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149

AgWater Solutions Project
Country Synthesis Report

Investing in Agricultural Water Management to Benefit Smallholder Farmers in Burkina Faso

Alexandra E. V. Evans, Meredith Giordano and Terry Clayton, Editors

International Water Management Institute

Research Program on Water, Land and Ecosystems

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Improved livelihoods for smallholder farmers

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Project

The AgWater Solutions Project was implemented in several countries in Africa and Asia between 2009 and 2012. The objective of the project was to identify investment options and opportunities in agricultural water management with the greatest potential to improve incomes and food security for poor farmers, and to develop tools and recommendations for stakeholders in the sector including policymakers, investors, NGOs and smallholder farmers. This report synthesizes the research findings and contributions made by the team and stakeholders in Burkina Faso over the project period.

The leading implementing institutions were the International Water Management Institute (IWMI), the Food and Agriculture Organization of the United Nations (FAO), iDE, the International Food Policy Research Institute (IFPRI) and the Stockholm Environment Institute (SEI).

For more information on the project or for detailed reports, please visit the project website (http://awm-solutions.iwmi.org/home-page.aspx) or contact the AgWater Solutions Project Secretariat (AWMSolutions@cgiar.org).

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Summary

This Working Paper summarizes research conducted as part of the AgWater Solutions Project in Burkina Faso between 2009 and 2012. The agriculture sector contributes almost 40% to the country's gross domestic product (GDP) and 80% to export earnings. Yet, it remains a "low-income food-deficit country" according to criteria of the Food and Agriculture Organization of the United Nations (FAO). There are an estimated 8 billion cubic meters (BCM) of surface water in Burkina Faso and 9.5 BCM of groundwater, but agriculture remains largely rainfed and farmers are typically traditional subsistence farmers. Smallholders are increasingly developing irrigated vegetable plots in areas with water and good market connections, but the extent of this remains limited. The potential irrigable land is estimated to be 233,500 hectares (ha), but only 14% of the developed area is harvested annually.

Researchers from the AgWater Solutions Project examined the potential for small reservoirs, inland valley cultivation and the use of motorized pumps. Research methodologies included rapid rural appraisals, interviews, survey questionnaires and literature reviews.

The main findings indicate the following:

- Small reservoirs need better management at all stages to reduce costs and improve equity. Costs could be comparable with other AWM options. The total investment to reach 50% of the potential demand in Burkina Faso could be as much as USD 1,136 million. Costs could be reduced by tightly controlling planning, implementation and management, and should be compared with all the benefits over the lifetime of the reservoir. If implemented, some 321,000 households are likely to benefit.
- Inland valleys, commonly known as *bas fonds*, can be used to increase rice cultivation as well as other crops through improved water management, agronomic and post-harvest practices. Investment in physical infrastructure and extension could amount to USD 384 million.
- Motor pumps can increase yields and incomes, but problems in areas, such as financing, cost reduction of electricity supply, distance to pump suppliers, poor operation practices and maintenance, and environmental damage need to be addressed. Motor pumps used upstream of reservoirs can support profitable dry-season vegetable cultivation, but care must be taken regarding over-abstraction, pollution and conflicts. Greater adoption of motor pumps could benefit some 332,000 farming households irrigating up to 4% of the total agricultural land area at a total investment cost of USD 121 million.
- Combination of a range of agricultural water management options – capture/storage + lifting + irrigation technologies + soil conservation + watershed management – are recommended to enable supplementary irrigation in areas where dry spells become a common occurrence.

INTRODUCTION: SMALLHOLDER AGRICULTURAL WATER MANAGEMENT

Across Africa and Asia, a growing number of smallholder farmers are finding ways to better manage water for agriculture to increase yields and income, and diversify their cropping and livelihood options. Farmers buy or rent irrigation equipment, draw water from nearby sources, and individually or collectively build small water storage structures. This development is often overlooked by external investors, yet the smallholder agricultural water management (AWM) sector is contributing to food security, rural incomes, health and nutrition. While small-scale AWM practices could potentially benefit hundreds of millions of farmers, this potential is far from being realized.

The AgWater Solutions Project examined this trend together with the opportunities and constraints associated with smallholder AWM in five countries in Africa, Burkina Faso, Ghana, Ethiopia, Tanzania and Zambia, and two states in India, West Bengal and Madhya Pradesh. Through this, the project identified a number of ways in which the potential of the smallholder AWM sector can be realized, including:

- **Building supportive institutional structures:** Existing governing bodies typically cater for public irrigation systems and are often not adapted to capitalize on the opportunities and to handle the challenges posed by this alternative mode of irrigation development. Traditional agricultural institutions rarely focus on market-oriented smallholder crop production, such as high-value vegetable production in the dry season.
- **Overcoming value chain inefficiencies:** Market inefficiencies negatively affect farmer decision-making and access to technology. Inefficiencies include: poorly developed supply chains; high taxes and transaction costs; lack of information and knowledge on irrigation, seeds, marketing and equipment; and uneven information and power in output markets.
- **Improving access to technology for all sectors of society:** Better-off farmers have greater access to information and technology than their poorer counterparts and women who face several hurdles: high upfront investment costs, absence of financing tools, and limited access to information to make informed investment and marketing choices.
- **Managing potential trade-offs:** While smallholder AWM can be beneficial for an individual farmer, its uncontrolled spread can have unexpected consequences. If not managed within the landscape context, the many small dispersed points of water extraction, can negatively impact downstream users and cause environmental damage.

Addressing these challenges requires a fresh look at new and existing AWM technologies, products and practices to enhance the potential of the smallholder AWM sector and find solutions.

WHY INVEST IN SMALLHOLDER AWM IN BURKINA FASO?[1]

Burkina Faso has a large agriculture sector contributing almost 40% to the country's GDP and 80% to export earnings. Yet, it remains a "low-income food-deficit country" according to criteria of the Food and Agriculture Organization of the United Nations (FAO). This is due, in part, to the high rainfall variability that ranges from 400 millimeters (mm) in the northeast to 1,200 mm in the extreme southwest.

[1] Based on AgWater Solutions Project 2010a, 2010b, 2010c.

There are an estimated 8 BCM of surface water in Burkina Faso and 9.5 BCM of groundwater, but agriculture remains largely rainfed and farmers are typically traditional subsistence farmers. Smallholders are increasingly developing irrigated vegetable plots in areas with water and good market connections, but the extent of this remains limited. The potential irrigable land is estimated to be 233,500 ha, but, in 2004, the Ministère de l'Agriculture, de l'Hydraulique et des Ressources Halieutiques (MAHRH) estimated that only 32,258 ha (14%) of the developed area was actually harvested annually. A particular impediment to accessing groundwater for smallholder farmers is the geology.

The Agwater Solutions Project mapped the potential for AWM to improve the livelihoods of smallholder farmers in Burkina Faso and found that almost 6.5 million people (over half the rural population) could benefit from agricultural water management (Figure 1).

AWM Investment Opportunities in Burkina Faso

The AgWater Solutions Project identified many existing AWM practices that could support the realization of the estimate that 6.5 million people could benefit from AWM. In consultation with local stakeholders in all 13 agricultural regions and at national level, it was agreed that options should be considered that apply to rainfed staple crops and enable diversification, for example, drip irrigation, supplementary irrigation with water-lifting devices, and development of water sources and 'valley bottoms' (*bas fonds*) (Table 1).

TABLE 1. AWM options reviewed and prioritized with stakeholders.

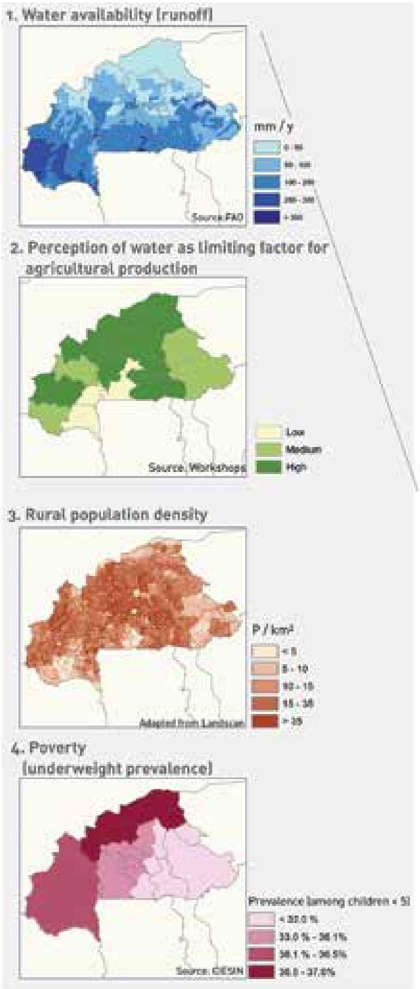
Water access/storage	Water lifting	Water transportation and application
• Small dams and *boulis* (small ponds) • Large diameter wells and boreholes for horticulture production • Deep wells • Soil and water conservation (in-situ rainwater harvesting)	• Motor pumps • Solar pumps	• Drip irrigation • Furrow irrigation (gravity) • Improvement irrigation water transportation efficiency (e.g., buried PVC pipes) • Border irrigation (for vegetables) • Basin irrigation (for rice) • Low valley bottom development
AWM Support measures		
• Organization management of small dams and associated schemes • Improve capacity to select or use AWM options, and to innovate • Financial support for access to quality AWM equipment and nutrients • Improve value chains for AWM equipment		

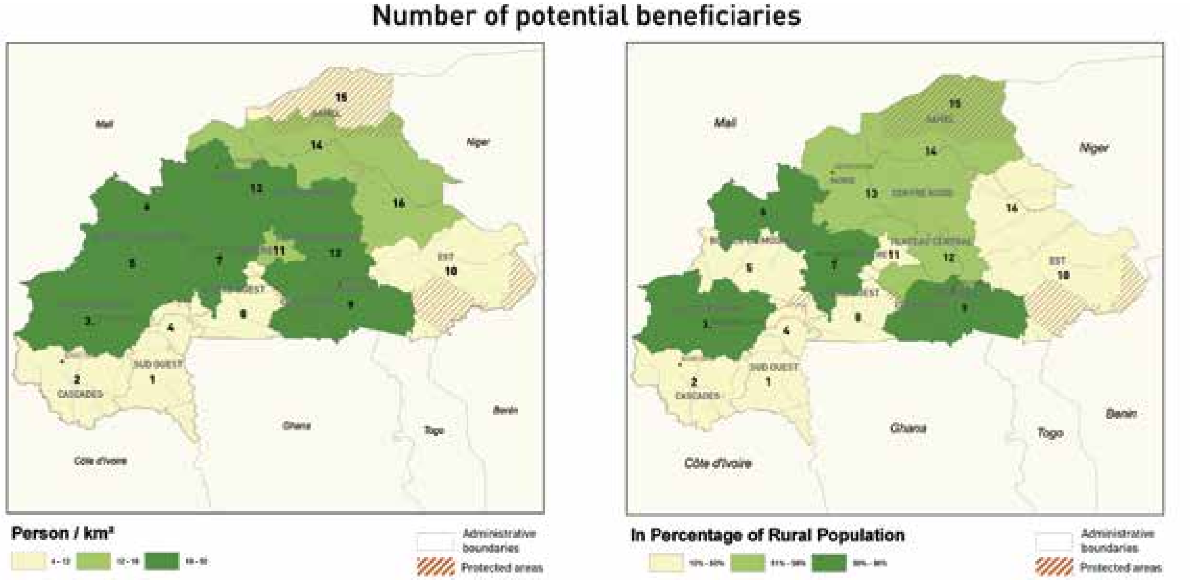
Source: FAO 2012b; AgWater Solutions Project 2010c.

The Hydro-Agricultural Development Policy, 2004, emphasizes small-scale irrigation and promotes user participation, farmers' organizations, and private investment in large and medium facilities. These are defined as:

Large schemes cover areas of hundreds to thousands of hectares. Management may be delegated to a state, self-managed by farmer beneficiaries or private. Farm size generally varies between 0.5 and 2 ha, but can reach 10 ha for companies dedicated to agribusiness.

FIGURE 1. Potential beneficiaries of agricultural water management in Burkina Faso.





Livelihood zone		Water availability: IRWR/cp (m³/p/y)	Rural population			Perception of water as limiting factor for agricultural production	Potential beneficiaries	
No	Name		Total (,000)	Density (p/km²)	% poor (underweight)		Person (,000)	In % of rural population
1	South-west sub-humid, cereals-root crops (sorghum-yam)	2,765	369	26	36.0	Low	55	15%
2	West sub-humid, cereals (rice, maize), tree crops and cotton	3,841	390	25	36.2	Medium	195	50%
3	West moist-semiarid, cotton, cereals (rice-maize), vegetables	2,143	906	38	36.2	High	725	80%
4	West moist-semiarid, cotton, cereals (sorghum-maize)	924	388	55	35.6	Low	58	15%
5	West moist-semiarid, cotton, cereals (sorghum-maize) and sesame	1,125	718	44	36.2	Medium	359	50%
6	North-west moist-semiarid, cereals (sorghum-rice), irrigated cash crops and remittances	691	705	41	36.5	High	528	75%
7	Centre-west moist-semiarid, cereals (sorghum-millet), horticulture and remittances	645	867	72	33.1	High	628	72%
8	South moist-semiarid, , cereals-root crops and tourism zone	1,980	326	30	33.1	Low	49	15%
9	Centre-east, moist-semiarid, cereals (sorghum,- rice), groundnut, livestock	1,192	1,135	58	32.9	High	908	80%
10	South-east, moist-semiarid, cereals (sorghum-millet), forestry and fauna, tourism	2,295	621	19	32.9	Medium	310	50%
11	Central peri-urban, horticulture and livestock	298	337	136	33.1	Low	51	15%
12	Central Plateau moist-semiarid, cereals and market gardening zone	431	1,205	86	33.0	High	696	58%
13	Centre-north dry semiarid, cereals-vegetables- groundnut	385	1,812	73	34.7	High	974	54%
14	North dry semiarid, agro-pastoral, sorghum-millet , vegetables	358	974	37	36.0	High	498	51%
15	North-east arid, transhumant pastorals and millet	397	221	16	36.7	High	121	55%
16	East dry semiarid, cereals-livestock, transboundary trade	1,041	623	31	32.9	Medium	311	50%

Source: FAO 2012a.

Medium schemes are between 20 and 100 ha. They are usually downstream gravity fed schemes from small dams or schemes supplied by pumping from dams or natural lakes. The individual farm family is the preferred implementer. Individual plots are 0.1 to 0.25 ha.

Small-scale irrigation facilities vary in size depending on the technology and management conditions. Manual irrigation may cover 25 square meters (m^2); pumps irrigating commercial farms cover 3 to 20 ha; treadle pumps cover 30 to 40 acres (16 ha); and small centrifugal pumps of 3.5 to 5 horsepower (HP), irrigating 1 to 2 ha. These arrangements may be individual (private) or collective (village cooperative).

Bas fonds are developments of lowlands (wetlands) to reduce overland water flow and make use of rainfall, usually for paddy cultivation. They are important because they are an open access resource often used by poor farmers. Management of *bas fonds* is provided by the operators, together with associations, groups or cooperatives. The operators have responsibility for managing water and maintenance of infrastructure under the supervision of farmer organizations or through management committees.

Stakeholders, including farmers, government officials, extension officers and suppliers of AWM technologies were asked what the reasons were for low levels of AWM adoption and their recommendations for overcoming these constraints. Their perceptions and recommendations are given in Table 2.

Based on these stakeholder comments and a detailed research process, a series of recommendations were made on how to increase adoption and sustained use of these AWM options by smallholder farmers (Table 3). Analysis was also undertaken to determine the number of potential beneficiaries and agricultural land area that could be irrigated.

TABLE 2. Stakeholder perceptions of AWM constraints and solutions.

Factors limiting the adoption of AWM options by smallholder farmers	Recommendations for increasing adoption
• There are limited options available on the local market. This makes it difficult for the farmer to select the most appropriate technology for his or her needs and to maintain the equipment.	• Farmers need support strategies to allow them to make informed decisions. • There could be more dissemination, training and extension particularly after an option has been introduced.
• Farmers and extensionists have inadequate knowledge of the range of AWM options available, because they are rarely provided with sufficient advice or demonstrations.	• Spare parts need to be available. • Credit facilities should be tailored for smallholders. • Rethink small dams to take into account multiple uses of the water as well as equity issues from the design stage.
• Adoption seems to be driven by availability due to project investments, government imports or products marketed in the country, rather than needs of the farmers or the actual potential of the solution.	• Improving land tenure and land access are critical conditions for successful AWM – in particular, around small dams and for low valley bottom developments.
• It is often hard for farmers to access the credit required to cover the initial investment costs.	• Smallholders prefer individual systems over community systems and groundwater over surface water systems (even when collective systems are justified economically), because individual systems are more reliable and have lower transaction costs.

Source: FAO 2012b.

TABLE 3. Review of AWM options, recommendations and potential beneficiaries.

AWM Solution	Beneficiary households (% of rural households)*	Area in hectares (% of total agricultural land)*	Estimated investment costs (USD)
Small reservoirs provide multiple uses and security in drought years. They need better management at all stages to reduce costs and improve equity. If this is done, costs can be comparable with other AWM options.	100,000-321,000 (1-3%)	100,000-321,000 (1-5%)	750,000/cubic meter (m^3) of stored water
Inland valleys/*bas fonds* can be used to increase the extent of rice cultivation as well as other crops. Improving water management, agronomic and post-harvest practices will all be required for success.	361,000-426,000 (3-4%)	541,000-639,000 (8-9%)	600/household
Motor pumps can increase yields and incomes, but problems in areas, such as financing, cost reduction (e.g., electricity supply), distance to pump suppliers, poor operation practices and maintenance, need to be overcome. Motor pumps used upstream of reservoirs can support high-value, profitable dry-season vegetable cultivation, but care must be taken regarding over-abstraction, pollution and conflicts.	276,000-332,000 (2-3%)	221,000-266,000 (3-4%)	400/household

Source: This study; all data: FAO 2012a.

Note: *Figures assume that out of the total potential beneficiary households calculated, 50% adopt the AWM option.

These findings are derived from an approach that combines primary and secondary data collection, stakeholder involvement and mapping. Details of the approach taken by the AgWater Solutions Project and the related studies are given in Box 1 and elaborated in subsequent chapters. Further information, including case studies and mapping data can be found on the project website (http://awm-solutions.iwmi.org).

Box 1. AgWater Solutions Project approach.

Situation analysis and selection of AWM options: An initial analysis was undertaken of the conditions in each country and the AWM practices already being undertaken. These were reviewed with stakeholders and some of the most promising practices were selected.

Field-scale and community-level case studies: Researchers used a participatory opportunity and constraint analysis and methodology to understand the complex interactions among social, economic and physical factors that influence the uptake and success of AWM options, and to identify technologies appropriate to different contexts in each of the project countries.

Watershed-level case studies: Researchers used a multi-disciplinary approach to look at how the natural resource base impacts on, and is impacted by, AWM in four watersheds

(Continued)

Box 1. AgWater Solutions Project approach (Continued).

in Tanzania, Burkina Faso, West Bengal (India) and Zambia. The analysis concentrated on the hydrological impact of current and potential AWM interventions; the current resource-based livelihoods and dependencies on sources of water and water management practices; an impact assessment of potential AWM scenarios; and a review of formal and informal institutional capacity to deal with AWM interventions and potential emerging externalities.

National AWM mapping: Maps were developed to help assess where AWM will have the greatest impact within a country or state, and where specific interventions will be most viable. The steps followed were to use a participatory process in which experts defined the main livelihood zones based on farming typologies and rural livelihood strategies, and the main water-related constraints and needs in the different rural livelihood contexts. Using this, the potential for investment in water to support rural populations could be mapped based on demand and availability of water. A further step was to map the suitability and demand for specific AWM interventions, such as motor pumps or small reservoirs, and to estimate the potential number of beneficiaries, application area and investment costs. These allow investors to choose entry points and prioritize investments in AWM that will have the most beneficial impacts on rural livelihoods.

Regional AWM analysis: Researchers used geographic information system (GIS)-analysis, crop mix optimization tools and predictive modeling techniques to assess the regional potential for the 'best-bet' AWM technologies in South Asia and sub-Saharan Africa in terms of: potential application area (in hectares), number of people reached, net revenue derived and water consumption. Scenarios were also developed to factor in climate change and potential changes in irrigation costs.

Stakeholder engagement and dialogue: An integral part of the entire project was the engagement of stakeholders from the initial assessment of AWM opportunities through to the identification of possible implementation pathways. The dialogue process was used to ensure that project results reflected stakeholder perceptions and addressed their concerns. National and sub-national consultations, dialogues, surveys and interviews were fed into all stages of the project.

AWM OPTIONS REVIEWED

Surface Water Storage[2]

Water Storage is an insurance mechanism for the smallholder. It acts as a buffer against rainfall variability and increases the resilience of farmers. With stored water, a farmer feels able to invest in agricultural inputs and equipment to improve productivity.

[2] Based on Venot 2011; FAO 2012c; AgWater Solutions Project 2011a, 2012b.

Where the opportunity lies

Small reservoirs (Box 2) were often designed for a single purpose, but they increasingly tend to be used as multi-purpose infrastructure. In Burkina Faso, they were mostly developed to grow rice in the rainy season and vegetable on smaller areas of land in the dry season. As far as agricultural production is concerned, reliable access to irrigation water from storage creates potential for crop diversification away from these planned uses. This can provide dietary diversity and the potential for profit, provided markets can be accessed and labor is available.

Box 2. What are small reservoirs?

Small reservoirs include water storage (mostly above but occasionally underground) of less than 1 million cubic meters (MCM), the uses of which include agricultural production (for crops, livestock and fish).

Small reservoir development in Burkina Faso
In the 1950s and 1960s, many small reservoirs were constructed, primarily for livestock watering. In the 1980s, they were constructed mostly to develop irrigation. In the 2000s, performance expectations were not being met and infrastructure was degrading. Thus, construction of reservoirs fell to a very low level.

Rehabilitation needs rose sharply and there was a shift from hardware to 'software' investments. The consensus was that operation and maintenance issues could be resolved through Water Users Associations (WUAs). WUAs were established but the capacity building effort to make them functional was insufficient.

Source: FAO 2012c.

New approaches

Water storage allows diversification of economic activities. It is already possible to see a move from collective, gravity fed, low-efficiency, management-demanding irrigation schemes focusing on the production of staple crops, towards water-saving (pressurized), on-demand, individually-managed irrigation installations increasingly dedicated to high-value crops (mostly vegetables). However, this will not necessarily happen spontaneously and requires capacity building and the introduction of AWM technologies and techniques to make the best use of the stored water. Careful management is also required so that both systems can co-exist and the greatest benefit can be obtained from the resources available. Rethinking the design, management and coordination around small dams is at the core of making them a viable solution (Table 4).

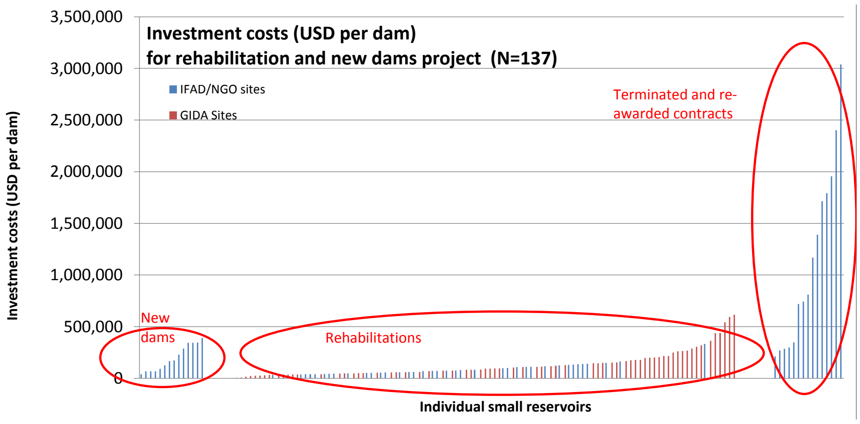
Storing surface water is an expensive way to invest in AWM, but it is sometimes the only way to provide rural communities with access to water. The high costs often arise from mishandling projects (Figure 2). The investment costs for small reservoirs can be prevented from escalating by improving procedures. Accurate feasibility studies, better preparation and stricter accountability to decision-makers, funders and local communities can all help to control costs and improve the outcome.

TABLE 4. Suggestions for improving the economic value of small reservoirs.

Business as usual	The alternative
Rice-dominant irrigation downstream of a small reservoir is not the best or the only agricultural option.	To the extent that market linkages favor it, growing high-value crops, such as vegetables, is a much better alternative.
Conventional gravity irrigation is constrained by topography.	Individual or pressurized irrigation systems are less constrained by topography and allow irrigation of the land around a reservoir instead of only downstream.
Gravity irrigation is usually considered to be the least expensive option but can be costly on flat land. The recurrent costs of gravity irrigation have been underestimated, and insufficient routine maintenance allocations have led to considerable deferred maintenance costs.	Water-lifting technologies and Pressurized system costs were high but have declined.
Currently, most small reservoir projects include an institutional component focusing on creating WUAs. They are not appropriate 'tools' as they ignore the multiple arrangements and scales that characterize natural resources management.	Water governance must be suitable for multiple uses and new irrigation systems. This can be achieved through various mechanisms and institutional architectures.

Source: FAO 2012c.

FIGURE 2. Investment costs for the construction and rehabilitation of small dams.



Source: Venot 2011.

To effectively evaluate small reservoirs and compare them to other AWM interventions, a cost-benefit analysis needs to be considered per capita and for the entire lifetime of the project. If well managed, costs are comparable to investments in other types of interventions. Benefits are even greater, if multiple uses, existing farming systems, water recharge and direct pumping are taken into account. Investments in irrigation extension and monitoring are also needed.

The research

Research was conducted in several small reservoirs across Burkina Faso. The approach to analyzing the performance of reservoirs used qualitative evaluation based on ranking. The rankings related to four main indicators: the status and functioning of dam infrastructure; effectiveness of management of the reservoir; benefits of the reservoir to users; and equity in the institutional arrangements for the use and management of the reservoir.

The research findings were used to formulate a comprehensive approach to improve the benefits that can accrue to communities around small reservoirs (Table 5).

TABLE 5. Solution pathways to build smallholder resilience through water storage.

1. Ensure strategic planning	**2. Raise design and construction quality**	**3. Make best use of storage infrastructure**	**4. Adopt new management approaches**
1a. Inform decision makers on the range of possible options.	2a. Design with people and integrate multiple uses.	3a. Encourage and facilitate multiple uses.	4a. Identify apropriate institutions and strengthen organizations for water management.
1b. Mainstream appropriate planning and implementation methods within the government and amongst partners (official development assistance, NGOs, …).	2b. Improve the know-how of designers on the options and design issues.	3b. Integrate and support upstream users in small reservoirs.	4b. Recognize and address water-use conflicts.
1c. Favor 'distributed storage': bring storage closer to the user.	2c. Build flexibility into the design.	3c. Strengthen farmer knowledge of technology, production systems and practices.	4c. Better assess environmental impacts at multiple scales and mitigate them.
1d. Plan storage on the basis of a clear understanding of demand and water availability.	2d. Move away from the downstream model of gravity irrigation.		
1e. Use stakeholder valuation in cost-benefit analysis.	2e. Improve knowledge of hydrological and other small reservoir design parameters.		
1f. Budget for participatory design.	2f. Strengthen the construction process: quality assurance in procurement and supervision.		

Source: FAO 2012c.

The research also indicated the importance of strategic planning:

- More strategic and better informed planning is needed to ensure the highest return on investment in water storage for agriculture.
- Within irrigation investment projects in sub-Saharan Africa, small-scale schemes currently offer significant performance advantages over large-scale systems. There is a trade-off between the economies of scale derived from collective water storage and the benefits associated with simplified operation and maintenance.

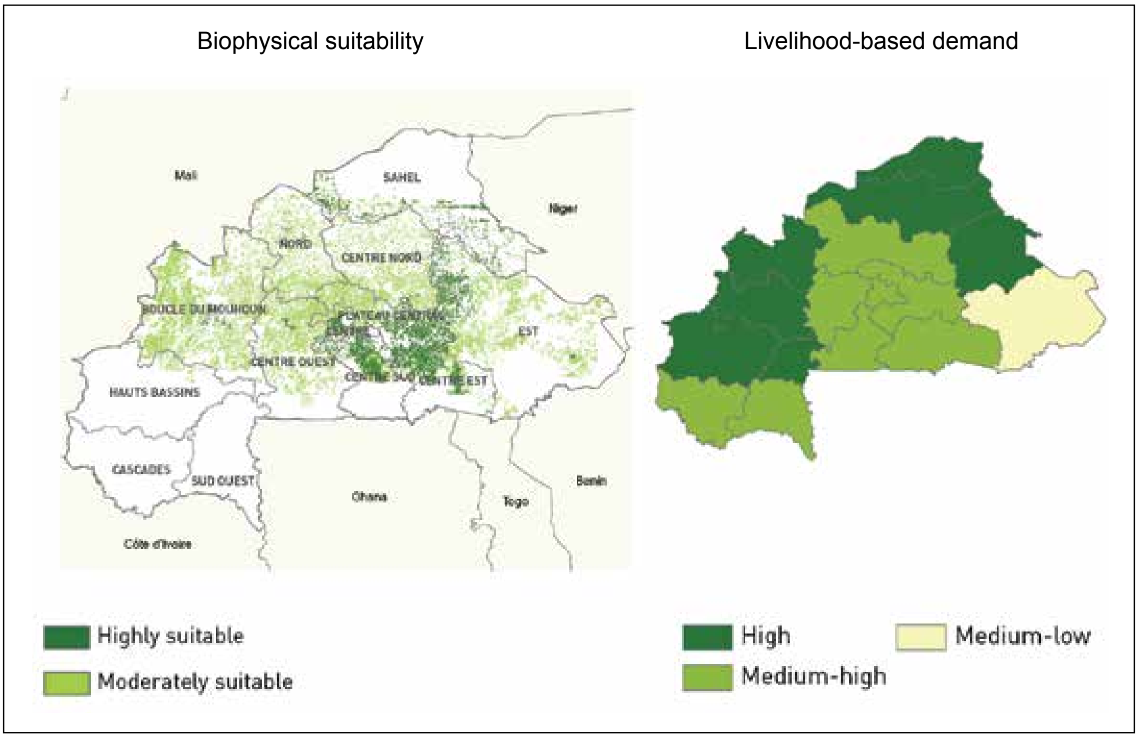
- Once the limiting factor of water is removed, other factors make themselves felt. Only if sufficient efforts are made to overcome these constraints, will return on investment be positive.
- Management models for storage often do not match the reality on the ground and, in particular, do not take into account the variety of stakeholders and beneficiaries.

Investment potential

Using the biophysical criteria of aridity index and livestock density, combined with livelihoods maps and experts views, the AgWater Solutions Project estimated that, at a 50% adoption rate, small reservoirs could benefit between 100,000 and 321,000 households, equating to 1 to 3% of rural households.

The potential application area is 100,000 and 321,000 hectares, which is 1 to 5% of the total agricultural land area in Burkina Faso. Figure 3 provides details of where small reservoirs could have the greatest livelihoods benefits in Burkina Faso.

FIGURE 3. Suitability of small reservoirs based on physical characteristics and livelihood demand.



Source: FAO 2012a.

Stakeholder recommendations.

Participants insisted on the importance of small dams for Burkina Faso, but also listed a number of problems and concerns over the conditions for their success. The disconnect between the conception that they would be used only for irrigation or livestock and the realities of multiple uses were highlighted as well as key management issues at local, watershed and national levels. Rethinking the design, management and coordination around small dams is at the core of making them a viable solution.

Source: FAO 2012b.

Dry-season Vegetable Cultivation[3]

The use of the Korsimoro Reservoir for dry-season vegetable production upstream of the dam has had both positive and negative outcomes. Formalizing water management arrangements would help regulate water use among the users, stem the flow of new entrants to vegetable growing and protect the environment.

Where the opportunity lies

Reservoirs in Burkina Faso are intensively used and generate considerable value. At the Korsimoro Reservoir, there are now over 1,000 'informal' upstream vegetable producers using small pumps to draw water directly from the reservoir. Irrigated vegetable cultivation is three times more profitable per unit of area than downstream rice irrigation. The unofficial irrigated area along the reservoir banks is seven times larger than the official command area downstream. The demand for cultivable land is high and the area is expanding. Introducing formal management mechanisms will support this unforeseen development while managing related trade-offs.

The research

Researchers studied the situation of the Korsimoro Reservoir to illustrate the positive and negative impacts of unplanned individual irrigation around communally managed water bodies. Data were obtained through structured questionnaires among 100 farmers involved in rice cultivation, vegetable production, fishing and livestock rearing. Semi-structured interviews were conducted with officers from farmers' organizations, local government and other institutions.

Results of the survey were shared in a meeting with villagers and the Department of Irrigation to verify and finalize them. They were also discussed at expert workshops on small dams and in a national consultation.

[3] Based on AgWater Solutions Project 2012b.

Main findings

Organizational and economic aspects

The 1,000 or so vegetable farmers cultivate 230 ha, mainly upstream, during the dry season and sell to local and regional markets. They can generate healthy profits but returns can be variable due to market gluts, pests and diseases. As a comparison, incomes from paddy are around 1,130-3,340 USD/ha compared to 5,000-15,000 USD/ha for onions grown on rented land.

Most vegetable farmers live in the area and also own paddy land downstream, but the expansion of rice cultivation is limited by the lack of suitable land. More people are coming to Korsimoro for the dry season to earn additional income.

Cattle owners and fishers have common interests (access to good quality water) but they are insufficiently organized to address difficulties. Groups have been formed but remain inactive.

Impacts and emerging issues

- **Vegetable growers** are feeling the impact of increased pumping. Towards the end of the dry season, small pumps cannot draw water from the reservoir.
- **Rice farmers** are concerned about the growth in pumping. They see it as unfair that vegetable farmers do not pay water fees, do not contribute to maintenance of the downstream irrigation system and do not seek permission to withdraw water.
- **Fishers** are concerned about agrichemicals and pollutants from vegetable fields accumulating in the reservoir. Field observations confirm the improper use of large quantities of fertilizer and pesticides, and poor agronomic practices. Oil and petrol leaking from motor pumps adds to the pollution load.
- **Pastoralists** claim that the vegetable cultivation is blocking the passage used by their cattle to get to the water.
- **Signs of over-use and conflicts** are emerging.

Where to invest

Some form of water user management mechanism is needed to regulate water use among the various user groups, control the number of vegetable growers and protect the environment.

One potential entity to undertake this is the Comité Local de l’Eau (CLE) or Local Water Committee. Initiated by the government in 2003, CLEs are supposed to serve as platforms for consultation, mobilization and promotion of water management rather than a decision-making body with enforcement powers. The CLE for Korsimoro was created in 2006 and includes representatives of the vegetable farmers’ union, the rice cooperative, cattle farmers, fishers, local chiefs, members of the district council, traditional chiefs and other office holders.

The CLE is ideally suited to address water issues around the reservoir. It falls within its objectives to bring together the diverse groups of water users to discuss and exchange water distribution and management issues. The CLE needs a clear mandate, strong leadership and resources to become an active agent for addressing water management issues. International donors could be the catalyst in shaping a re-invigorated CLE.

Who benefits and where

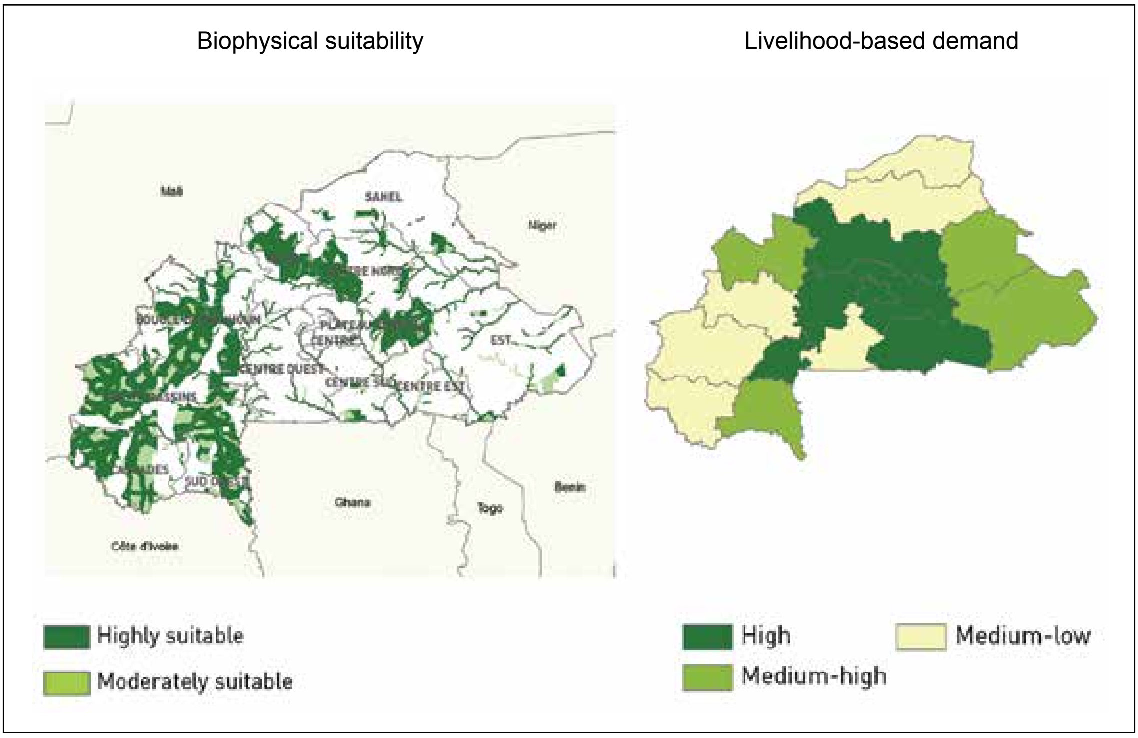
Korsimoro is now known as a hub for onion cultivation in the region. At harvest time, traders come from as far as neighboring Ghana to buy in bulk. With an effective local water management mechanism in place, upstream vegetable farmers could be seen as pioneering an innovative and profitable way of using small reservoirs. Storage and market facilities are needed to ensure optimal use of the water and spread production throughout the year.

There are more than 1,300 small reservoirs in Burkina Faso. The government and donors have been promoting them to enhance irrigated production, in particular, rice, downstream from the reservoirs. However, the trends observed at Korsimoro Reservoir are typical of other reservoirs in Burkina Faso, and indicate that broadening the planning and management approach of small reservoirs in the country to incorporate the broader group of users and uses might yield greater benefits.

If the use of motor pumps is supported in Burkina Faso, to take advantage of water in small reservoirs as well as other surface water storage structures and groundwater aquifers, it has been estimated by the AgWater Solutions Project that some 276,000-332,000 farming households could benefit, equating to 2 to 3% of rural households. They could potentially irrigate 221,000-266,000 ha, which amounts to 3 to 4% of total irrigable land in Burkina Faso.

Motor pumps are most suitable for irrigating land less than 1 kilometer (km) from a surface water body or in close proximity to shallow groundwater (assessed on the basis of the presence of alluvial soils), or where yearly surface runoff is more than 250 mm. Land must be close to a market (less than 8 hours away) to take advantage of growing high-value dry-season crops. Suitable areas for small pump use are shown in Figure 4.

FIGURE 4. Locations suitable for small pump use based on biophysical factors and livelihood demand.



Source: FAO 2012a.

Stakeholder recommendations.

Motor pumps are suitable all over the country. They are multiplying around small dams through private investment. However, the pumps available on the market are of low quality and there is an insufficient range to meet the different needs.

Markets are driving the development of small-scale irrigation around small reservoirs. However, farmers often have to sell their crops at the same time, which lowers prices. If adequate storage facilities were available for high-value crops, such as onions, they could keep some of the production and sell it when the prices are higher.

Source: FAO 2012b.

Improving *Bas Fonds*[4]

Vast areas of inland valleys are currently not under cultivation. Introducing rice production or providing water to extend the growing season could bring much-needed profitability to smallholder farmers.

Inland valleys are low-lying areas, including valley bottoms and floodplains, receiving runoff from hills and mountains. Through the use of water capture and delivery structures, the systems provide supplemental irrigation and improve soil moisture retention (Box 3). They also reduce flooding and soil erosion. In Burkina Faso, the potential area for inland valley rice production has been estimated at 1 million hectares (Mha) (FAO 2012a).

Between 1998 and 2004, a series of three surveys of inland valleys was conducted in Burkina Faso by the Programme Spécial pour la Sécurité Alimentaire (PSSA), funded by the United Nations Development Programme (UNDP); the Programme National de Gestion des Terroirs (PNGT), funded by the Ministry of Economy and Finance (MEF) through the Sahel Integrated Lowland Ecosystem Management (SILEM); and the Plan d'actions pour la filière riz (PAFR), funded by the European Union (EU). These surveys calculated that, in the entire national territory, inland valleys cover 1,900,000 ha.

Box 3. Paddy yield potential.

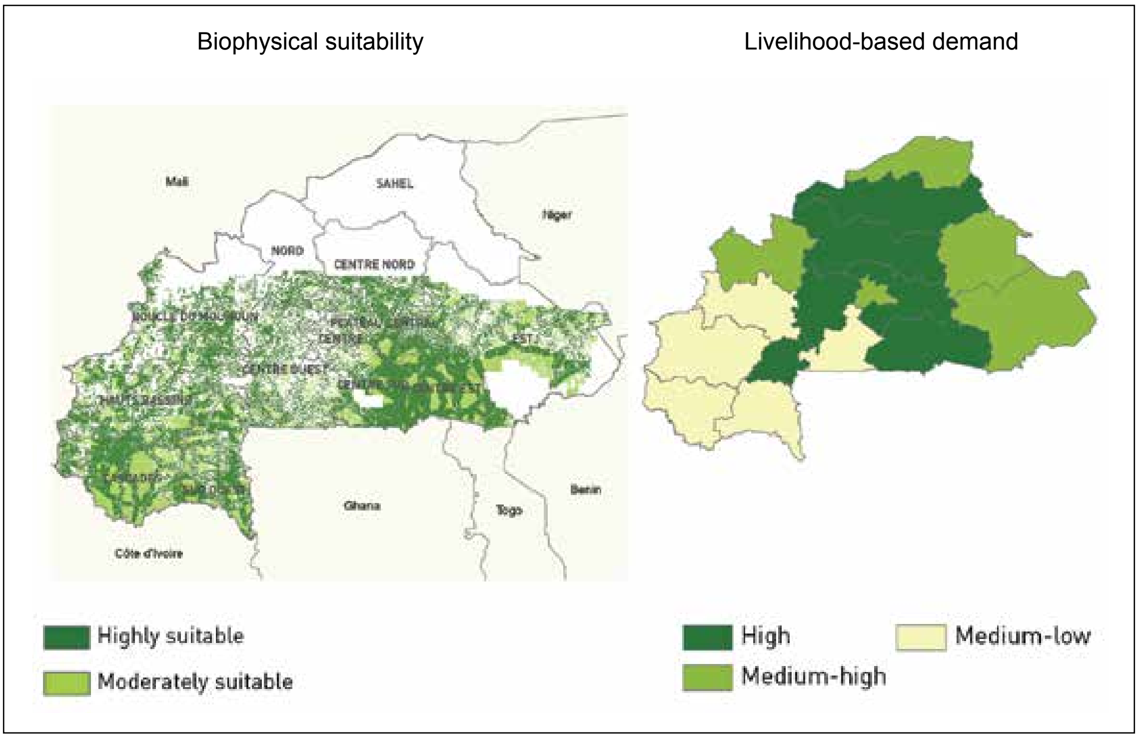
Paddy yields vary according to water control but are approximately 4 to 5 tonnes/ha (t/ha) under total control (or a potential of 6 t/ha with the possibility of two crops a year). Purely rainfed inland-valleys yield 0.7-1 t/ha, but this can increase to 2 to 2.5 t/ha or more with water control, depending on the system.

Source: Moussa Laurent Compaore, National Dialogue Facilitator, Burkina Faso, 2012, pers. comm.

[4] Based on AgWater Solutions Project 2011b, 2011c; Moussa Laurent Compaore, National Dialogue Facilitator, Burkina Faso, 2012, pers. comm.

Most of the inland valleys were mapped (Figure 5) and characterized according to biophysical and socioeconomic criteria. This has allowed classification based on 'hardly developable' and 'non-developable'. Suitable areas for inland valley development are valleys where the length of growing period (number of days during which T > 5°C and ETa >= 0.5 ETo[5]) is more than 120 days. Areas closer to markets are also more suitable. The livelihood demand for cultivating inland valleys was also taken into account. Approximately 541,000-639,000 ha could be developed benefitting 361,000-426,000 households (if 50% of all the farmers who could potentially adopt the AWM option did so). This represents 3 to 4% of the rural population and 8 to 9% of the total agricultural land in Burkina Faso.

FIGURE 5. Opportunities to develop *bas fonds.*



Source: FAO 2012a.

Some challenges

Bas fonds were intensively discussed at a regional and national level with a diverse group of stakeholders, including key experts. The following constraints to the further development of inland valleys were noted:

- Lack of developed schemes.
- Persistence of land tenure problems, making it difficult to access land and water resources.
- Animals straying and causing degradation of unprotected cultivated areas (particularly vegetables crops).
- Poor targeting or wrong choice of the beneficiaries of the projects.

[5] Where T is temperature, Eta is actual evapotranspiration and ETo is reference evapotranspiration.

- Conservative attitudes to the change.
- Limited involvement of, and access to, information for women.
- Competition between farmers, ranchers and other actors over water.
- Isolation of some sites.
- Inadequate organization of potential users.
- Limited cooperation of officials in management training.
- Decline in the level of the water table.
- Incorrect planning or implementation of certain schemes.
- Lack of staff.
- Low mastery of marketing opportunities for producer channels.

The research

Research was not conducted in Burkina Faso but findings are based on a study in Ghana, analysis of previous studies in Burkina Faso and stakeholder recommendations. The AgWater Solutions Project National Focal Point is an advocate of *bas fonds* development for smallholders and gathered a panel of experts to discuss the options in June, 2011.

Where to invest

- Improve water management. Options include full control irrigation to allow dry-season cropping or supplementary irrigation during the rainy season. Burkina Faso has experimented with different types of management systems from full control to field bunding according to site, crops and farmers. They are revising guidelines for low valley bottom water management for diverse cropping systems.
- Ensure tenure security through tenancy agreements.
- Improve agronomic recommendations (fertilizer application rates, variety, choice of crops, etc.) based on site-specific farm experiments and by applying technical and economic criteria.
- Institute affordable, long-term financing mechanisms for input procurement and investment that take into consideration the economic viability of inland valley rice cultivation.
- Improve post-harvest handling and storage systems, e.g., mechanical threshers, storage facilities.
- Improve the land management capability of farmers by introducing affordable equipment, such as power tillers.
- Initiate capacity building for researchers, extension personnel and farmers in appropriate agronomic practices for *bas fonds* farming for different crops.
- Assess environmental consequences of scaling-up *bas fonds* farming.

ASSESSING SOCIAL AND ENVIRONMENTAL IMPACTS OF AWM INTERVENTIONS: LESSONS FROM THE NARIARLÉ WATERSHED[6]

An AWM solution that benefits one farmer may negatively impact someone else or the environment, for example, by diverting water from ponds used for fisheries or livestock or lowering the water table. For any AWM solution to be sustainable, the negative impacts have to be anticipated and minimized as much as possible. AWM solutions may also have unexpected benefits.

The possible and probable impacts of interventions were investigated in the Nariarlé watershed. These studies showed that while expansion of most AWM options will have some negative impacts, overall, the implications for poverty reduction and gender equity are positive.

The Watershed

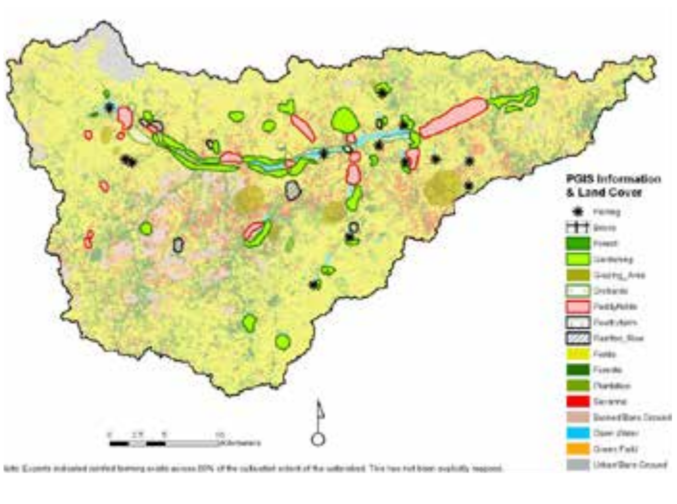
Physical environment

The Nariarlé watershed covers approximately 1,000 square kilometers (km^2) in central Burkina Faso, south of Ouagadougou. The northern part of the watershed has the highest population densities. Access to markets, infrastructure and transport are good.

Average annual rainfall is 739 mm/year, but variation is high within and between years. Evapotranspiration accounts for 88% of this, 9% is streamflow and 3% recharges groundwater. A characteristic of the watershed is the proliferation of small reservoirs of less than 0.1 hectare.

Approximately, 72% of the watershed consists of rainfed agricultural land; less than 0.5% is irrigated (Figure 6). The remaining area is degraded savanna, forest and plantations (Figure 7).

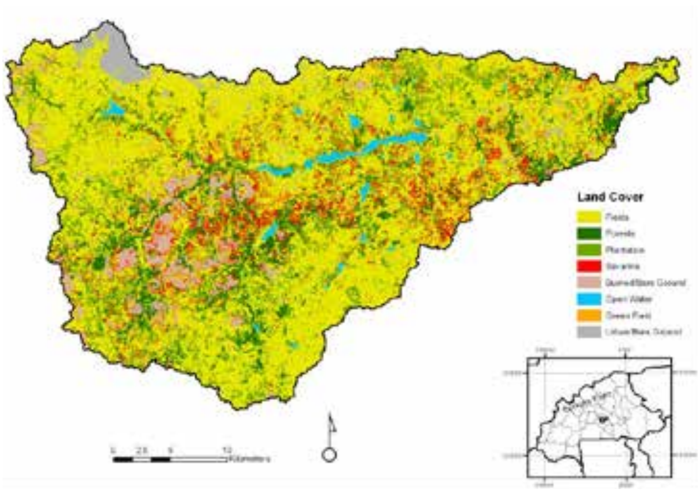
FIGURE 6. Dominant livelihood activities in Nariarlé.



Source: SEI 2012.
Note: PGIS = Participatory Geographical Information Systems.

[6] Based on SEI 2012.

FIGURE 7. Land use in Nariarlé.



Source: SEI 2012.

The Assessment

A number of scenarios for AWM interventions were reviewed with stakeholders and assessed in terms of social and environmental impacts. Hydrological modeling was also used to determine the potential water resource and yield impacts. Four types of AWM interventions were compared to existing water balance and crop yields. These were:

- **Improved rainfed agriculture** through improved soil and nutrient management in existing rainfed crops.
- **Expansion of irrigated areas through the use of additional pumps and canals** could increase the irrigated area from the existing canals, drainage channels and reservoirs.
- **Intensification of irrigation through improvement of existing cropland** (considered to be the addition of a fully irrigated post-rainy season vegetable crop on existing irrigated land on 0.4% of the watershed), so that two crops are grown per year.
- **Increasing storage in reservoirs by 50, 100 and 200%** for multiple uses and benefits. The current storage volume is approximately 0.15 cubic kilometers (km^3)/year compared to total rainfall resource of 0.74 km^3/year.

The Findings

Hydrological modeling

Improved rainfed agriculture could increase maize yields from 2 t/ha to 4.7 t/ha and millet yields from 2.3 t/ha to 2.8 t/ha. Yield variation between years could decrease, from 10 to 7% for maize and 9 to 3% for millet. This intervention would potentially benefit farmers currently relying on rainfed farming.

Expansion of irrigation areas through the use of additional pumps and canals into 20% of rainfed agricultural land could: triple millet yields to 2.8 t/ha; double maize yields to 5.5 t/ha; and result in no changes in surface water and groundwater flows.

Intensification of irrigation through improvement of existing cropland could result in:

- a fourfold increase in the volume of water used for irrigation each year, which would be withdrawn from small reservoirs and surface streams;
- surface flows decreasing by 10%;
- overall outflow from the watershed decreasing by 15%; and
- total production gains from irrigated vegetables of 30% per year.

Increasing storage in reservoirs by 50, 100 and 200% could:

- reduce outflow from the watershed by 19, 21 and 26%, respectively;
- have other multiple use benefits such as domestic water supply, water for livestock and habitats for fish; and
- have only marginal impacts on the streamflow if the water is used for irrigation, as it would mean a shift from unproductive surface water evaporation to productive crop evapotranspiration.

There is room for AWM interventions to increase agricultural production in the Nariarlé watershed. However, different AWM options could have different social and environmental outcomes and impacts that need to be carefully considered before interventions are made (Table 6). Table 6 presents a summary of the potential outcomes and impacts of different AWM options based on consultations with experts in the Nariarlé watershed.

TABLE 6. A social and environmental assessment.

Outcomes and impacts of the AWM scenarios		**Social impacts**			**Environmental impacts**		
Technology	Outcomes	Equity	Gender	Poverty reduction	Water quality	Water quantity	Natural resources
Improved irrigation channels	• Access to water for a greater number of farmers • Increase of field sizes and production • Reduction of water conflicts • High pressure on land reducing the areas for pasture	-	+	+	-	-	+
Diesel pumps	• Increase in farmers' income • Improved food security (quantity and quality) • Conflict between upstream and downstream users	+	+	+	-	-	-

(Continued)

TABLE 6. A social and environmental assessment (Continued).

Outcomes and impacts of the AWM scenarios		Social impacts			Environmental impacts		
Technology	Outcomes	Equity	Gender	Poverty reduction	Water quality	Water quantity	Natural resources
Drip irrigation	• Efficient use of water • Huge reduction of time for irrigation • Increase in farmer's income	-	+	-	+	+	-
Expansion in garden wells (small ponds)	• Access to water for greater number of farmers • Reduction of water course degradation • Increased farmers' incomes (legumes and fruits) • High risk of conflict between multiple users of water	+	+	+	+		-

Source: SEI 2012.

Notes: + (positive impact); - (negative impact); NA (no specific impact); Unclear (there could be no impact or the impact could be positive or negative).

Involving Formal and Informal Stakeholders

A diverse set of mainly informal institutional arrangements has emerged around the numerous small reservoirs in the watershed. Typically, each reservoir has a maintenance committee, as well as gardening, fishing, livestock and irrigation groups. Sometimes formal organizations complement or overlap with informal arrangements.

The various committees and groups tend to have localized interactions. There appears to be no single organization that coordinates the diverse land- and water-related activities across the entire watershed.

The formal water governance system has limited influence on everyday decision-making in the watershed. Attempts are being made by governmental authorities to establish water user groups. NGOs have been relatively successful in bringing together user groups from across the watershed.

There already exists a diverse network of collaborative relations around land and water management and these should be strengthened and built on.

CONCLUSIONS[7]

There are a large number of AWM options that smallholders are currently investing in and that the government authorities are supporting. These range from water storage to technology options to access water. The AgWater Solutions Project looked at three AWM options: small reservoirs,

[7] All figures provided in this section assume that 50% of the total potential users adopt the AWM option. All figures are taken from FAO 2012a.

use of pumps to irrigate dry-season vegetables and development of *bas fonds* primarily for paddy cultivation. The study found that:

- Small reservoirs are an important option for providing smallholders with access to water to meet a variety of needs. They can, however, be costly and the total investment to reach 50% of the potential demand in Burkina Faso could be as much as USD 1,136 million. However, the study also found that costs could be reduced by tightly controlling planning, implementation and management, and that costs should be compared with all the benefits over the lifetime of the reservoir. If implemented, up to 321,000 households are likely to benefit.
- Motor pumps are increasingly being used to maximize the benefits of small reservoirs and to facilitate upstream irrigation of high-value vegetables crops. These provide large incomes for farmers but there are a number of barriers to starting such a business and a number of issues that are arising through this practice, such as over-abstraction, conflict with livestock owners and pollution. Their use could be a major benefit to smallholder farmers but the negative impacts must be carefully balanced. This will require some sort of management structure which could be filled by the existing Comité Local de l'Eau (CLE) or Local Water Committee. Greater adoption of motor pumps could benefit some 332,000 farming households irrigating up to 4% of the total agricultural land. The total investment cost would be as much as USD 121 million.
- The development of inland valleys is a popular choice in Burkina Faso not only for paddy but also for other crops. The extent of land that could be developed is somewhere in the region of 9% of the total agricultural land, which would be farmed by up to 426,000 households. The investment would be in both physical infrastructure and extension and would amount to some USD 384 million.

Other AWM Solutions to Consider

The project did not research all possible AWM options but discussed a wide range of possibilities with various stakeholders. Two of the AWM options they felt should be investigated further were:

- Drip irrigation, which appears promising but there are many examples of farmers abandoning the technology. Further research is needed and is being carried out: IWMI initiated a new case study to understand the causes; iDE is piloting various technical options to demonstrate and inform farmer investments; and the government is producing a documentary for farmers to raise awareness of the potential of drip irrigation.
- Kitchen gardens, rainwater harvesting and development of crop insurance schemes deserve attention.

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