Led by:

CGIAR Research Program on Water, Land and Ecosystems: Volta Synthesis

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Volta synthesis

Contents

1 Background

1.1 General description of the basin

The Volta basin covers 395,000 km^2 and is shared by six West African countries (Ghana, Burkina Faso, Côte-d'Ivoire, Mali and Togo). Ghana and Burkina Faso occupy 83% of the basin area. The population density in the Volta at ca. 48 persons per km^2 is generally low[1]. The basin is inhabited by 19 million people, of which 13.5 million (ca. 70%) are rural. Herders constitute 4% of the basin's rural population. Economies in the basin are reliant on rain fed agriculture. While30–60% of the total land resources in the basin are considered arable, only half of this area is cultivated (Lemoalle & de Condappa, 2010). Irrigation is under developed in the basin, covering less than 0.5% of the cultivated area, and is also only a small fraction (2%) of the irrigation potential[2]. Most of the production increase during the last decade has come from an increase in the cropped area rather than from increased productivity. Technical possibilities for improvement have been clearly identified, however social and economic preconditions preclude their implementation.

Agricultural yields and water productivity are low, often 10% or less of potential. Contributions from fisheries and livestock to productivity are underestimated and need careful socio-economic appraisal. According to Rockström and Barron (2007) gains in yields and water productivity of rainfed agriculture offer the main prospect for the food self-sufficiency of the basin. Other measures include improvements in infrastructure, secure and transparent land tenure, access to agricultural water and affordable micro-credit to invest in fertilizers and small-scale irrigation. The main drivers of change are demographic growth, migration, increasing urbanization and the impacts of climate change[3]. The basin population is projected to increase to 50-60 million by 2050. The ratio of rural to urban population is expected to change dramatically from 2.3 now to 0.5 in 2050 (Lemoalle, 2008; Lemoalle & de Condappa, 2010).

Rainfall in the Basin varies between 500-1100 mm/year with a mean of about 1,040 mm/year. Total rainfall for the basin is estimated to be 400 km^3/year. Average basin discharge is about 8–9% of total rainfall. The total available stream flow in the basin was about 32 km^3 per year during the period 1990–2000. Natural vegetation, mostly savannah grasslands, uses the major part of the rainfall (around 80%) throughout the basin. River discharge is highly sensitive to variations in annual rainfall (Lemoalle & de Condappa 2009). Most rivers in Burkina Faso dry up during the dry season, except where the two hydropower reservoirs Bagré and Kompienga maintain a continuous flow. Runoff increases from less than 5% in the northern part of the basin to >10% in the south. Groundwater resources are poorly quantified and apparently under-

[1] In comparison, rural population density in the Middle and Lower Gangetic Plains averages 795 inhabitants per km^2 (Erenstein, Hellin & Chandna, 2007)

[2] One estimate of current irrigation in Ghana states a figure of 207,000 ha with the potential for 1.9 million ha

[3] Although no solid evidence such as statistically significant trends in annual rainfall totals has been reported, there are signs of increased temperatures and shorter rainy seasons as well as statistically significant trends in agriculturally important rainfall characteristics in parts of the basin (Ghana), such as a reduction in the amount of light rainfall, a delay in the onset of the rainy season and lengthening of periods with no rainfall during the wet season (Lacombe, McCartney & Forkuor, 2012)

exploited, and should be assessed as a possible option for development of small-scale irrigation. Surface water in the Volta is largely concentrated in the reservoirs of the hydropower schemes. At the basin scale, a very small fraction of the renewable water is stored in reservoirs for uses other than hydropower. Lake Volta is a major component of the aquatic system, with a surface area of 8500 km^2 and storage capacity of 148 km^3. Water in the lake has a residence time of three years (Volta River Authority 2010). Flows and revenues from the Akosombo-Kpong hydro-electricity schemes are less than anticipated and low inflows to the dam seem to be a consequence of long-term reduction in annual rainfall. The smaller Bagré (1.70 km^3) and Kompienga (2.03 km^3) reservoirs in Burkina Faso are also important for hydropower and irrigation.

Formal, state-owned irrigation schemes amount to 13,000 ha and 6500 ha respectively in Burkina Faso and Ghana. The associated total water demand is 0.509 km^3 / yr. About 1400 small reservoirs have been developed for small-scale irrigation, household use and cattle watering in Burkina Faso and northern Ghana. Ca. 1100 of these, with a storage volume estimated at 0.232 km^3 are within the basin, especially in the northern part of the basin. 90% of them are located in Burkina Faso. They complement rainfed production, contributing to dry season vegetable production on about 10,000 ha.

1.2 Water scarcity

Economic water scarcity occurs when water resources are abundant relative to water use, but insufficient infrastructure or financial capacity prevents people from accessing the water they need. Renewable surface and groundwater resources per capita per year are more than 2000 m^3, a little above Falkenmark's (1997) per capita water scarcity threshold of 1700 m^3/yr. However, most of the northern part of the basin suffers physical water scarcity. The per capita renewable water resource in Burkina Faso is only ca. 900 m^3/yr. Temporal and spatial distribution of rainfall influences agriculture more than total rainfall. There is a marked gradient between the drier north and the wetter south. The Basin crosses four agro-ecological zones ranging from the wetter Guinean zone to the arid Sahel.

- The Sahel, located in the northernmost part of the basin, less than 500 mm annual precipitation, is a zone of rangeland where livestock herding is the primary activity, complemented with the drought-resistant crops millet and cowpea. The probability of a failed growing season is 53%. 23% of herders are highly vulnerable to droughts (Clanet & Ogilvie, 2009).
- The Sahelo-Sudan, covering most of Burkina Faso and a small part of Mali, receiving 500–900 mm annual rainfall. Millet, sorghum and maize are the main cultivated food crops. Cotton, groundnuts and some sedentary cattle contribute to cash income. The probability of a failed growing season is 24%.
- The Sudan, including the northern half of Ghana, and parts of Côte-d'Ivoire, Benin and Togo that lie within the basin, receiving between 900 mm and 1100 mm annual rainfall. This is a transition zone with production of both cereals and root crops. Some transhumant cattle are present seasonally. Sedentary cattle are widespread. The probability of a failed growing season is 17%.

- The Guinean zone, covering the southern part of Ghana, receives in excess of 1100 mm annual rainfall. Rainfall distribution becomes increasingly bimodal toward the south. Yam, cassava and plantain are the main food crops. The risk of a failed growing season is only 8%.

Rain-fed crops follow the distribution of rainfall and soil type: from north to south, pasture, millet, sorghum, maize, cotton, cassava, yam, and plantain. Farmers have developed a variety of risk avoidance strategies (*which ones?*) to cope with uncertainties about water availability, but failed crops are still common. The irregular distribution of rainfall in time and space and risk of within-season dry spells influence cropping choices. Farmers use little or no input of fertilizers. Productive assets such as draft animals and man power are limited by frequent diseases.

1.3 Water management

The Volta Basin Authority (VBA) has the mandate to implement international co-operation for the sustainable management of the Volta Basin water resources. VBA is the focus of attention of several funding agencies and acts to transfer identified research and development needs to donors. Priorities for water use are not the same in Burkina Faso and Togo (irrigation) as in Ghana (hydropower). Ghana and Burkina Faso are making attempts to develop IWRM principles for water governance, with the creation of the Water Resources Commission and the White Volta Basin Board in Ghana, and the Nakambe Agency in Burkina Faso. At the national scale the duality between the legal state and the traditional hierarchy impacts everyday life through a number of social determinants such as land tenure and access to water. Basin states have a limited ability to implement and enforce policies and reforms at the local level. Social control is highly fragmented, and policy implementation takes place in the context of multiple foci of power and multiple institutions. Institutional development is therefore key to assist development, which in turn depends on strong political will (Lemoalle, 2008).

Water resources development in the Volta basin requires interventions that bolster resilience and water security. This necessitates much more systematic planning of water storage, greater cooperation between the riparian states and consideration of innovative approaches to water storage, such as managed aquifer recharge. Major water management issues focus on surface water, on the impact of the development of small reservoirs, and on the possible effects of climate change on the operation of the Lake Volta hydropower system and on the livelihoods of more than 70,000 fishers. Variation in rainfall caused by climate change may become important by mid-century. A study by McCartney et al. (2012) ascertains the joint impacts of changes in water demand and supply within the basin. The results indicate that basin-wide average annual rainfall, mean annual runoff and mean groundwater recharge, will all decline by the middle of the twenty-first century, undermining the technical performance of existing and planned reservoirs. The changes are likely to have dire consequences for economic development, food security and poverty in the region. Inter-annual variability will remain the main cause of variation in water inflow to Lake Volta. The Akosombo/Kpong hydropower scheme is already making use of all the water available, with power cuts happening at critical periods. Small reservoirs require careful monitoring to prevent reducing flows into hydro-electric projects but these risks seem modest compared to rainfall variability and the possible effects of climate change[4]. Very strong development of small reservoirs would only decrease the inflow to Lake Volta, and hence hydropower generation, by 3% under the present climatic conditions, but this development may have an impact on the other water demands in the upper sub-basins. Improving water use in rainfed agriculture is more directly related to outcomes at the sub-basin and villages scale but may have some impact at the basin scale, via modification of runoff and evapotranspiration.

Domestic water demand was estimated at 0.156 km^3 / yr in 2005. In the near future the demand for domestic water remains a small fraction of the total resource, even with increased urban populations. The same applies to the watering needs for cattle and livestock, which demands 0.070 km^3 / yr (Clanet and Ogilvie 2009). Large cities in the south, and Ouagadougou, are mainly supplied by surface water. Underground water from boreholes supplies most of the other cities in the north and part of the rural population of the basin. Groundwater resources are poorly understood but appear to be under-exploited. Groundwater recharge is estimated to be 12.6 km^3 / yr or 3.7 % of rainfall. Most boreholes are used for rural domestic supply and give access to good quality water for about 44% of the population. Groundwater use is conservatively estimated at 0.088 km^3 / yr. This corresponds to ca. 0.7 % of average annual recharge and leaves ample opportunities for development (Martin & van de Giesen 2005).

1.4 Gender, Poverty & Institutions

Poverty remains strongly rural and is characterized by low agricultural productivity, limited market access and price variability. Poverty increases from south to north. In Ghana and Burkina Faso and Togo, national surveys show that the incidence of poverty is higher in the drier north than in the wetter south. In Ghana, for example, the proportion of the population below the poverty line is 70% in the rural savannah (north) against 38% in the rural forest (south) (Coulombe and Wodon 2007, cited in Lemoalle & de Condappa, 2010). Recognized causes of poverty are lack of access to potable water, and diarrhea from unsafe domestic water (close to 50% of households use poor-quality water in both in Ghana and Burkina Faso), which have important consequences for health and manpower and have strong economic impacts at both household and basin scales. Other main water-related diseases in the basin are malaria, schistosomiasis (bilharzia), onchocercosis (river blindness), and trypanosomiasis. Malaria occurs throughout the basin, with 100% prevalence in the central part of the basin.

Poverty alleviation is hindered by financial, infrastructure and institutional constraints. In Burkina Faso, 52% of the rural population was considered poor in 2003. Because Burkina Faso is predominantly rural, this accounted for around 92% of the poverty found in the whole country. The incidence of poverty was lower among cash crop (groundnut) farmers (46%) than among subsistence farmers (56%) (Lachaud 1998 cited in Lemoalle & de Condappa, 2010). People are poor because of low agricultural productivity, limited access to markets, unstable prices, and insecure land tenure (Burkina Faso, Ministère de l'économie et du développement 2004 cited in Lemoalle & de Condappa, 2010). Only larger farmers using fertilizer have a food surplus to sell (Ducommun et al. 2005).There are more poor and vulnerable households amongst subsistence

[4]Currently, there is little information on the possible implications of climate change for planned large-scale water resources development in the basin. However, the uncertainty associated with climate change will complicate the management of water resources in the basin (McCartney et al., 2012).

farmers without livestock or draught animals, herders who do not own the cattle under their care and households that are vulnerable to environmental changes or social restrictions (for example, migrants). Subsistence farmers who own poultry or small ruminants are typically better off. Poor families typically lack draught animals and tools such as a plough or a cart so that they can only cultivate as much area as their human work power can manage. Wild rice, fonio (*Digitaria exilis*) and materials for basketry may be very important in some periods of the year for the poorest rural people.

The Ghanaian Water Resources Commission is the organization in charge of coordinating the development and management of water resources at the sub-basin level. The WRC is a joint decision making body, in which each member has a vote and the majority rule applies (Water Resources Commission Act). WRC has been established as a coordinating mechanism for joint decision-making among the different line Ministries and agencies concerned with water resources management, with the participation of a representative of the traditional authorities, a women's representative and an NGO representative. WRC has a far reaching mandate, which includes both planning and regulation. The Water Resources Commission Act gives WRC the mandate to propose plans for the utilization, conservation and development of the water resources, and to initiate, control and coordinate activities connected with the development and utilization of water resources (Birner et al., 2005).

Private sector companies play an important role in water resources development in the region, because they are contracted for the provision of infrastructure and, in case of drinking water supply, also for community capacity building. Unlike public sector agencies and NGOs, private sector companies do not represent public interests. Hence, the WRC at the national level does not include a representative of the private sector. Private sector enterprises operating in the White Volta Basin do not have an umbrella organization. Hence this is a challenge for coordination with this sector.

One challenge in the Upper East Region is the fact that the NGOs do not have an umbrella organization. Another complicating factor in the Upper East Region is the fact that the *tindanas*, rather than the chiefs, are incharge of natural resources – and they do not have a regional representation.

1.5 Farming systems and food production

The distribution of the main crops varies across the agro-climatic regions of the basin, with a successive north–south dominance of millet, sorghum and maize, and cassava, yam and plantain in the south. Maize is better able than sorghum and millet to take advantage of wetter conditions to produce higher yields. In contrast, yields of sorghum and millet do not decrease as much as that of maize in drier areas or in drier years. Over most of Ghana rainfall is sufficient for a satisfactory production of rainfed agriculture. Rainfed production of food and cash crops is largely dominant, but uses only 14% of the total rainfall on the basin. In the two northern regions some small reservoirs and dugouts have been constructed, and in the south near the coast supplemental irrigation from the reservoirs or Lake Volta is available (van de Giesen et al. 2001). Informal urban and peri-urban irrigation, mostly devoted to vegetable production, is rapidly expanding but remains poorly documented. Peri-urban cultivation is the main user of irrigation water in Ghana. With an estimated 45,000 ha it is important in and around the main cities. Urban irrigation is mostly using wastewater, and will increase as urbanization increases in the future.

The overall low production of rainfed crops in the basin is a combination both of a limited use of the arable land and low yields, often less than 1 t/ha for maize. The average cereal productivity was 1.4 t/ha in Ghana for the period 2002–2005, but only 1.0 t/ha in Burkina Faso (World Bank 2007). The yield gap mainly manifests itself in the inability to cope with the dry spells during the rainy season, low crop water-uptake capacity, and poor soil fertility. Water harvesting and soil and water conservation techniques can, to some degree, improve the effective use of rain water by crops, for example by increasing the water-holding capacity of the soil by using mulches and incorporating crop residues. Sedentary farmers often grow trees in conjunction with agricultural crops or livestock. These trees generate short-term income, provide environmental benefits (e.g. erosion control), edible leaves, and fruits for household livelihoods or even for the national economy (e.g. shea nuts). The crop-livestock system covers 80–90% of all livestock keepers. Livestock are often a farmer's largest non-land asset, providing the main cash income to 86% of rural households (IEPC 2007). In Burkina Faso they account for more than half of rural households' wealth (World Bank 2007). The pastoral system contributes 65% of the meat export of Burkina Faso (the third ranked export income of the country) and 585,000 tons of milk. The livestock feed on crop residues and the surrounding rangeland. Sheep and goats are common. Rangeland provides 90% of the fodder for ruminants in the basin. Crop residues and agro-industrial by-products provide the remainder (IEPC 2007 cited in Lemoalle & de Condappa, 2010). Livestock consume only about one third of the range forage. The rest is lost to stalling, termites and normal senescence processes. Sedentary farmers increasingly deny herders access to pasture, crop residues and water.

Meat production from cattle, small ruminants and poultry, and fish catch, especially from Lake Volta, must be taken into account, both for food production and as an important social and economic activity. In Ghana, poorer households tend to engage in household-level poultry production as part of a diversified livelihood strategy. Almost 35 percent of all Ghanaian households engage in small-scale poultry production. Households with more children and women are more likely to keep poultry. The Upper East region supports the highest proportion of households that engage in poultry production (80 percent). Households in this region derive also the highest percentages, 15.4 percent of total annual household income from poultry (Mensah Bonsu et al., 2009).

Lake Volta supports about 70,000 active full-time fishers (Braimah 2003 cited in Lemoalle & de Condappa, 2010), suggesting that around 300,000 people depend on fishing, which contributes over 70% of the income of these communities (Pittaluga et al. 2003 cited in Lemoalle & de Condappa, 2010). Actual production data for the fishery sector have been reported to range between 40,000 and 215,000 tons per year for Lake Volta (Lemoalle & de Condappa, 2010). The value of fish production in the late 90s was estimated at US$30 million to as much as $160 million (Pittaluga et al. 2003 cited in Lemoalle & de Condappa, 2010), with annual revenues ranging from US$420 to US$2,250 per fisher. In the last decades, the numbers of fishermen and fishing boats have steeply increased, and fishing practices have become more intensified

(Ofori-Danson, 2005). The majority of the population living around the reservoirs of Bagré (25,000 ha), and Kompienga (18,000 ha) and the Sourou floodplain (68,000 ha) in Burkina Faso and Mali belong to farming communities for whom fishing is an important secondary activity. About 70% of the households around Bagré diversify their farming activities with seasonal fishing (Béné & Russell, 2007). The fisheries of some 300,000 ha of rivers, ponds, seasonal floodplains and small reservoirs in the basin are estimated to produce about 9000 t/yr for 100,000 people who rely in part on fishing for their livelihoods (Béné & Russell, 2007).

1.6 Markets

Farmers growing cash crops, cotton and groundnut in both Burkina Faso and Ghana, and cocoa, oil palm and coffee in Ghana, are better off than subsistence farmers. The development of cash crops has benefited both the farmers and national income in Ghana and Burkina Faso. In Burkina Faso, a strong political will, with several incentives offered to farmers, including subsidized fertilizer has resulted in a spectacular increase in cotton production. At present, the total sales of food crops in Burkina Faso are estimated to be between US$320 million and US$440 million, two to three times the cotton exports. The development of national cereal markets would alleviate part of the cost of more than 200,000 tons per year of rice and wheat that are currently imported (Ducommun et al. 2005). The import of cereals amounts to about US$80 million. The urgency of the need to develop national food crop markets in Africa is amply demonstrated by the recent world food crisis. In the context of burgeoning urbanization, better organization of national and regional markets would help alleviate rural poverty. An innovative and pro-poor approach to develop national food crop markets requires (Ducommun et al. 2005):

- Credit for equipment, supported by insurance to smaller farms
- Enhanced infrastructures for physical access to local markets
- Development of small agro-industries to transform the local production for national markets in the first place, and for export in the second place
- Organization of the national market with floor prices
- Customs barriers (import tariffs or quotas) to protect local food production from international dumping.

2 Risks and opportunities for change

Global, regional and national drivers of change that can profoundly influence future progress in the Volta Basin include economic growth, population growth, technical change, land degradation, climate change, globalization, urban development, political change and trade liberalization. Main global scenarios identify the risk of an increase in the population whose food needs would not be met by a sufficient increase in local food production. Lemoalle & de Condappa (2010) have estimated that the total basin population will increase from 17.2 million inhabitants in 2000 to 32 million in 2025. The rate of increase in population, currently 2.5 to 3.0% per year (Andah et al. 2004; Owusu et al. 2008) may fall in the future, and a population of 50 to 60 million in 2050 in the basin seems a reasonable figure. Together with this large increase, the ratio of rural to urban populations will change dramatically. The rural population only increases slightly but the urban population will have much increased in 2025, to 16 million instead of 5.8 million in 2000. By 2050 each rural dweller must provide food for almost two urban dwellers. Production will change according to the changes in urban diet and the demand for rice, maize and animal proteins. The demand for livestock will increase strongly. The greater production of food required cannot be achieved only by an increase in the area of cultivation. Large increases in productivity will be necessary as well. Changes in both the nature and quantity of the main staple foods, as well as rangeland productivity, may occur with climate change. Terrasson et al. (2009) showed a steep sensitivity of cereal yields to rainfall change in the range 500 mm to 1000 mm rainfall per year.

Water, agriculture and poverty are linked through land tenure, access to water and access to markets. Economic water scarcity plagues smallholder farmers in the Volta Basin, who mainly rely on low-yield, rainfed agriculture. Half of all rural households depend on low-quality water. The three main causes of water-related poverty in Ghana (Asante & Asenso-Okyere 2003; Asante 2007 cited in Lemoalle & de Condappa, 2010) are low productivity of fishing and agriculture; water insecurity (rainfall variability, poor access, health impacts, loss of labor) and water-related diseases. Water-related diseases are widespread. Malaria and schistosomiasis have effects at the micro (household) and macro (state) scale by reducing labor availability and productivity. Malaria is a principal constraint to development and the main cause of mortality in children under five. At the national level, malaria costs Ghana US$50.1 million in direct and indirect costs (Asante & Asenso-Okyere 2003 cited in Lemoalle & de Condappa, 2010). It is widespread especially in the central basin. Schistosomiasis is directly related with the development of irrigation and small reservoirs, with up to 70% incidence in Burkina Faso. Control of water-related diseases in the basin requires proper management of the water and the environment, changes in social and cultural behaviour, and improvements in health services.

Rainfed agriculture is the activity of the majority of the rural poor and thus the main focus for improvement in food security. The challenge is to improve the use of the available rainwater. Livelihoods are constantly threatened by unreliable precipitation, dry spells, droughts and lack of access to good quality household water. Rainfed cropping becomes increasingly risky as the rainfall decreases from south to north and rural poverty increases. Food production is especially vulnerable due to rainfall variability in the north and central parts of the basin. In this region one possibility would be to increase the number of small reservoirs, and thus develop a complement to the farmers' income by dry-season cultivation. The possibility of cultivating during the dry season would avoid the need for seasonal migration. Scarcity of productive assets and water, not land, limits production. Inter-annual rainfall variability (droughts) and intra-seasonal variability (dry spells), infertile soils, low inputs, poor infrastructure, and low labor productivity lead to low yields. The combination of high evaporation and poor water-holding capacity of the soil is an important limitation.

The main links between rural poverty and institutions in the Volta Basin have been identified as access to credit, to market, to land and to water (Lautze et al., 2006; Opoku-Ankomah et al., 2006). Institutional and policy changes are often critically important to promote adoption of desirable agricultural and water management practices. The institutional and policy context of a country controls the way in which water and food problems unfold, and within which they must be solved. "Institutions" include informal norms and customs as well as more formal organizations and structures. Duality between the legal state and the traditional hierarchy complicates land tenure, hindering investment. In much of the Volta Basin, formal, national institutions coexist with traditional structures of hierarchy. Policy implementation takes place in the context of multiple power foci and multiple institutions (Lautze et al., 2006). Customary land tenure is perceived by community members to be well adapted to local conditions but decisions regarding land tenure and access to land and water made by the traditional authority can reduce security of tenure[5] and actively discourage investment in technologies that improve land and conserve resources (Lautze et al., 2006). Competition between local authorities and formal institutions, and a lack of local legitimacy and poor enforceability of official rules, make resource management prone to conflict and renegotiation. This, for example, compromised the efficiency, sustainability and equity in the allocation of land in irrigated schemes in Ghana, as well as the prospects for the implementation of water reform (Laube, 2005).

Governments have improved infrastructure to help farmers who produce cash crops because of their importance for export earnings, which has led to improved quantity and quality of cotton (World Bank 2007) and cocoa. If similar policies were implemented for food crops, increased production would improve livelihoods and could help avoid food crises. Gains in yields and water productivity of rainfed agriculture offer the main prospect for the food self-sufficiency of the basin in the future (Rockström & Barron, 2007). Many small farmers in the drought-prone areas of the basin consider access to dry season irrigation important to alleviate their vulnerability and poverty and to increase food production (Ducommun et al., 2005). Drilling of tube wells and introduction of drip irrigation could lead to significant improvement in water availability and productivity, and hence the livelihoods of thousands of farmers in northern Ghana (Barry et al., 2010). Additional investment in the water sector, especially for small-scale irrigation and dry-season crops, could play a transformative role in poverty alleviation (WRI 2007). According to de Condappa et al. (2009) a 10% growth per year in water demand from small reservoirs could lead to additional irrigated areas of about 110,000 ha in 20 years in the upstream part of the basin, which would result in a significant improvement of livelihood of small farmers in Burkina Faso versus a slight but probably noteworthy negative effect on hydropower downstream of the basin. It is foreseen that the Bagre hydropower scheme in Burkina Faso would be affected by further development of small reservoirs upstream.

Field observations in the Sahel and farm trials in northern Ghana have indicated the high potential of fertilizer use (Bationo et al., 2008), but smallholder farmers are often unwilling to use fertilizer technologies because of risk avoidance, insecurity of land tenure, and lack of access to credit and to markets. Credit, subsidized fertilizers and land tenure may help towards a more sustainable agriculture in the central plateau of Burkina Faso (Ouédraogo, 2005 cited in Lemoalle & de Condappa, 2010).

Livestock production is limited by access to water and prophylaxis for endemic diseases (anthrax, brucellosis), and parasites. Water productivity of cattle systems could increase by

[5] In Ghana, for example, the Traditional Councils were the land-granting authorities in large-scale land acquisitions for two large-scale plantations in Yendi Municipality, Northern Region and Kobre, Brong-Ahafo Region. In the latter case displaced farmers were not compensated, and most farmers claimed that they have been pushed to degraded lands and their farm incomes have significantly declined (Kizito, Williams, McCartney & Erkossa, 2012)

complementary browse from trees and shrubs that use water from deeper in the soil profile, and hence stay green longer into the dry season. Proper veterinary services would greatly increase the livestock productivity (Clanet & Ogilvie, 2009). Terrasson et al. (2009) indicate that millet has an important role in mixed crop animal systems. Millet can provide large amounts of vegetative material for animal feed, which will increase total water productivity. Moreover, it would provide an important hedge against risk for smallholder producers, particularly in drier areas in the north of the basin.

3 Public and private agricultural investment

3.1 NEPAD and the private sector

The New Partnership for Africa's Development (NEPAD) emphasizes the key role of the private sector in contributing to Africa's economic growth. Private sector participation in NEPAD programs has nevertheless been rather limited, due to weak organization as well as limited awareness of and institutional ability to benefit from opportunities in NEPAD programs. Regional and sub-regional private sector associations are especially relevant in Africa, given the large numbers of small and medium enterprises (SMEs) and weak development of the private sector, which require effective umbrella organizations to provide support and guidance. Most associations however do not have deliberate policies, or activities to promote NEPAD projects among their members, and they lack technical and administrative competencies to engage in the NEPAD initiative. Private sector associations are statutorily non-profit making organizations and non- investors, which are financially fragile and unable to facilitate access their members to multilateral finances and bilateral donor funds. Private sector associations have also limited ability to promote joint venture agreements with governments and PPPs in NEPAD projects (Kim, 2008).

At the root of the implementation problems of NEPAD are some major constraints, such as inadequate coordination among relevant stakeholders, related to a lack of institutional linkages, preventing Associations from effectively helping their members to exploit NEPAD-related opportunities. There is a need for institutional consolidation and strengthening of the associations' capacity to broker strategic partnerships of all stakeholders and facilitate PPPs and to secure requisite funding. It is essential to identify capacity gaps in the private sector associations. Capacity building should aim at building skills in the associations on project preparation, packaging, marketing and securing funding. African governments should also eliminate or reduce legal and institutional constraints hampering private sector participation in NEPAD projects (Kim, 2008).

3.2 CAADP

NEPAD's Comprehensive Africa Agriculture Development Programme (CAADP) is a commitment of African governments to pursue economic growth through agriculture-led development, and reduce poverty and hunger on the continent (Kolavalli et al., 2010). CAADP participants have pledged to spend 10 percent of their public resources on their respective nations' agriculture, with the goal of an annual agricultural growth rate of 6 percent, in order to achieve food security and remove hindrances to private sector participation in agriculture. A study across 10 African countries, amongst which Ghana, shows that most of these countries have huge potential to increase agricultural growth and poverty reduction by closing yield gaps and enhancing land-use efficiency, but realizing these goals will require substantial increases in agricultural investment. Public institutions need to be reformed to improve the provision and delivery of agricultural public goods and services. Faster non-agricultural growth and urban development are also necessary to achieve the first Millennium Development Goal of cutting the poverty rate in half. The agricultural sector's potential to produce benefits other than poverty reduction is an important topic for future study (Diao et al., 2013).

3.2.1 Burkina Faso

Public investment into the agriculture sector in Burkina Faso is for more than 75% coming from development aid, of which close to 20% is awarded in the form of budget help. This provides an opportunity and constraint at the same time because of its unpredictability in the planning budget and the diverse Donor procedures needed for implementation. This translates in weak uptake of development aid directly linked with weak national planning and budget planning capacities, as well as weak monitoring and evaluation. Agriculture is dominated by low yield smallholder agriculture on family plots of 3 to 6 ha. Irrigation occupies only 0.6% of cultivated land and 14% of irrigable land in the country. Improvement of rainfed agriculture through supplemental (drip / precision) irrigation is an important component of Burkinabe agriculture. Irrigation promotion in Burkina Faso aims to:

- Rehabilitate 5,000 ha of large and medium irrigation schemes; develop 17,000 ha of new large schemes and 3,000 ha new medium schemes
- For small-scale irrigation develop 15,000 ha of village irrigation schemes and 15,000 individual smallholder irrigation schemes
- Develop 5,000 ha of irrigated rice schemes; validate the intensification and diversification of winter rice culture; strengthen socio-economic capabilities of farmer organizations

Burkina Faso's integrated water resources management program aims to:

- Create an enabling environment for basin agencies;
- Put in place a suitable water information system;
- Define practical procedures and modalities for implementing water laws and regulations;
- Ensure water- and water resources research and development;
- Capacity development in water- and water resources management;
- Inform, educate and raise awareness about integrated water resources management amongst actors;
- Put in place an appropriate institutional framework;
- Take urgent measures to find alternative surface water resources, the protection of fragile aquatic ecosystems and river banks, and for the restoration of water bodies affected by the proliferation of aquatic plants

The sustainable land management and climate change adaptation program aims to:

- Increase agricultural, pastoral and forest production through improved productivity;
- Ensure better protection and valuation of ecosystem goods and services;
- Increase revenues by diversifying and intensifying rural economic activities;
- Strengthen organizational capacities and public awareness in environmental management and its resources;
- Enhance coherent action between different actors in the rural space.

The overall objective of the sustainable agriculture development program is to restore, improve and maintain soil fertility in order to ensure sustainable agro-silvo-pastoral production. This program promotes large scale production and utilization of organic manure, with 30,000 additional ha / yr fertilized from 150,000 pits constructed per year. It also promotes the transformation of agro-industrial and urban waste in organic manure to satisfy the needs of peri-urban agriculture. The program aims to achieve 600,000 ha of agricultural area using mineral fertilizer by 2015.

3.2.2 Ghana

Agriculture remains the most important sector for employment in Ghana. Its growth is not driven by productivity growth. Yields of most crops are still far below their potentials. The level of modern technology adoption in agricultural production and processing is still extremely low. Agriculture remains highly dependent on rainfall. The potential for land expansion has been reaching its limits in some agro-ecological zones, urging a rapid shift toward productivity-led growth to transform traditional agriculture. Policies and public spending decisions that encourage private investment in farm capital will be very important. For example, Ghana's unsuccessful experience with public irrigation provides a strong argument for the country to encourage private sector investment rather than continuing to spend public funds on poorly operated and maintained public irrigation schemes (Namara et al. 2011). Policies and public spending that help improve use and efficiency of agricultural inputs will also be critical for raising overall agricultural productivity, reducing total resource requirements and both public and private contributions (Breisinger et al., 2012).

Breisinger et al. (2012) simulate a business-as-usual situation of economic development assuming that the Ghanaian economy will continue to grow along recent trends until 2015 vs. an accelerated growth path associated with an increase in agricultural productivity, in which crops and livestock production are the driving forces for growth to attain achievable yields nationwide by 2015. A single agricultural-growth strategy at the national level, however, is generally insufficient to decrease regional inequalities and reduce poverty in lagging regions significantly. Heterogeneous natural and economic environments necessitate regionally differentiated agricultural strategies. In Ghana for example, the Northern Savannah zone produces more than 34 percent of the country's cereals and about 40 percent of its livestock but contributes only 10 percent to agricultural exports. With its long-term trend of land degradation, achieving a 30 percent increase in maize yields in this zone may be a challenge. Poverty remains high in the Northern Savannah zone. More targeted measures will be needed to reduce poverty in this region.

CAADP implementation in Ghana is investment-oriented in the sense that it is expected to generate additional investments in the agricultural sector. The assumption is that appropriate investment opportunities will generate demand for investments from private sector and other stakeholders, donors in particular. Building state capacity and facilitating private-sector development become critical issues in enhancing expenditure effectiveness. A number of factors might account for the low share of public expenditures and investments in the sector. Some of these factors include weak leadership, lack of technical capacity and absence of business culture in agricultural ministries, problems with budgetary processes, and weak M&E systems (Headey, Benson, Kolavalli & Fan, 2009). CAADP implementation in Ghana however appears to pay marginal attention to institutional and governance issues, and is not likely to have contributed to greater alignment in terms of donors' supporting the government's agenda (Kolavalli et al., 2010).

Foreign direct investment in biofuel and food crop production may lead to positive economic, social and environmental benefits for stakeholders in marginal lands. For example intercropping Jatropha with compatible annual crops under rainfed conditions appears to be a feasible option to enhance economic and food security benefits. A study by Kizito et al. (2012) indicates that large-scale biofuel plantations on marginal lands can provide a positive ecosystem buffer to reduce runoff and pollution of water bodies, and can help in the reclamation and restoration of marginal lands through reduced soil erosion. The displacement of poor usufruct land users, required to create the large-scale farms needed to achieve economies of scale, could be compensated by the creation of contract farming opportunities and fair wage employment for displaced farmers and other rural dwellers in production and agro-processing. Positive livelihood outcomes may also arise where irrigation infrastructure benefits not only the plantations but nearby farmers as well (Kizito et al. 2012).

The Food and Agriculture Sector Development Policy (FASDEP II) outlines the Government of Ghana's vision for the agriculture sector. Agricultural GDP growth is targeted at least at 6% per annum, in line with CAADP targets. By closing the existing yield gaps and achieving comparable productivity growth in the livestock sector, Ghana may be able to reach its average annual agricultural growth as envisioned. The sector policy orientation is guided, amongst other things, by the value chain concept and promotion of public-private partnerships. Targets for productivity improvement foresee improved technologies adopted by smallholder farmers and yields of maize, rice, sorghum, cassava and yam increased by 50% and cowpea by 25% by 2015. Yield gaps for various commodities currently average around 50% of achievable yields; e.g. cassava at 12.4mt/ha against potential of 28.0 mt/ha. Post-harvest losses along the maize, rice, sorghum, cassava and yam value chains should be reduced by 30%, 35%, 20%, 40% and 50% respectively by 2015.

Incomes will be enhanced through diversification. Activities involving a range of commodities including cash crops, livestock, indigenous commodities and value addition would be promoted through the value chain approach and application of science and technology to improve productivity. This would include the development of rural infrastructure and support to urban and peri-urban agriculture. The current escalation in food market prices presents an opportunity for a higher level of commercialization by smallholders.

Objectives for irrigation and water management include the development of 150 micro and 25 small scale irrigation schemes as well as agricultural water management schemes, benefiting 50,000 households in all regions of the country by 2015. The production and value of output of existing large scale irrigation schemes is targeted to have increased by 30% to 50% respectively by 2015. Feasibility studies for large scale irrigation projects in Accra Plains, Afram Plains and northern savannah irrigation areas should have been completed and funds for implementation sourced by 2012. Irrigated agriculture would be made viable by backward linkages to infrastructure, inputs and research and forward linkages to agro-processing and marketing.

3.3 Possible avenues for WLE activities in the Volta Basin

The Volta Basin has been earmarked as the first WLE 'flagship' regional focus where the CRP can demonstrate the benefits of integrating different activities from the program across scales. This approach encourages interactions between SRPs. The current WLE 2013 activity plan, for the Volta and Niger basins together, consists of activities contributed by individual Centers and CPWF, which is the largest single contributor to our activities in the Volta. CPWF activities, in the Volta only, constitute ca. USD 1.3 million, and may lay the basis for a consolidated effort focusing on an integrated research for development approach in the basin.

Governments have improved infrastructure to help farmers who produce cash crops because of their importance for export earnings. Similar policies, if implemented for food crops, would improve livelihoods and could help avoid food crises. There is an urgent need to develop national food crop markets. Diao et al. (2013) conclude that producing more staple crops such as maize, pulses, and roots and more livestock products tends to have a greater poverty reducing effect than producing more export crops such as coffee or cut flowers. According to Rockström & Barron (2007) gains in yields and water productivity of rainfed agriculture offer the main prospect for the food self-sufficiency in the Volta basin in the future.

A consolidated WLE plan of action in the Volta could focus on improving dry season irrigation in the central part of the basin, through making better use of shallow groundwater irrigation where groundwater is underutilized and improved management of rainwater and small reservoirs. Irrigation, rainfed and basin SRPs would interact directly, with the basin SRP focusing on mitigating potential negative effects of small reservoir development on hydropower schemes downstream, and on accounting for groundwater withdrawal and recharge. The ongoing RiU project on 'Enhancing uptake and socio-economic benefits of shallow groundwater irrigation in the White Volta Basin' should be directly engaged in this effort.

WLE could help develop food- and cash crop value chains by promoting public-private partnerships or private sector development, working with boundary partners such as iDE connecting small-scale farmers to input- and output markets. As peri-urban agriculture is bound to increase with urbanization, WLE should strategically engage in this area. WLE is well-positioned to do so as it offers expertise in peri-urban irrigation and recovery and reuse of wastewater and nutrients from agro-industrial and urban waste. The irrigation SRP and Resource Recovery and Re-use (RRR) SRP would interact in this activity. RRR would also take a leading role in the development of viable business models for peri-urban agriculture and the development of related value chains.

The immediate objective of WLE in the Volta basin, focusing on the central part of the basin, could be improving food security and reducing poverty through diversified and increased production from agro-silvo-pastoral systems. Reversing progressive land degradation, improved ecosystem services and better water productivity through dry season irrigation from small reservoirs and shallow groundwater would be development outcomes contributing directly to this objective. The rainfed SRP and the Ecosystem Services & Resilience (ESS&R) working group would lead this initiative and the irrigation SRP, possibly with inputs from RRR, would contribute. ESS&R would characterize, quantify and value the bundles of ecosystem services provided by small reservoir-fed agro-ecosystems and together with the Information Systems SRP provide decision support for plausible land management interventions around these reservoirs that minimize resource degradation and enhance resilience.

The longer term objective would be to improve agricultural value chains and help develop an institutional and policy environment that supports future food production for a much increased urban population in 2025, taking into account the projected changes in urban diet and demand for rice, maize and animal proteins. This would come accompanied by rapid increases in energy demand. The irrigation SRP, particularly the activity cluster on peri-urban irrigation, the RRR SRP and the Basin SRP, activity cluster on Water and Energy for Food (WE4FOOD) would contribute to this objective. The Decision Analysis activity cluster of the Information Systems SRP would provide forecasting and decision support, which does play an important role in this scenario.

Attention should be paid to the control of water-related diseases in the basin, directly related with the development of irrigation and small reservoirs. This requires conjunctive management of the water and the environment. This could be partially achieved directly through harnessing aquatic ecosystem services (for example biological control of mosquito larvae by natural predators), possibly in collaboration with the AAS CRP, by improving the water quality for various uses, as well as indirectly by improving ecosystem services in landscapes around the reservoirs. Growing trees in conjunction with agricultural crops or livestock can generate short-term income and provide environmental benefits. Trees and shrubs that use water from deeper in the soil profile stay green longer into the dry season, which increases the water productivity of livestock systems (Lemoalle & de Condappa, 2010). This effort, potentially led by the ESS&R working group with contribution of the RRR SRP in areas of water quality and safe reuse of nutrients should be accompanied by proper sanitary measures in order to decrease the prevalence of water-borne diseases affecting humans and livestock.

A CRP Results Strategy Framework for the Volta Basin

CGIAR SLOs

Goal 1: Improved food security and livelihoods through sustainable agriculture intensification and resource recovery and reuse

Goal 2: Reduced inequities among users of ecosystem services

Goal 3: Enhanced sustainability of natural resources

WLE Impact Pathway 1

Direct Benefit IDO: **Expanded area with improved practices in irrigated and rainfed agriculture within diversified systems reverse degradation and increase productivity, yields, ecosystem services, resilience and incomes**

Immediate Outcomes

- Improved smallholder access to and utilization of irrigation and enhanced skills in soil, nutrient, water, and crop management.
- Improved agricultural value chains that provide inputs, services and output market access for smallholder farmers

WLE Impact Pathway 2

Enabling Environment IDO: **Strengthened institutional arrangements (policies, regulations, institutional collaboration) that support sustainable agriculture intensification**

Immediate Outcomes

Regional bodies, governments and/or development partners improve investments, plans and policies in:

- Incentives for sustainable agricultural intensification and management of ecosystem services
- Water, food security, and energy development by integrating trade- offs (i.e. for the poor and the environment) into decision-making.
- Benefit and risk sharing among ecosystem users

WLE Impact Pathway 3

Business IDO: **Value from waste captured in rural-urban/sanitation-agriculture interface through increased resource recovery and reuse and through reduced costs in waste management**

Immediate Outcomes

- Increased recovery and safe re-use of water, nutrients and energy from wastewater and excreta through improved knowledge and business opportunities among business schools, donors and the private/public sector recovery from waste

WLE Outputs

1. Assessments of the state of the system and scenarios:
    a. Identification of key hotspots for loss of ecosystem services, spatial variability in soil fertility and land degradation, and variability in water resources in time and space.
    b. Assessment of natural and built water storage infrastructure and groundwater availability in large aquifers at basin scale and establishment of ecological thresholds for groundwater use.
    c. Trends, causes, and socially-differentiated impacts (in particular, on the poor and on women) of current and projected land and water resource usage on food production, nutrition, livelihood security, and ecosystem services, including national or basin-level implications of various development scenarios.
    d. Health and environmental risk assessment of resource recovery and reuse and options for risk mitigation.
2. Catalysing the Potential:
    a. Recommended practices, management interventions, technologies, business models, and institutional/governance arrangements to support sustainable intensification of agriculture at scale, inclusive of pathways to mitigate land degradation, potential for irrigation; demonstration of technical performance of underground water storage and use solutions and wetlands; factors affecting farmers' choices; policy and institutional analysis at multiple scales; enhanced understanding of how to capitalize on benefits of floods and droughts while mitigating their negative consequences. Potential for catalysing these recommendations, including enabling factors and incentive systems (including economic incentives) that support sustainable land management.
    b. Design of resource recovery and reuse options for risk mitigation of health and environmental risks.
    c. New methods of agricultural and natural resources information delivery and data collection to /from farmers and communities (e.g. mobile technology).
3. Documentation:
    a. Documented investment opportunities for decision makers, investors (e.g. economics of land degradation), NGOs, etc. to catalyse recommended practices, technologies, business models, management interventions, and institutional/governance arrangements for sustainable intensification of agriculture at scale that enhance ecosystem services and positively benefit the poor and marginalized. Includes business models for resource recovery and reuse, and investment plans to enable replication of business models across the Volta,
    b. Decision support tools for decision makers to assess synergies and trade-offs of above development investments.
    c. Resource recovery and reuse guidelines on safety options and regulations drafted for Ghana.
    d. Catalogues of promising resource recovery and reuse business cases and models for nutrient, water and energy.
    e. Improved input data provided to basin scale hydro-economic models.
4. Capacity Building
    a. National scientists, universities and development organizations trained in measurement systems to support intervention decisions.
    b. Capacity building requirements to plan, manage and maintain local irrigation.
5. Tools, Methods and Frameworks:
    a. Tools to assess and analyse trade-offs of technologies, policies, institutions and investments in relation to landscape integrity, biodiversity, and ecosystem services to increase benefits for enhanced water, food and environmental outcomes.
    b. Tools for ecosystem services monitoring in landscapes.
    c. Methods for participatory landscape and environmental planning.
    d. Tools and approaches for managing floods and droughts conjunctively in a river basin.
    e. Improved availability of various water data, methods and protocols describing surface and ground water resources and processes.
    f. Improved availability of various soil data, methods and protocols, describing major soil constraints and their spatial variability.
    g. Contribute to global soil and water resources monitoring metrics.
    h. Protocol for soil health monitoring in the World Bank Living Standards Measurement Study
6. Engagement: Engagement with actors at various scales (national, regional and international conventions, campaigns, meetings, innovation platforms to jointly develop pathways towards sustainable agricultural intensification. Volta Basin Authority; RUAF; relevant water management committees; Hydropower companies etc.

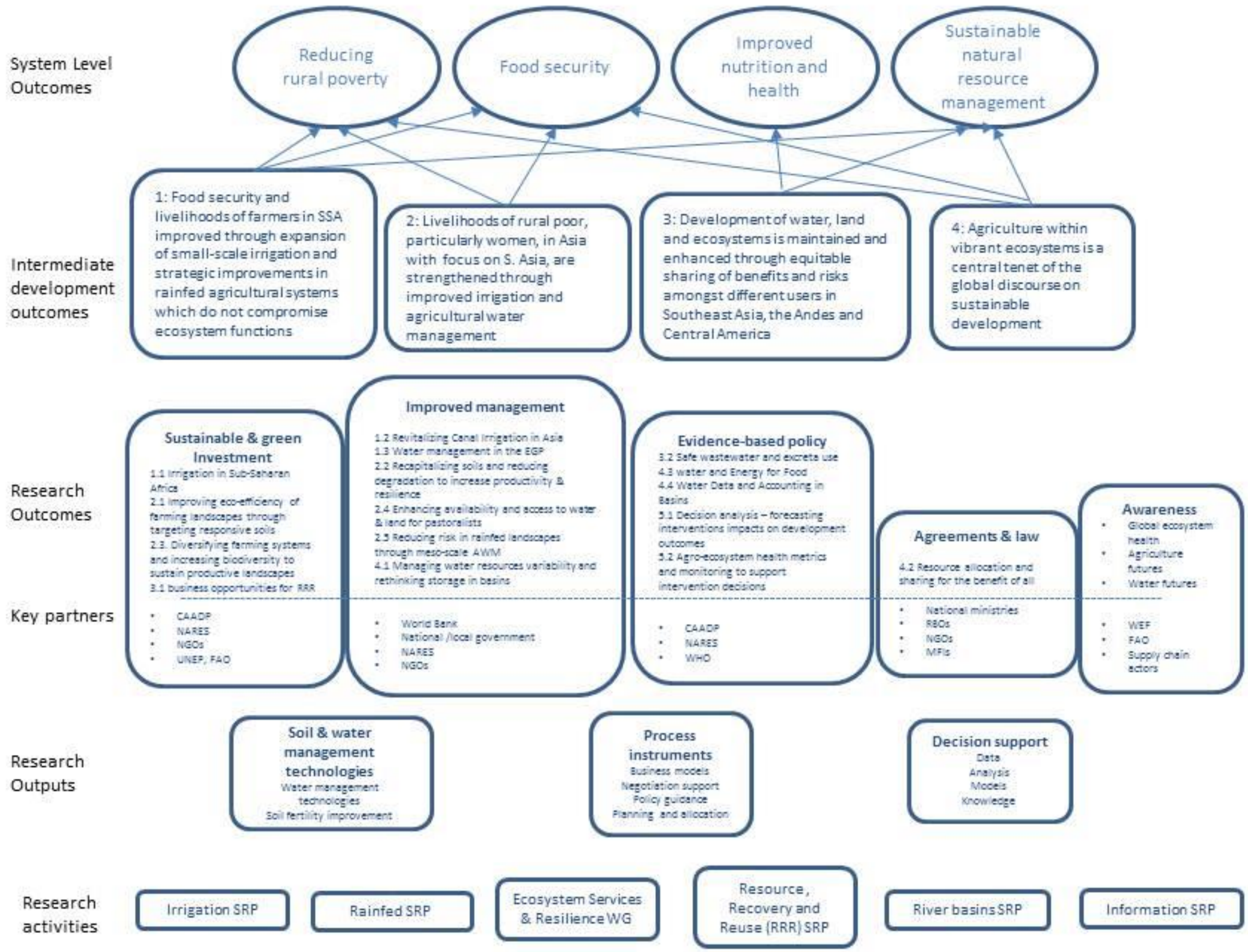
Narrative

Our WLE impact pathways in the Volta aim to lay the foundation for our longer term engagement in the basin and capitalize on the opportunities and challenges that present themselves within a highly likely future scenario, but we will explore alternative scenarios too. Together with a forecasted significant increase in population, the ratio of rural to urban populations in the basin has been forecasted to change dramatically from 2.3 now to 0.5 in 2050, so that by 2050 each rural dweller must provide food for almost two urban dwellers. Informal urban and peri-urban irrigation, mostly devoted to vegetable production, is rapidly expanding. Production will change according to the changes in urban diets and the demand for rice, maize and animal proteins. The transformation of agro-industrial and urban waste into organic manure to satisfy the needs of peri-urban agriculture is currently being pursued by Burkina Faso's sustainable agriculture development program. In Ghana activities involving a range of commodities including cash crops, livestock, indigenous commodities and value addition are being promoted through the value chain approach. This includes the development of rural infrastructure and support to urban and peri-urban agriculture. The current escalation in food market prices presents an opportunity for a higher level of commercialization by smallholders within the context of eco-efficient agricultural production systems.

WLE Impact Pathway 1 responds to the direct benefit of improved practices in irrigated and rainfed agriculture in the basin that delivers increased ecosystem services and enhances resilience in these systems. WLE encompasses a broad and integrated view of food security. Long-term food security requires sustainable land and water management as well as increased incomes. Rainfed agriculture is the activity of the majority of the poor rural population and reducing risk and dependency on rainfed agriculture at a landscape level will be the main focus for our contribution to the SLOs of improved food security, reduced rural poverty and sustainable management of natural resources. Food production is especially vulnerable to rainfall variability in the north and central parts of the basin. We will work through relevant boundary partners on improving dry season irrigation in the central part of the basin, through making better use of shallow groundwater irrigation where groundwater is underutilized and through improved management of rainwater and small reservoirs. We will aim to establish public-private partnerships as a key prerequisite for improved agricultural value chains that provide inputs, services and output market access for smallholder farmers.

WLE Impact Pathway 2 contributes to the SLO of reduced rural poverty. Governments in the basin have improved infrastructure to assist farmers who produce cash crops because of their importance for export earning. Most of these investments however are not accompanied by incentives, capacity building and support for sustainable production. If we can encourage governments to integrate support for sustainable agricultural production, implementing similar policies for food crops could help increased production to avoid food crises. Institutional and policy changes are critically important to promote adoption of desirable agricultural and water management practices. The main links between rural poverty and institutions in the Volta Basin have been identified as access to credit, to markets, to land and to water. WLE Impact pathway 2 will create the enabling environment for improved investment plans and policies that support sustainable agriculture intensification. We will bring together relevant partners from government, NGOs, private sector and micro finance institutions to provide innovative financial products and services that stimulate development of small agro-industries to transform the local production for national markets and for export. Such products and services could include credit for equipment, supported by flood- and drought insurance to smaller farms. We will align our efforts with Governments' agriculture investment plans established under CAADP, and add value by focusing on ecosystem services upfront, as a prerequisite for sustainable agricultural intensification.

WLE Impact pathway 3 will identify business opportunities to pursue increased recovery and safe re-use of water, nutrients and energy from wastewater and excreta, in collaboration with relevant partners in the public and private sectors. This impact pathway links to our direct benefit pathway and contributes particularly to the SLO on sustainable management of natural resources, but also to the SLO on improved nutrition and health. Recognized causes of poverty in the basin are related to the lack of access to potable water, and diarrhea from unsafe domestic water (close to 50% of households use poor-quality water in both in Ghana and Burkina Faso), which have important consequences for health and manpower and have strong economic impacts at both household and basin scales. Through impact pathway 3 we will pursue improved quality of domestic water, and opportunities to turn waste captured in the rural-urban/sanitation-agriculture interface into valuable re-usable resources such as fertilizer and mulch to improve soil conditions in degraded agricultural landscapes.


System Level Outcomes
Reducing rural poverty
Food security
Improved nutrition and health
Sustainable natural resource management
Intermediate development outcomes
1: Food security and livelihoods of farmers in SSA improved through expansion of small-scale irrigation and strategic improvements in rainfed agricultural systems which do not compromise ecosystem functions
2: Livelihoods of rural poor, particularly women, in Asia with focus on S. Asia, are strengthened through improved irrigation and agricultural water management
3: Development of water, land and ecosystems is maintained and enhanced through equitable sharing of benefits and risks amongst different users in Southeast Asia, the Andes and Central America
4: Agriculture within vibrant ecosystems is a central tenet of the global discourse on sustainable development
Research Outcomes
Key partners
Sustainable & green Investment
1.1 Irrigation in Sub-Saharan Africa
2.1 Improving eco-efficiency of farming landscapes through targeting responsive soils
2.3. Diversifying farming systems and increasing biodiversity to sustain productive landscapes
3.1 business opportunities for RRR
CAADP
NARES
NGOs
UNEP, FAO
Improved management
1.2 Revitalizing Canal Irrigation in Asia
1.3 Water management in the EGP
2.2 Recapitalizing soils and reducing degradation to increase productivity & resilience
2.4 Enhancing availability and access to water & land for pastoralists
2.5 Reducing risk in rainfed landscapes through meso-scale AWM
4.1 Managing water resources variability and rethinking storage in basins
World Bank
National /local government
NARES
NGOs
Evidence-based policy
3.2 Safe wastewater and excreta use
4.3 water and Energy for Food
4.4 Water Data and Accounting in Basins
5.1 Decision analysis – forecasting interventions impacts on development outcomes
5.2 Agro-ecosystem health metrics and monitoring to support intervention decisions
CAADP
NARES
WHO
Agreements & law
4.2 Resource allocation and sharing for the benefit of all
National ministries
RBOs
NGOs
MFIs
Awareness
Global ecosystem health
Agriculture futures
Water futures
WEF
FAO
Supply chain actors
Research Outputs
Soil & water management technologies
Water management technologies
Soil fertility improvement
Process instruments
Business models
Negotiation support
Policy guidance
Planning and allocation
Decision support
Data
Analysis
Models
Knowledge
Research activities
Irrigation SRP
Rainfed SRP
Ecosystem Services & Resilience WG
Resource, Recovery and Reuse (RRR) SRP
River basins SRP
Information SRP

Stakeholders & partners

The engagement of WLE in the Volta Basin would start with a 'design' workshop in which a limited group of key experts with thorough knowledge and insights into the key development challenges that the region faces. This could be followed by wider stakeholder consultation at the start of the project and (re-) establishment of partnerships including and building on successful partnerships already in existence through current and past engagement of CPWF and Centers with regional presence, contributing to WLE.

A tentative list of potential and existing partners includes:

- EcoAgriculture Partners
- Natural Capital
- SRC
- FAO (possibly Mr. Moïse Sonou, Senior Water Development Officer of the FAO Regional Office for Africa)
- iDE
- CIRAD
- CIDA - CIDA is the most active donor in northern Ghana's drinking water sector and acts as forerunner in institutional development (Eguavoen, 2008).
- Environmental Protection Agency (EPA), Ghana
- WASCAL (West African Science Service Center on Climate Change and Adapted Land Use)- Large-scale research-focused program designed to help tackle the challenge of climate change and thereby enhance the resilience of human and environmental systems to climate change and increased variability. https://icg4wascal.icg.kfa-juelich.de/ WASCAL is coordinated by the Center for Development Research (ZEF, Bonn University). Barry Boubacar (IWMI) is seconded to WASCAL.
- Ghanaian Water Resources Commission (WRC)

Links to other sources

http://www.terrafrica.org/

http://www.gis4ghagric.net/data.html

http://www.wfp.org/food-security/assessments/comprehensive-food-security-vulnerability-analysis

Opportunities

Irrigation development (Thor Windham-Wright, 21 March 2013)

- Government will continue the rehabilitation, complete outstanding works on existing schemes dams/dugouts. This will facilitate the promotion of dry season farming of vegetables and high value crops.
- Facilitate the commencement of the Accra Plains Irrigation Project, covering 11,000ha

Pilot irrigation projects using groundwater carried out in the Accra Plain by the Water Resources Research Institute realized high yields (WOR140).

- The Vea Scheme will also undergo rehabilitation
- Mprumen dam will be constructed
- Rehabilitation of ten (10) dams in the Volta and Greater Accra Regions will begin in 2013.
- Construction of 3 dams in Koori, Zuedem and Tankasa in the Builsa district of the Upper East region will commerce in 2013

Agriculture

- Government will finance the construction and mechanization of 500 boreholes on farmer's fields for irrigation, animal watering and agro-processing.

Yields from boreholes are variable because of the lithological variation and structural complexities of the rocks, but are generally low, with few boreholes yielding more than 168 m^3d^{-1} and most in the range of 24-72 m^3d^{-1}. The total irrigation potential from boreholes and hand-dug wells is estimated to be over 200,000 ha (Obuobie and Barry forthcoming)

- In addition, 200 geophysical investigations will be conducted on farmers' fields.
- Promote solar intervention to lift water for small-scale irrigation
- Promote the use of agric. by products for bio-fuel

4 The Challenge Program on Water and Food (CPWF) in the Volta

CPWF research in the Volta focuses on:

1. Rainwater Management
2. Small Reservoirs Management
3. Landscape analysis & management

1. Rainwater Management

1.1. Technical options
- New and improved rainwater harvesting technologies
- Improved technologies on crop water use
- Improved soil water management
- Improved soil fertility

1.2. Socio-economic options
- Labor saving in RWH/M systems
- Improve market and value chain

1.3. Financial options
- Increase availability of credit (for water harvesting) for small-scale farmers
- Develop micro and macro finance schemes for farmers

1.4. Minimize environmental and health impact
- Low cost method to determine soil health

2. Small Reservoirs Management

2.1. Multiple uses of Small Reservoirs (SR)
- Strategies for other water users in and around SR (Fish and Livestock strategies in SR – technology transfer from large reservoirs to SR; Enhancing crop-livestock integration around SR)
- Enhanced opportunities for food production in SR (Enhance nutritive food production)
- Rational use of water for crop, livestock & fisheries - Increased water productivity
- Valuation of direct and indirect water related benefits (including valuation of social and ecosystem services and the multi-functionality of water); Comparative advantages of different water values

2.2. Infrastructure design

2.3. Tools for water quality management

2.4. Institutions and governance
- Clarifying ownership and management
- Conflict resolution to enhance use and management of SR (e.g. Companion modeling)
- Consider/enhance social and human capital

2.5. Small reservoirs systems
- Management of water in and around reservoirs (land use, grazing, etc.)
- Improving sustainability of SR in the context of the catchment and river basin
- Management of reservoirs ensemble: cumulative impact of water use

3. Landscape analysis & management

3.1. Management of reservoirs ensemble: cumulative impact of water use
3.2. Minimize environmental and health impact

3.3. Land and water interface
- Land degradation, erosion
- Reservoir siltation

3.4. Promotion to increase catchment/basin water storage
- Develop and promote storage options and systems

3.5. Adaptation of Agricultural Water Management - Technologies already available

3.6. Improving the impact of climate predictions (evaluate impact, mode of dissemination)

Phase 1 projects in the Volta (Annex 1)

PN 5 Enhancing rainwater and nutrient use efficiency for improved crop productivity, farm income and rural livelihoods in the Volta Basin

- Key objective: Promoting best bet technologies (water & soil conservation; integrated nutrient management; improving market opportunities, building capacity of farmers &

communities (partnership development & capacity building), promoting technologies for scaling up and out, improving farmer income & livelihoods.

- Key achievements: Volta Book *Synthesis of soil, water and nutrient management research in the Volta Basin* http://waterandfood.org/2011/10/21/rainwater-nutrient-use-efficiency/

PN 6 Empowering farming communities in Northern Ghana with strategic innovations and productive resources in dryland farming

- Key objective: Improved farm-level yield of staple crops while maintaining fertility of soils; Create opportunities for off-farm income generation during the dry seasons.
- Key achievements: Improved soil and water conservation, and fertiliser application in semiarid regions; Improved crop production from early maturing cowpea varieties, advanced breeding sorghum and crop rotation with maize; Increased production of fish (Tilapia) from existing dugouts through better management http://waterandfood.org/2011/10/21/strategic-innovations-in-dryland-farming/

PN 34 Improved fisheries in tropical reservoirs.

- Key objective: increase the productivity of reservoir fisheries and provide sustainable livelihoods to the rural poor through fisheries enhancement in tropical reservoirs; better understanding about the overall human contexts of those reservoirs; identify socio-institutional obstacles to the adoption of innovations for increased fishery productivity; improving stakeholders' management skills and fostering their institutional capacities

- Key achievements: technical feasibility of the cage culture system demonstrated, need for adaptive management highlighted; potential social tensions in fishing communities where *acadjas* (brush parks) are introduced indicate that *acadjas* are not pro-poor, or not even poor-neutral; development of low-cost post-harvest technologies that reduce fish post-harvest losses and have positive impacts on food quality and market externalities. http://waterandfood.org/2011/10/21/improved-fisheries-in-tropical-reservoirs/

PN 38 Safeguarding Public Health Concerns, Livelihoods and Productivity in Wastewater Irrigated Urban and Peri-urban Vegetable Farming

- Key objective: develop integrated and user-oriented strategies to safeguard public health concerns without compromising livelihoods and land and water productivity in wastewater irrigated urban and peri-urban vegetable farming.
- Key achievements: best practices identified for risk reduction from wastewater irrigation in major cities of Ghana; farm-based and post-harvest risk reduction interventions provide solutions to health challenges in wastewater-irrigated urban and peri-urban agriculture. http://waterandfood.org/2011/10/21/safer-peri-urban-vegetable-production/

PN 40 Integrating Knowledge from Computational Modeling with Multi-stakeholder Governance: Towards More Secure Livelihoods Through Improved Tools for Integrated River Basin Management

- Key objective: developing integrated simulation models for managing land and water resources in river basins in close collaboration with multiple stakeholders; promoting their use as decision-tools in multi-stakeholder governance systems.
- Key achievements: development of a dynamic bio-economic multi-agent model to analyze policy that can improve the income from farming and reduce rural poverty in the Upper East Region of Ghana. Simulation demonstrates that farm households access to credit and access to irrigation has the highest comparable poverty reduction effect. http://waterandfood.org/2011/10/21/integrating-governance-modeling/

PN 46 Planning and Evaluating Ensembles of Small, Multi-purpose Reservoirs for the Improvement of Smallholder Livelihoods and Food Security

- Key objective: develop a tool kit to analyze & improve planning & management of small reservoirs
- Key achievements: water allocation through distributed storage leads to lower evaporative losses than previously assumed, and collective downstream impact of present small reservoirs is minimal. New construction will often be justified, compared to more expensive and less reliable alternatives. http://waterandfood.org/2011/10/21/small-multi-purpose-reservoir-planning/

PN 47 African Models of Transboundary Governance

- Key objective: Transboundary water governance (Volta & Limpopo) towards an African Indigenous model.
- Key achievements: New and strengthened research and implementing partner networks; basin level governance profiles created; generic model and specific recommendations for inclusion of 'indigenous' institutional principles in basin governance. http://waterandfood.org/2011/10/21/african-transboundary-governance/

PN 51 Waste water irrigation – opportunities and risks

- Key objective: Evidence based support for public health policy development that mitigates health risks of urban waste water irrigation without compromising livelihoods of farmers and traders; Safer peri-urban & urban vegetable production
- Key achievements (jointly with PN38): A health risk reduction strategy with guidelines for health promotion, based on actual and perceived health risks of urban waste water irrigation; Book: Irrigated Urban Vegetable Production in Ghana http://www.cityfarmer.org/GhanaIrrigateVegis.html

PN55 Basin Focal Project Volta

- Key objective: Assessment of present conditions of the distribution of rural poverty, farming systems and water productivity; Analysis of opportunities and risks under the double pressure of demography and climate change, and modeling of water resources to identify sensitivity of water allocation to development and climate scenarios
- Key achievements: whole-basin assessment of water availability, poverty, food security, and water productivity; identification of researchable questions or breakthrough implementation promising major impact and change in the near and longer term future.

PN 65 Contribution of shallow groundwater irrigation (SGI) to livelihoods security and poverty reduction in White Volta Basin: current extent and future sustainability

- Key objective: use of SGI to improve the livelihoods in the Volta basin
- Key achievements: mapping and assessing potential of dryland farming and benefits of SGI in the White Volta basin http://waterandfood.org/2011/10/21/shallow-groundwater-irrigation-volta/

Ongoing research of CPWF in the Volta Basin

The CPWF Volta Basin Development Challenge (Volta BDC) aims to strengthen integrated management of rainwater and small reservoirs so that they can be used equitably and for multiple purposes. The Volta BDC explores the institutional and technical aspects of small reservoir development and maintenance, embedded within a wider rainwater management system for the Volta River Basin in northern Ghana and Burkina Faso http://waterandfood.org/basins/volta/.

The following CPWF research activities ongoing in the Volta Basin are now mapped into Water, Land and Ecosystems (WLE):

V1: Targeting and Scaling Out
http://cgspace.cgiar.org/handle/10568/16582

This project conducts research to understand spatial patterns of adoption and scaling out of agricultural water management interventions in the Volta basin, using participatory GIS (PGIS) as a tool for the assessment of successful water management. The project works from the premise that, while certainty is unobtainable, making use of available information in a systematic way will increase degrees of certainty about the chances of success of out-scaling agricultural land and water management (AWM) interventions. The envisaged output is an evidence and knowledge-based decision support tool that can map the likelihood that the introduction of AWM interventions for smallholder farming systems will be successful in given locations.

V2: Integrated management of rainwater for crop-livestock agro-ecosystems
http://results.waterandfood.org/handle/10568/12540

Mixed crop-livestock systems are projected to remain the main providers of food in the Volta Basin for the coming decades. Opportunities exist for smallholders to participate and benefit from emerging crop and livestock markets in the Volta Basin. Given the inherent high water scarcity and variability in the basin, smallholders need improvements in rainwater management for ensuring sustainable and equitable benefits. This project aims to increase crop and livestock productivity and achieve enhanced livelihoods and positive environmental impacts, through strengthened institutional capacity and improved equitable and gender-sensitive performance of crop and livestock value chains. Innovation platforms are built around key crop-live-stock value chains and best-fit integrated rainwater management strategies (RMS) are targeted to different biophysical and socio-economic domains. The envisaged outputs are guidelines for integrated RMS comprised of technological solutions, directed at different components of the agro-ecosystems, underpinned by enabling institutional and policy environments and linked to market incentives that can drive adoption.

V3: Integrated Management of Small Reservoirs for Multiple Uses
http://cgspace.cgiar.org/handle/10568/16581

This project focuses on integrated management options at local scale for small reservoirs in a multiple use context. Different aspects of water productivity are assessed and options for sustainable improvement are tested, with the following objectives: (i) perpetuating infrastructures for socio-agro-ecosystem durability; (ii) protecting and if necessary improving the water quality for the various uses; (iii) reaching and enhancing water productivity potentials; (iv) seeking for equity (pro-poor position). These goals are compared and discussed with stakeholders' perceptions and expectations, using participative diagnosis and modeling as a methodological baseline. The envisaged outputs are defined alternative management options with a consensual delimitation of benefits and risks, and their implementation in pilot sites.

V4: Sub-basin management and governance of rainwater and small reservoirs
http://results.waterandfood.org/handle/10568/12544

This project aims at understanding the processes that govern IWRM policy-making, practices and research in the Volta Basin (Ghana and Burkina Faso). It supports on-going Integrated Water Resources Management (IWRM) policy initiatives, by identifying socially acceptable land and water governance options through a participatory approach based on companion modeling. Livelihoods, health and environmental impacts are considered, including spatial and temporal trade-offs at the watershed level. The envisaged outputs are enhanced multi-level exchanges among actors involved in the shaping and implementation of IWRM policies, leading to a set of governance decisions that bring together sustainability and planning concerns and livelihoods priorities.

V5: Coordination and Change
http://results.waterandfood.org/handle/10568/12552

This project ensures coherence amongst the other 4 Volta BDC Projects. Through process research it investigates the way how scientific knowledge produced by these projects contributes to innovations and change providing recommendations for up- and out-scaling of interventions. Increased awareness of the benefits of integrated rainwater and small reservoir management should encourage evidence-based investments in small reservoir systems for multiple uses.

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