is recommended for management level. However, farmers must also understand the importance of preserving water quality in drains through avoiding water over-application. The following stakeholders are considered: • Interregional authorities • Governmental bodies • River basin organizations • WUAs • Institutions and organizations related to water-management

4. Improved arrangement for shared responsibilities in O&M	
Type of instrument	Agreement-based or co-operative instruments
Achievement in the project	The cooperative is responsible for the maintenance at main and secondary canal levels. Meanwhile, major water loss occurs at tertiary and final delivery levels, which are operated and maintained by farmers. Farmers have no means to carry-out maintaining works, furthermore, the large discharge exposes the earthen canals to deterioration. Through the project, a pilot site was rehabilitated, tertiary canals were lined, final deliveries were profiled and levelled, and discharge measurement structures were deployed and calibrated. The rehabilitation's major benefit is the extended lifespan of the hydraulic structures, improved water balance at farm level, reduced water loss through controlled discharge, decreased amount of runoff entering the drains, higher water quality in drains and better equity amongst farms. On other side, field guidelines was developed to present and promote inexpensive measures to enhance WUE by farmers. Field guidelines was tailored to local conditions, and achievement of the project was disseminated to farmers. Through distributing guidelines, PIM was strengthened, thus increasing farmers' knowledge on AWM and WUE.
Lessons learned	Enhanced WUE, thus decreased water loss, is important not only in water-stressed schemes, where water is constraining factor of production, but also in schemes, which are rich in water resources. Poor WUE can lead to deterioration of hydraulic structures and reduced lifespan, yield loss through over-irrigation, declining water quality in drains and many other consequences. Farmers' involvement in O&M can sustainably contribute to increase WUE while resulting in higher farming benefits.
Plug into existing policy frameworks	Increased WUE through shared management results in higher productivity, reduced unit cost of input and intensified production. As National Irrigation Plan defines productivity increasing irrigation should be developed to ensure its objectives.
Definition of the WUEi	*Improved arrangement for shared responsibilities* in O&M is a type of PIM which defines clear roles of farmers in irrigation management – including operation and maintenance works as well. WUE can be improved by better management rules, proper operation of the system, and regular maintenance. But, WUAs have often limited resources – both human and capital – to cover such expenses. Involving farmers through scaling O&M works ensures their commitment in increasing WUE.
Addressed AWM issues	Regular O&M works help increasing the performance and lifespan of the irrigation systems. But, WUAs' O&M policy is often constrained to system level without recognizing the importance of farm level management in enhancing WUE. Significant water loss can be associated with poor O&M at final delivery level, which can be tackled by strengthening farmers' capacities and involving them in the management. There is a general misunderstanding of distinguishing investment and maintenance works and costs. Also, maintenance works are often believed expensive machinery works; and, instead of regularity, they follow reactive scheduling. Regular inception and maintenance workplan should be introduced and budgeted as operating expenses. Beyond hard paths, improving WUE through O&M has many soft paths. PIM is an outstanding approach to tap irrigation potentials through soft measures. Increased capacity of farmers is often more effective than developing infrastructure without a solid knowledge on its O&M.

Potential stakeholders	Shared responsibility is both vertical and horizontal cooperation between stakeholders, but farmers have the key role in it: • WUAs • Farmers associations • Farmers • Institutions and organizations related to water-management • Governmental bodies • River basin organizations
5. In-system equity for pro-poor impact	
Type of instrument	Agreement-based or co-operative instruments
Achievement in the project	Noteworthy in-system inequity was observed between upstream and downstream Divisions due to farmers' little understanding of the negative effects of over-irrigation. Upstream farmers regularly opened their intake gates out of irrigation schedule leaving downstream farmers often without water. In dry periods, this behavior led to conflict between Divisions, although, there was no enforcement mechanism in force to eliminate the inequity. The project applied both soft and hard measures to address this yelling problem. As soft component, upstream farmers participated in information campaign on optimal irrigation practices, which also explained the unnecessary water stealing. Furthermore, new irrigation schedule was established based on water demand. The schedule defined new modalities of distribution to create equity. Hard measure included the equipment of offtakes with locks.
Lessons learned	Equal distribution amongst farmers have central role in poverty reducing impact of irrigation. Therefore, downstream farmers need tools/mechanisms to secure their equal access to water in right quantity and right time.
Plug into existing policy frameworks	Irrigation Master Plan aligns its objective to NDP "Poverty Alleviation and Economic Growth as a result of the sustainable realization of the country's irrigation potential mitigating the effects of climate change and contributing to the transformation of Uganda society from a peasant to a modern and prosperous country". Nevertheless, poverty alleviation needs systematic and harmonized development with equal rights to natural resources. Creating equity at micro-level might create pathways for balanced and equal distribution at large-scale (e.g. river basin level).
Definition of the WUEi	In-system equity for pro-poor impact is a set of practical measures to create equal access to water. Based on defined water demand, distribution of water should create balance between upstream and downstream parts. Measures can be soft or hard interventions.
Addressed AWM issues	Benefits of irrigation scheme can be maximized only if every part of the scheme is equally resourced. Otherwise, inequity in distribution leads also to imbalance at scheme level. In extreme cases, parts of the schemes can be over-irrigated, while other parts suffer from water-stress. This imbalance can be translated into reduced functionality and deterioration then. Balanced water distribution amongst users helps avoiding such effects. Inequity in smallholder scheme can result in vandalism. Desperate farmers, who do not receive sufficient amount of water, can destroy infrastructures and invoke conflict amongst users. Scheme management must ensure then that water users equally share both scarcity and limitations to avoid consequences.

Potential stakeholders	In-system equity refers to imbalances occurring within the system. Therefore, the stakeholders are limited to: • WUAs • Farmers associations • Farmers
6. Scaled technology to farmer-friendly	
Type of instrument	Knowledge and innovation instruments
Achievement in the project	Beyond traditional discharge measurement technologies, which are often difficult to interpret, discharge application was introduced to provide real-time and "instant" information to farmers about water supply. The discharge measurement fully integrated into online platform that was demonstrated to farmers and management equally. Throughout several measurement campaign, the application was calibrated to minimize relative measurement errors, thus improving its accuracy.
Lessons learned	ICT has numbers of exploitable potential, yet implementation and obtained data interpretation must be assisted to reach clear understanding.
Plug into existing policy frameworks	UGGSD plan defines the major strategies/interventions to achieve its goals. One of the interventions is "Sustainable production and private sector, research and technology linkages". However, accessibility and affordability of technologies are often far from expectations, and poor farmers are not in the position to deploy state-of-art technologies.
Definition of the WUEi	Scaled technology to farmer-friendly refers to the modalities and protocols to safely deploy technology in smallholders schemes, where costly investments discourages farmers to engage themselves in piloting new technologies. In fact, risky investments are more harmful than traditional production systems. If investment does not pay off, poor farmers are exposed to lose their production benefits. Therefore, technologies must be scaled to farmers while taking their capacities and resources into account.
Addressed AWM issues	Traditional irrigation systems can achieve their full potential through flexible water delivery systems that are supported by state-of-the-art measurement methods Nevertheless, many of the developing countries suffers from significant data gap, while accurate information is essential to understanding the high-efficiency mechanisms of each irrigation system. Appropriate technologies can plug this gap through providing inexpensive and flexible solutions for data acquisition. In century of rapidly developing ICT sector, many technologies have been already piloted in developing countries. However, large share of them cannot prove their feasibility in smallholder schemes. Their economic feasibility is one of the major issue since their benefits lag far behind their investment needs. This risk cannot be taken by poor farmers, therefore scaling these technologies to community-level is rather desirable.
Potential stakeholders	On-farm technologies are developed for farmers as direct beneficiaries, but their investment needs call for cooperation between potential beneficiaries and stakeholders: • WUAs • Farmers associations • Farmers

Conclusions

Water Use Efficiency (WUE) is a vital concept in ensuring sustainable water management, food security, poverty alleviation and decent rural income. Despite of the large investment in irrigation development in Sub-Saharan Africa (SSA), farmers and decision-makers still face shortcomings in scheme performance and water delivery services. Better policies are needed to address these problems while respecting the cross-cutting impacts of water management.

In principle, policies formulated by combined approaches are more likely to reach their objectives while providing easy adaption. However, policy-making must consider both bottom-up and top down approaches to achieve broad support from end-users to decision-makers.

This guide is built on innovative approach such as adaptive water management to establish practical recommendations to the effective mainstreaming of WUE into national policies. Practical recommendations are the combinations of evidence-based policy instruments drawn from field experiences. Although the three pilot schemes show some similarities in development needs, the guide proved that policy recommendations must be tailored to local contexts. For example, the lack of data acquisition was similar characteristics in the three schemes, but implementation of data systems required different methodologies and protocols according to the local contexts. Hydrological data collection enables increasing profitability of smallholders in Burkina Faso, while it improves drought resilience in Morocco. This cross-cutting nature of water policies entails broad consultation amongst stakeholders.

The potential for WUE should be seen as an opportunity to achieve multiple goals such as poverty reduction, decreased malnutrition, ensured environmental sustainability or overall rural development. However, many of fragmented policies and strategies already exist in national regulations and legislations. Prior to introducing WUE policies, existing frameworks should be revised and adjusted to find ways for integration. As the guide presented, national policies matched to field evidences is viable method to ensure social acceptance, applicability and sustainability.

The current guide attempts to overcome these challenges and provide support to enhance water use efficiency in small-scale irrigation. It, therefore, stays as a useful resource for professionals who contributes to the water sector at national or regional levels, and for those who participates in water policy making.

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Policy guide to improve water use efficiency in small-scale agriculture

The case of Burkina Faso, Morocco and Uganda

This Policy Guide is drawn from the results of the FAO Project "Strengthening Agricultural Water Efficiency and Productivity at the African and Global Level" funded by the Swiss Agency for Development and Cooperation (SDC). The long term vision of the project was that the in-country findings and processes which are of common nature can be synthesized and scaled up to other countries in a regional cooperation process and globally. This will eventually lead to the increase of investment in Agricultural Water Management (AWM) in the targeted countries – and beyond – that is socially equitable, profitable at the farm level, economically viable, environmentally neutral or positive, and sustainable. The guide focuses on the specific component of enhancing water use efficiency at small scale irrigation as one of the major outputs of the project. While creating and implementing Water Use Efficiency (WUE) measures at field level, existing policy frameworks were mapped and analyzed, and recommendations were defined as scalable policy instruments with the aim to demonstrate case-specific experiences to the collectively agreed goal of using water resources efficiently.

Although the concept of adaptive water-management is not a newly introduced approach in policy-making, it has not been used frequently in practice (Bormann et al, 1993; Pahl-Wostl et al, 2008; Pahl-Wostl, 2007). This guide is built on the systematic process of adaptive management "learning to manage by managing to learn". The guide is designed to lead the readers through the policy-making process in various conditions of the pilot countries. It presents the key steps overarching the country-specific implementation of development programme, design of combined WUE Instruments (WUEi), and formulation of policy recommendations for small-scale irrigation (SSI) by illustrating ad-hoc examples and case studies-based explanations.

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