SEI STOCKHOLM ENVIRONMENT INSTITUTE

POLICY BRIEF

Opportunities for Agricultural Water Management interventions in the Nariarlé watershed in Burkina Faso

Key Findings

- Many people's livelihoods in the watershed are heavily dependent on low yielding rainfed agriculture. Agricultural Water Management (AWM) interventions that aim at in-situ improvement of rainfed agriculture would impact the livelihoods of the widest group of stakeholders.
- There is room for agricultural production to increase via AWM interventions because water access is currently constrained, particularly in the dry season. The use of additional pumps and canals could expand the irrigated area from the current drainage channels, canals and reservoirs.
- Improving rainfed cropping through soil and nutrient management would increase maize yields by 2-3 times to 5.5 t ha^{-1}, and millet yields from current 2 t ha^{-1} to near 3 t ha^{-1} grain yield with insignificant impact on surface and groundwater flows.
- There are limited options for expansion of agricultural land. Intensification on existing land by increasing irrigated vegetable crops to two-three harvests per year could produce vegetable yields of 7.7 t ha^{-1} (dry weight) (50% increase) without significantly affecting the surface and groundwater flows as the overall area of irrigated vegetable is so small (<0.5%).
- The multiple reservoirs are an important feature of the watershed and most irrigated gardening occurs along their banks. Yet, siltation problems are reducing dam water storage capacity. Increasing dam storage by 50% and 100% would reduce surface flow by between 20 and 26%.
- Most AWM interventions explored have multiple and varying impacts in terms of livelihoods, environmental degradation and poverty alleviation. The development of gardening wells and ensuring wider access to reservoir water is expected to have the most positive outcome for the widest range of stakeholders.
- A few key individuals have been instrumental in initiating the construction of reservoirs, thereby transforming not only the biophysical landscape, but also the institutional landscape of the watershed. Around the numerous reservoirs in the watershed a diverse set of mainly informal institutional arrangements has emerged.
- The institutional landscape is undergoing a number of changes at the moment and it is not clear how the various actors will work together in the future. Up to now no single organization seems to coordinate the diverse land- and water-related activities across the entire watershed.
- The small reservoirs have improved agricultural production in the watershed, but the development of water resources has sometimes proceeded in an uncoordinated way. To ensure the sustainability and cost effectiveness of AWM interventions, adequate institutional arrangements should complement AWM interventions.

What are Agricultural Water Management interventions?

Agricultural water management (AWM) interventions are increasingly being promoted as a first step to enable positive development, alleviating food insecurity and poverty in the smallholder farming systems that dominate rural sub-Sahara Africa and South Asia. These AWMs range from in-situ soil and water management improvements (conservation tillage, terraces, pitting) to supplemental and full irrigation systems, drawing water from a wide variety of sources in the landscape. However, re-allocation of water can potentially undermine other uses of the same water, for other livelihood purposes or, indirectly, by reducing availability for support of different ecosystem services. In Nariarlé watershed, current livelihood strategies were studied and then potential

Figure 1: Traversing the reservoir barrier

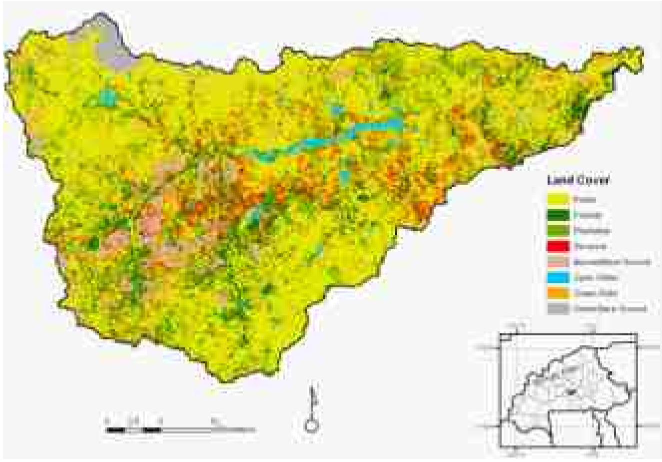

Figure 2: Location and land cover of the Nariarlé Basin, Burkina Faso

opportunities and possible water-related impacts of AWM interventions reviewed. Scenarios were developed through consultations with local watershed experts to identify potential impacts of various AWM interventions on the livelihoods present and water resources available in Nariarlé. An assessment of watershed-level relevant formal and informal actors identified opportunities and constraints for AWM implementation as well as potential options for negotiating negative externalities of AWM interventions.

Water and land for agriculture in Nariarlé

The Nariarlé watershed (Figure 2) covers an area of approximately 1000 km^2 and is located in central Burkina Faso south of the capital Ouagadougou. Koubri is the largest town found within the watershed whilst higher population density is located in the northern part of the watershed, which includes the residential outskirts of Ougadougou. The watershed is found in the semi-arid Sudano-Sahelian climate zone having an average annual rainfall of 739 mmy^{-1} with high variation within and between years. Of the annual rainfall, 88% is used as evapotranspiration from land and water bodies in the landscape, and 9% is partitioned to streamflow and the remaining water is recharging groundwater. Approximately, 72% of the watershed is rainfed agricultural land, and less than 0.5% is irrigated. The remaining areas consist of degraded savanna, forest and plantations. A major characteristic of the watershed are the number of small reservoirs (defined as having area less than 0.1 ha). As the watershed is close to Ouagadougou, with a main road traversing the watershed, access to market, infrastructure and transport is good.

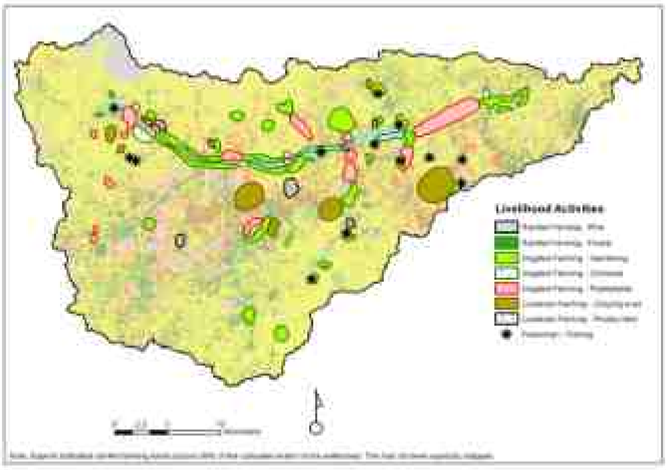

Figure 3: Livelihood activities in the watershed according to local experts

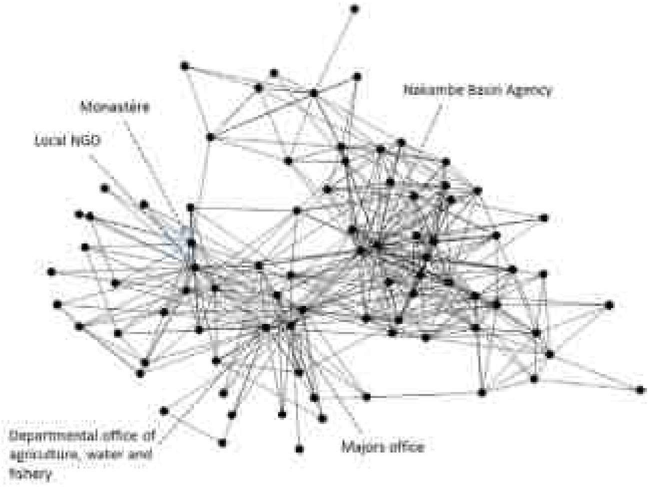

Figure 4: The institutions influencing land-, water- and ecosystem management in the watershed and how they relate to each through collaborative relationships

The four main livelihood groups in the watershed are broadly defined by the dominant farm system income: rainfed agriculture, irrigated agriculture, livestock production, and fishing (Figure 3). The majority of people in the Nariarlé watershed are small-scale (0.08-5 ha) farmers dominated with rainfed crops, primarily for subsistence. The main crops include pearl millet, maize, cowpea, sorghum, groundnut, paddy rice, sesame and bambara nut. Most farmers also have small gardens where they irrigate rice and vegetables as cash crops. Gardens are irrigated using traditional wells, gardening wells, irrigation channels and/or motor pumps. Most farmers keep some animals, and there are pastoralists in the watershed. A growing influx of small and medium agro-business farmers are being established. These agro businesses supply nearby markets in particular with fruit and vegetables which are irrigated.

In the watershed, there are no formally delimited grazing areas. Although anyone can access the large communal dams in the watershed, less than 3% of the population is involved in fishing. When the water level is very low, fishing is forbidden. The fishing community commonly depends on a second income-generating activity like cropping, breeding livestock or non-agricultural ventures.

Livelihoods in the watershed are heavily dependent on low-yielding rainfed agriculture. Despite easy access to markets, income levels remain low. Table 1 gives an overview of some of the constraints of each livelihood group.

Institutional networks supporting water resource management

A diverse set of mainly informal institutional arrangements has emerged around the numerous small reservoirs in the watershed. Typically each reservoir has a small reservoir maintenance committee, as well as a gardening-, fishing-, livestock- and irrigation- group. Sometimes formal organizations established through government projects complement or even overlap with the more informal arrangements. The exact institutional configuration varies across the watershed but is strongly linked to the multiple-use of reservoirs. Over several decades the key actors who facilitated the construction of the small reservoirs and the creation of new institutional arrangements around them, have shaped not only the biophysical landscape, but also the institutional landscape. In areas where there are no reservoirs there tend to be less local level organizations.

Table 1: Constraints to various livelihood groups

Major constraints of rainfed agriculture	Major constraints of irrigated agriculture	Major constraints of livestock production	Major constraints of fishing
Access to land	Siltation of dams and rivers	Unavailability of good quality grazing area	Difficulties to conserve fishing products
Access to inputs	Proliferation of invading aquatic plants	Lack of access routes to water	Proliferation of invading aquatic plants
Financial constraints	Water pollution by pesticides and other chemicals	Livestock monitoring	Water pollution by prohibited pesticides that kill fish
Drought	Water related diseases (malaria etc.)	Insufficient availability of agro-industrial by-products	Use of fishing nets with mesh that does not conform to the regulation
		Lack of technical support	

The social network analysis suggests that the various committees and groups that exist around the reservoirs tend to have rather localized interaction. Not surprising but important for managing land and water at larger geographic scales, collaborative relations regarding land and water are much more common among groups sharing a reservoir compared to the relations that would encompass the wider catchment. Non-governmental organizations have been relatively successful in their efforts to bring together user groups from across the watershed. Attempts by governmental authorities to establish water user-groups are currently being developed. For the time being the formal water governance system has fairly limited influence on everyday decision-making in the watershed.

It appears that there is currently no single organization that coordinates the diverse land- and water-related activities across the entire watershed. This limits the capacity to deal with potential negative impacts of AWM interventions on water and land resources. On the other hand the results from the social network analysis indicate that there already exists a rich and diverse network of collaborative relations around land and water management (Figure 4). When putting into place new governance structures, the existing social structures should provide opportunities to further strengthen and build on.

What potential impacts could AWM interventions have?

There is room for agricultural production to increase in the watershed via water-based interventions because current yield levels are low and water access is currently constrained, particularly in the dry season. The use of pumps and canals could expand the irrigated area from the current drainage channels, canals and reservoirs. Table 2 highlights how different AWM interventions could result in very different outcomes in terms of social and environmental impacts. Scenarios were also assessed for potential water resource and yield impacts through hydrological modelling where four types of AWM interventions were compared to existing water balance and crop yields:

- *Improved rainfed agriculture through improved soil and nutrient management in existing rainfed crops* could increase maize yields from current 2 t ha^{-1} to up to 4.7 t ha^{-1}, millet yields from 2.3 t ha^{-1} to 2.8 t ha^{-1}. In addition yield variation between years decreased, from 10% to 7% for maize, and from 9% to 3% for millet. The livelihood impact and food security gain would thus be substantial with surplus to sell for income, and less risk from year-to-year production level. This intervention would potentially ben-

Table 2: Outcomes and impacts of the different AWM scenarios

Technology	Outcomes	Equity	Gender	Poverty Reduction	Water Quality	Water Quantity	Natural Resources
Improved irrigation channels	• Increase of field sizes and productions • Reduction of water conflicts • High pressure on land reducing the areas for pasture	-	+	+	-	-	+
Diesel pumps	• Increase of farmer's income • Improved food security - quantity and quality • Conflict between upstream/ downstream users	+	+	+	-	-	-
Drip irrigation	• Efficient use of water • Huge reduction of time for irrigation, which could be used for other purposes • Increase of farmer's income	-	+	-	+	+	-
Expansion in garden wells (small ponds)	• Access to water for greater number of farmers • Reduction of water course degradation • Increased farmer's incomes (legume and fruit) • High risk of conflict between multiple users of water	+	+	+	+	+	-

Figure 5: Motorpump withdrawing from hand dug dike for irrigation on shores of small reservoir

efit a majority of farmers as most are partly depending on rainfed production for income and food security.

- *Expansion of irrigation areas through the use of additional pumps and canals* could increase the irrigated area from the current drainage channels, canals and reservoirs. Expanding irrigation into 20% of rainfed agricultural land could potentially triple smallholder millet yields to 2.8 t ha^{-1} and maize yields at least double to 5.5 t ha^{-1} with no changes in surface water and groundwater flows.

- *Intensification of current irrigation areas through improvement of existing cropland.* The watershed has a high population density and 73% of the land area is already in cultivation thus, improvements will need to be made through intensification on existing land. The intensification means to add a fully irrigated post-rainy season vegetable crop on existing irrigated land of 0.4% of the watershed so that two crops are grown per year. A four-fold increase in the volume of irrigation per year would be withdrawn from small reservoirs and surface streams. This could decrease surface flows by 10% and overall outflow from the watershed by 15% while attaining total production gains from irrigated vegetables of 30% per year.

- *Increasing storage in reservoirs* by 50/100/200% for multiple use and benefits reduces outflow from the watershed by 19%/21%/26%. The current storage volume is approximately 0.15 $km^3\ y^{-1}$ in the watershed compared to total rainfall resource of 0.74 $km^3\ y^{-1}$. Dams could potentially have other multiple use benefits such as domestic water supply, water for livestock, habitat for fish. If new reservoir capacity is used for irrigation, there are only marginal impacts on the stream outflow of the basin, as it would mean a shift from unproductive water surface evaporation to productive crop evapotranspiration.

Dealing with impacts of development, and expansion of urban areas

The construction of the small reservoirs has helped to improve agricultural production and peoples' livelihoods in the watershed. To ensure the sustainability and cost effectiveness of past and future AWM interventions, supportive institutional arrangements should complement AWM developments. Currently the institutional landscape in the Narialé watershed is undergoing a number of changes and it is not always clear how the various actors will work together to harmonize their activities across sectoral boundaries and administrative scales. The master plan of the urban expansion of the Burkina Faso capital, Ouagadougou, "Schéma d'aménagement de Grand Ouaga" includes options to increase settlements in the Nariarlé watershed. The potential expansion may affect smallholder farmer's willingness to invest in new water management technologies due to future uncertainties in land and water access for farming.

Further information available on demand:

Cambridge, H., J. Barron, 2011. 'Application of SWAT for impact assessment of agricultural water management interventions in the Nariarlé watershed, Burkina Faso'

Ouattara, K., S. Paré, S. Sawadogo-Kabore, S. Cinderby,. 'Assessment of impacts of AWM interventions on resource-based livelihoods: Agriculture Water Management Scenarios in the Nariarlé watershed, Burkina Faso'.

Ouattara, K., S. Paré, S. Sawadogo-Kabore, S. Cinderby,. 'Assessment of impacts of AWM interventions on resource-based livelihoods: Baseline Assessment of Current Livelihood Strategies in the Nariarlé watershed, Burkina Faso'

Stein, C., Barron, J., Ernstson, H., 2011. Water resources management: Three case studies from catchments in Burkina Faso, Tanzania and Zambia. Proceedings of XIVth IWRA World Water Congress September 25-29, 2011 Porto de Galinhas, Pernambuco, Brazil

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