Agricultural Water Management

WATER AND DEVELOPMENT STRATEGY

Implementation Brief

January 2015

GOAL OF USAID WATER AND DEVELOPMENT STRATEGY 2013-2018:
To save lives and advance development through improvements in water, sanitation, and hygiene programs, and through the sound management and use of water for food security.

I. Introduction

The Water and Development Strategy was released in May 2013. This series of Implementation Briefs was developed to provide supplemental guidance in complement to the existing Water and Development Strategy Implementation Field Guide. This series of Implementation Briefs will provide additional information to facilitate and support programming decisions on the following key themes related to the Strategy: WASH-Nutrition, Agricultural Water Management, Sanitation, Water Quality, and Sustainability of WASH Services.

Meeting the second strategic objective of the USAID Water and Development Strategy – Enhance food security through the sustainable and more productive management of water in agriculture – is critically urgent. Globally, agriculture accounts for the majority of freshwater withdrawals, with some water sources being drawn down faster than they are being replenished – and the push to exploit more water for food security in the face of a changing and more variable climate is increasing. In this Implementation Brief we present strategic approaches to improving agricultural water management (AWM) to increase both water resource and project outcome sustainability. To help USAID staff and their partners identify and implement best-fit AWM practices for particular sociocultural, market, and environmental contexts, we present a simple guide for conducting a Water Resource Sustainability Assessment (WRSA) for agricultural activities.

Key Messages

Best-fit agricultural water management practices:

- are environmentally, socially, and economically sustainable;
- increase food security;
- improve livelihoods; and
- increase resilience to climate change and variability.

II. Background

A. Environmentally Sustainable Development and Food Security

Agriculture is critical to development – the majority of the world's poorest and hungry people depend on it for their livelihoods. Agriculture in turn depends on basic natural resources: biodiversity, soil, and water. Good stewardship of natural resources is central to sustainable development: agriculture's long-term viability is a function of how well we – individuals and communities – fulfill our roles as stewards.

Globally, there are high expectations for the potential of improved water management to drive agricultural growth and poverty reduction (Mollinga et al., 2007). These expectations are understandable; the regions where there are high levels of poverty and stunting coincide with those characterized by soil nutrient depletion and land degradation (Leakey et al., 2009) and include major farming systems in South Asia, the Sahel, and eastern and southern Africa,[1] where there is a high probability of drought affecting large areas of cultivation (Hyman et al., 2008). The millions of people whose livelihoods and nutritional status depend on these major agricultural systems provide a glimpse of the extensive impact that improved AWM, including the promotion of improved varieties and agricultural system diversity, could have on food security. In Africa alone there are more than 33 million small-scale farming households (Nagayets, 2005) where the sustainable and productive management of water could contribute to transforming degraded soils and landscapes into healthy agroecosystems capable of enhancing food security, improving livelihoods, and increasing resilience to climate change and variability.

Simply put, **good agricultural water management means using water in a way that provides crops and animals the amount of water they need, enhances productivity, and conserves natural resources for the benefit of downstream users and ecosystem services.** Although AWM includes irrigation, it is not simply about applying water; it includes soil, land, and ecosystem conservation practices, such as drainage and watershed management; fisheries management; and technologies for lifting, storing, and conveying water.

B. Systems Approach to Managing Agricultural Water

A systems approach that identifies and assesses the roles of multiple actors is required to achieve sustainable development outcomes. A systems approach to AWM begins with the identification of the significant contextual relationships. Analyzing the relationships among the components of a system provides an understanding of the connections and feedback loops among the relevant actors; practices in local crop and livestock farming systems, including tillage, soil fertility management, crop rotations, grazing patterns; availability and access to inputs (including, but not limited to water); geography; environmental water flows; transport; markets; and land and resource tenure. Understanding and building on these interactions is a hallmark of adaptive integrated water resources management (Boelee, 2011).

A watershed is a natural boundary for identifying contextual relationships in how water flows through, and is used by, different actors within the same geographic catchment area. Strategies that utilize a watershed approach include:

- Developing institutions where stakeholders participate in allocating water equitably and efficiently, e.g., water users associations
- Managing wetlands, forests, grasslands, and other natural habitats in a way that provides a clean and dependable water supply, including water for agriculture, ecosystems, and livelihoods
- Incorporating water monitoring practices that gauge water balance, availability, and quality
- Promoting landscape planning to reduce risks of flooding, drought, and land degradation
- Supporting agronomic practices that can improve water infiltration into soils, leading to aquifer recharge and better regulation of stream flow

In the past, traditional AWM was concerned with improving the efficiency of water use in large-scale irrigation schemes in which the objective was to control, not manage, water. In contrast, improved AWM is more holistic and aims to mitigate the environmental costs and risks of irrigation (land degradation, salinization, and erosion; reduction or loss of environmental flows; pollution; destruction of natural habitats and livelihoods through drainage of wetlands and through land expansion and deforestation; and waterborne disease.) (World Bank, 2006). Now, as larger numbers of farmers are investing in small-scale irrigation systems (Giordano et al., 2012), and regulation is either 'absent or uncoordinated' (Giordano and de Fraiture, 2013), the need for improved practices in small- and large-scale systems is evident.

With small-scale irrigation now touted as a way to increase food security and increase resilience to climate variability and change (Cooper et al., 2008), it is even more important to increase farmer awareness, knowledge,

[1] Major farming systems comprise those in South Asia (rice-wheat, rainfed mixed, rice, highland mixed, dry rainfed); sub-Saharan Africa (cereal-root, maize mixed, root, agro-pastoral millet/sorghum, highland temperate mixed); East Asia and Pacific (upland intensive mixed, lowland rice, temperate mixed, highland
extensive mixed); and Latin America and Caribbean.

and practice of improved AWM and help put in place regulations that address the unchecked proliferation of water abstraction from both surface and groundwater sources.

Table 1. Investment Options for Agricultural Water Management *(adapted from Giordano et al., 2012)*

More Efficient / Productive Use of Water	**Sample Interventions**
Increase resilience, decrease risk, & expand dry season opportunities	• Optimize the design and management of rainwater storage, e.g., rooftop and surface harvest, above- and below-ground catchments • Manage watersheds to protect groundwater recharge zones, reduce risks from floods and droughts, and maintain ecosystem resilience • Protect surface water catchments via afforestation, etc. • Increase soil-water holding capacity through additions of organic matter • Decrease evaporation through use of cover crops and mulches • Increase infiltration and decrease erosion by using deep tillage to break up hard pans • Design for multiple users, including natural productivity and fisheries • Improve soil fertility • Diversify agricultural systems, e.g., mixed crop-livestock and agroforestry • Use complementary crop architecture above- and below-ground
Address inefficiencies throughout agricultural systems	• Improve input supply • Introduce innovative financing schemes • Improve access to markets • Provide farmers and agro-dealers the information and incentives they need • Increase value addition through agro-processing • Increase market outlets by creating wholesale and retail markets

C. Agricultural Water Resources Sustainability Assessment (WRSA)

Agriculture exists in a complex economic, sociocultural, and environmental context. A WRSA uses a systems approach to assess contextual dynamics and the relationships among water users and uses, including the water needed to maintain environmental flows and ecosystem health. It builds awareness of availability of and access to water resources, competing demands, legal and customary systems. It helps prioritize investments in agriculture water management (see Table 1) and "fosters a broader approach to integrated water resources management that facilitates more optimal and harmonious outcomes." (USAID, 2013)

A WRSA for agricultural activities does not have to be onerous in terms of time or money. A desk-top study combined with stakeholder consultations can provide the information needed to **select best-fit practices**, thus *building in sustainability from the start.*[2] It can also be used throughout a project lifecycle to monitor both the natural resource base and project progress towards desired results and outcomes. Hence, conducting a WRSA would provide value throughout the life of a project: from design stage, to selecting technologies and practices, to development of an Initial Environmental Examination (IEE), to implementation, to monitoring and evaluation.

Table 3 (see Page 8) is an illustrative guide to conducting a WRSA for agricultural activities that outlines a series of questions to help the user assess key risks related to the natural resource base; identify current water capture, storage, and application practices; determine the relevant sociocultural, market, infrastructure, and governance context; and assess stakeholder knowledge of water sustainability issues. As a globally applicable tool, the questions are necessarily broad and will have more or less relevance for particular projects; users should modify the questions accordingly.

Users of this tool should be familiar with the local area, agricultural systems, and best practices in stakeholder consultation. Analysis of particular issues, however, may reveal a level of risk or complexity that requires further

[2] A key Agency operational principle for achieving and measuring results; USAID Policy Framework: 2011-2015.

analysis through consultation with subject matter specialists in land tenure, hydrology, infrastructure sustainability, water quality, fisheries, or environmental assessments. In these cases, this tool can be integrated into the approaches used by those practitioners.

At a later date, annotations will be added for each question in the tool to further guide the user in the intent of each question, elaborate on data collection, and highlight issues that would indicate to a user that subject matter specialists should be consulted. These annotations will be appended to the next version of this Implementation Brief.

D. Examples of Improved AWM Practices

AWM comprises a suite of management practices that includes, but is not limited to, watershed management, water capture, storage, conveyance, and application. This holistic focus is strategic because the sustainable and productive management of water requires attention to other factors, including inter alia, climate change and variability, crop selection, animal nutrition, maintaining ecosystem goods and services, and soil quality. For example, irrigation alone will not guarantee increased crop productivity on nutrient-poor soils; pests and diseases can severely diminish water productivity; and changes in precipitation or temperature may render some agricultural options untenable (Jones and Thornton, 2009).

Improving management practices must be approached on multiple levels: from individual households to basin management to national law and policy on water use. Management at the watershed and landscape scale is critical to mitigating risks from floods and droughts, thus enhancing resilience to climate change and variability. Wetlands, forest, and natural vegetation can act as natural water reservoirs during droughts and buffers during floods. Similarly, food production from both cultured and natural systems, such as wild fisheries, should be calculated at the basin level. This will ensure that water use and allocation within the watershed increases overall production and food security, as well as equitable access to resources.

The suite of management activities includes soil and water conservation practices that reduce erosion and increase water infiltration into soil. Slope stabilization, bunds, and terraces are some of the more commonly used practices with these aims. Care must be taken to use practices appropriate for the context. For example, contour or graded bunds should only be used on grades ranging from 2-10 percent, whereas vegetation and engineered structures are used on slopes up to 30 percent. Soils characterized by swelling and shrinking are not suitable for bunds. Terraces can be quite effective at reducing erosion, but must not be used on duplex soils, e.g., sandy topsoils overlaying a clay or gravelly subsoil, because the top layer will erode, eventually resulting in deep gullies.

Diversified agricultural systems can make more productive use of water. For example, agroforestry systems close their canopies earlier, which reduces soil evaporation and run-off, and they tap water from deeper soil horizons (Riha and McIntyre, 1999). Farmers have historically coped with climate change and variability by diversifying their agricultural systems (Mortimore, 2010). Integrating crop and livestock production is a common risk mitigation strategy in semi-arid and arid environments.

Sometimes large-scale infrastructure water management interventions are not the best investment. Numerous studies have shown that supplemental irrigation – irrigating only during critical crop growth and development periods – can result in greater crop and water productivity (Fox et al., 2005; World Bank, 2006; Rockstrom and Barron, 2007). Coupling supplemental irrigation with rainwater harvesting can increase yields 2-3 times more than conventional rainfed agriculture. Re-use of wastewater and recycled water can reduce the demand for additional freshwater withdrawals and energy consumption (World Bank, 2006).

Security of access and tenure to land is critical to the productive use of and long-term investment in sustainable agricultural water management. Innovative practices, such as drip irrigation, small affordable pumps, and small-scale water harvesting and storage, can dramatically boost the productivity of small-scale farmers; a lack of secure access and tenure, however, is a huge barrier to farmer adoption of improved AWM. Subsidies and other market distorting interventions often send the wrong signals regarding the value of water, encouraging inefficient behavior. Energy subsidies, for example, are regarded as the biggest driver of groundwater depletion (World Bank, 2006) and have led to groundwater over-abstraction in countries such as India and Jordan.

Some practices may provide multiple benefits and have multiple trade-offs, e.g., bunds store water and reduce run-off, but the increased water surface area may result in more cases of malaria and greater evaporative losses. Constructing water storage structures with a low surface area to volume ratio will mitigate these issues. Some practices, such as minimum tillage and mulching, can retain or increase soil organic matter and hence, increase the capacity of the soil to hold water and decrease evaporation, facilitating groundwater recharge (Leakey et al., 2009). Yet, minimum tillage may increase weed pressure and labor, and there are multiple competing uses for mulch material – fuel, fodder, and construction. In addition, the quantity of biomass needed may be unrealistic in resource-constrained environments. Mulching may also result in a larger labor burden, particularly on women. Managing trade-offs among efficiency, equity, cost, and sustainability is part of selecting best-fit AWM strategies (Giordano et al., 2012).

III. Programming Implications

A. Programming AWM Interventions

Since there are no funds attached to the second strategic objective of the Water and Development Strategy (SO2), Missions programming under SO2 will be required to leverage other resources. Potential sources of funding include Feed the Future, Global Climate Change Initiative, Biodiversity, and other water- and food-related discretionary programs.

B. Indicators

To report on the progress of meeting the goals set forth in the USAID Water and Development Strategy, four standard indictors from the Feed the Future initiative will be reported. These indicators also support two critically important USAID program areas: building resilience to recurrent crisis[3] and adaptation to climate change.[4] (See Table 2)

As noted above, the most important step in selecting best-fit AWM strategies that will directly contribute to meeting SO2 is the completion of a water resource sustainability assessment (WRSA) (Indicator 4.5.2-41). The only indicator specific to IR 2.2 reports on the land area under improved or new irrigation and drainage services (4.5.1-28). Indicators 4.5.2-2 and 4.8.2-26 are applicable to both IR 2.1 and IR 2.2.

Table 2. SO2 Indicators and Targets

INDICATOR	TARGET	NOTES
4.5.2-41 Number of water resources sustainability assessments (WRSA) undertaken	Completion of 20 WRSAs by FY 2018	NB: It is desirable to see all projects completing a WRSA to help inform an IEE
4.5.1-28 Hectares under new or improved/ rehabilitated irrigation and drainage services as a result of USG assistance	250,000 ha by FY 2018 (50,000 annually)	
4.5.2-2 Number of hectares under improved technologies or management practices as a result of USG assistance	1,000,000 ha (200,000 annually)	This land area equates with **2,000,000 people** benefiting from improved AWM (400,000 annually)
4.8.2-26 Number of people with increased capacity to adapt to the impacts of climate variability and change as a result of USG assistance	125,000 people by FY 2018	NB: Since indicator is disaggregated by practice/action, this means 125,000 people benefiting from endeavors that result in the sound management and use of water for food security

[3] USAID Building Resilience to Recurrent Crisis: USAID Policy and Program Guidance, Dec 2012. http://1.usa.gov/1nDH4jo
[4] USAID Climate Change and Development Strategy: Clean Resilient Growth. http://1.usa.gov/1l8FaWp

IV. Examples from the Field

A. Bangladesh

In Bangladesh, USAID's Cereal System's Initiative for South Asia (CSISA) project is promoting axial flow pumps (AFP), an inexpensive surface water irrigation technology that reduces fuel consumption and thus irrigation costs by up to 60 percent. Mounted on a two-wheeled tractor, AFP gives owners increased business opportunities during the dry season. USAID/Bangladesh's Accelerating Agriculture Productivity Improvement project is substantially reducing the use of nitrogen fertilizer in rice production via the promotion of a technology known as fertilizer deep placement. This technique lowers nitrogen fertilizer application and improves plant nutrient uptake, significantly increasing yields (20-25 percent) and contributing to increased water productivity.

B. Haiti

USAID/Haiti's Feed the Future West project works with farmers producing and harvesting vegetables, flowers, and fruit to promote sustainable agriculture on hillsides by focusing on protected and vertical agriculture through small, drip-irrigated greenhouses. By protecting crops from humidity, rain, and other external factors, greenhouses boost production from one or two harvests on traditional hillside plots to three harvests per year. The greenhouses, managed by 22 farmers associations, use less water and increase yields. Since 2010, USAID assistance helped build more than 370 greenhouses. This work freed land area for high-value tree planting to combat deforestation, with more than one million trees planted in 2012. Feed the Future introduced improved seeds, fertilizers, and new technologies to approximately 17,000 Haitian farmers. To date, the project has also provided training to about 2,000 certified master farmers, over a quarter of whom are women, who technically support other farmers to improve their skills, management practices, and income potential.

C. Nepal

USAID/Nepal has incorporated a host of practices to promote climate smart agriculture in its Feed the Future program. The Hill Maize Research Program and CSISA in Nepal are selecting crop varieties for traits, such as early maturation (to provide residual soil moisture for a second crop) and tolerance to water logging. Conservation tillage is one of the practices helping farmers adapt to erratic weather patterns. Climate change is affecting plant pest and disease dynamics. The Integrated Pest Management Innovation Lab (IPM IL) is responding to these changes by promoting resistant varieties and practices that avoid the use of harmful pesticides. In addition, IPM IL is working with the USAID Initiative for Climate Change Adaptation activity to integrate IPM packages into local plans for climate change adaption process. IPM IL is promoting low cost, small-scale greenhouses, which allow farmers to produce off-season monsoon tomatoes. Previous project successes with the use of drip irrigation for vegetable crops are being replicated, allowing farmers to produce vegetable crops in the dry season and irrigate their high value crops during dry spells in the monsoon season.

D. Senegal

USAID awarded $8 million to the World Food Program in 2011 to support the 5-year Rural Resilience Initiative in Senegal. This Initiative is designed to test a comprehensive risk management approach that will build the long-term resiliency of chronically hungry populations to severe weather shocks, thereby addressing the growing challenges of climate change, food insecurity, and natural disasters. The project aims to reach 18,000 households with four risk management tools: community-based risk reduction activities (e.g., soil and water conservation projects), access to credit, savings programs, and micro- insurance to help households cope with and recover from more severe droughts. A rigorous impact evaluation will generate learning that will then be applied to other countries facing food insecurity.

E. West Africa

In 2012, USAID trained 40 representatives from West African hydrological and agro-meteorological services to develop seasonal forecasts to help farmers anticipate and better prepare for wet and dry years. Seasonal forecasting is one of the best adaptation strategies to climate variability and climate change in West Africa. By developing and disseminating information characterizing the rainy season before it starts, farmers and other stakeholders can adapt their cropping systems to make better use of rainfall.

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Additional Resources

Feed the Future
Sustainable Agriculture Water Management
USAID Water and Development Strategy
USAID Water and Development Strategy Implementation Field Guide
USAID Water and Development Strategy Webinar focused on AWM

WRSA Resources

Climate

- Adaptation Learning Mechanism – Brief, qualitative climate scenarios for many countries. http://www.adaptationlearning.net/
- Climate Information Portal (Stockholm Environmental Institute and University of Cape Town – Easy-to-use historic and projected climate data for Africa. http://cip.csag.uct.ac.za/webclient/
- National Adaptation Programmes of Action – Country overviews. http://unfccc.int/cooperation_support/least_developed_countries_portal/submitted_napas/items/4585.php
- The World Bank Climate Risk and Adaptation Profiles for 49 countries. http://climate4development.worldbank.org/
- Data from various climate-modeling scenarios. http://www.ccafs-climate.org/data/

Biodiversity Hotspots

- http://www.cepf.net/resources/hotspots/Pages/default.aspx and http://www.iucnredlist.org/

Water and Wetlands

- Water data portal of International Water Management Institute. http://waterdata.iwmi.org/index.php
- Independent Assessments of Water Flows, Fluxes, Stocks, Consumption, and Services. http://www.wateraccounting.org
- Ramsar sites: List of Wetlands of International importance. http://www.ramsar.orgsites-countries/the-ramsar-sites

World Soils Data

- http://www.isric.org/content/new-generation-soil-property-maps-africa

This Implementation Brief will be periodically updated. Comments from readers are welcome, especially comments to help clarify the information provided or where additional information may be useful.

Table 3. A Tool for Agricultural Water Resources Sustainability Assessment (WRSA)

Scale: Field to Basin	Planning: Inventory	Planning: Design	Implementation and Evaluation: Performance Assessment/ Monitoring
Natural Resources Base	**Water** • Water resource availability and accessibility at point of use • Depth to water table (m) & aquifer productivity (L s^{-1}) • Seasonality of surface water **Climate** • Mean annual and seasonal precipitation over last 5 years (mm) • Maximum/minimum air temperature • Arid, semi-arid, or humid • Projected changes in precipitation (amount/ timing) and temperature **Land** • Clarity of use, rights, and secure tenure for occupants • Land governance systems, formal and informal **Landscape and Soils** • Erodible, hilly, flat, etc. • Biodiversity, tree/forest cover • Area in cash/staple crops • Soil texture • Fertility	• Calculate project resource needs • How will project affect resource base in terms of quality and quantity? • Assess how changes in demography and competing uses will affect quality and quantity of water resources available for project • How will climate variability and change affect resources for project? For example: Will minimum temperatures exceed optimum for rice flowering? Will maximum temperatures exceed optimum for maize germination? Will rainfall patterns and hence seasons shift? • Assess use rights to land, noting any conflicts between occupants and others claiming rights, such as pastoralists	• Assess how project is affecting resource quality and quantity • Modify changes in resource availability and use projections as needed
Technologies and Practices	**Current Technologies/ Practices** • Crop, soil, and animal (including wildlife), including soil and water conservation • Water capture/store/lifting/ application in agriculture **Inputs** • Type/amount/frequency, e.g., fertilizer • Roads, rail, communications, etc. • Weather forecasts	• Are current agricultural systems resilient to climate variability and change and market perturbations? Are erosion control measures capable of more intense/ frequent rainfall? Are farming systems comprised of diverse components? What are best-fit AWM technologies/practices given context (including different roles of men and women?) • Can current practices by stakeholders be modified to conform to best-fit AWM? • Are farmers able to access usable weather forecasts to inform their decision making?	• Best-fit AWM practices in use by men and women

Socio-Cultural and Market Environment	**Stakeholders** • Competing uses/users • Gendered division of agricultural resource management between men and women • Child labor? **Market** • Type/distance • Supply chains for operation & maintenance • Access to market (men and women)	• Stakeholder (sex-disaggregated) input into decisions on water use and management • Competing demands on time that affect access/use of water by men and women	• Monitor how project is perceived by stakeholders (sex-disaggregated) on user needs and demand • Satisfaction among stakeholders (men and women) with respect to project participation
Infrastructure and Governance	**Legal and Customary Systems** • Security of access to and control over water and land (sex-disaggregated) • Water users associations, advisory services • Roles, effectiveness of government policies and institutions • Roles, effectiveness of private sector service providers **Financial** • Tariff structure • Cost recovery, incentives	• Mechanisms for equitable security of access to water resources • Mechanisms for permitting and enforcement • Role for women in decision making in groups	• Monitor changes in regulatory environment • Equitable security of access to water resources • Women have equitable decision-making role in use and management of water resources
Farmer Knowledge & Awareness	• Participatory needs assessment (sex-disaggregated) • Knowledge, awareness, practice of AWM and Natural Resource Management (NRM) • Awareness of projected climate change impacts that could affect water availability, agricultural production, and market access • Awareness of other users/uses; attitudes, tensions	• Training designed and methods identified to meet specific needs of men and women • Training available for youth – potential labor force	• Knowledge, awareness, and practice of AWM, NRM, and climate change adaptation (sex-disaggregated)