The ADAPTS programme in Ghana

Synthesis report

IVM Institute for Environmental Studies

Both ENDS Environment and Development Service

Acacia Water Solutions in Groundwater

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1. INTRODUCTION

1.1 ADAPTS background

Climate change is not only expected to result in gradual changes in temperature, rainfall patterns and sea level rise, but also to increased climate variability and extreme events which will threaten water availability and food security for millions of poor people. Local communities and national governments both urgently need adaptation strategies to deal with these impacts.

In 2008, the Institute for Environmental Studies, ACACIA Water, and Both ENDS started the ADAPTS project, funded by the Dutch Ministry of Foreign Affairs. The overall aim of ADAPTS was to increase developing countries' adaptive capacities by including considerations about climate change and options for adaptation within water policies, local planning and investment decisions.

ADAPTS has worked with local communities, civil society organisations, local and national governments, scientific institutes and the private sector. It has shown that adaption is already taking place at the local level. ADAPTS sought to combine local and global knowledge in water management and to empower vulnerable communities to design and implement cost-effective and sustainable adaptation measures. Through dialogues with local and national governments it sought to ensure the inclusion of the knowledge and visions of local people in the development of climate-proof water policies and investments.

To increase adaptive capacities in developing countries, ADAPTS focused on:

1. **Knowledge development:** developing information about climate change and studying how local water management can be made climate proof.
2. **Local action:** the identification, support, documentation, analysis and dissemination of innovative, locally-based interventions to ensure that local knowledge and visions are included within dialogues about basin-level and national policy.
3. **Dialogue:** establishing policy dialogues between local and national stakeholders on the issues of sustainable water management and adaptation to climate change.

The project took place in six countries between November 2007 and December 2011. This report summarises the main activities, results and insights of the Ghana case. Similar reports for Ethiopia, Peru and Vietnam can be found at www.adapts.nl.

1.2 ADAPTS in Ghana

The main goals of the Ghana project were to assess changes in water availability in the Dayi River basin and to support local farmers in setting up irrigated agriculture and agroforestry, as a local climate adaptation initiative. In addition, the project supported the development of a Basin Management Plan which took into account climate change, water use for irrigation (through a licensing system) and agroforestry (the latter to create buffer zones for rivers and lakes), and got local actors more involved in planning the basin's development. The project was implemented by the Ghanaian NGO the Development Institute (DI), the Water Resources Commission of Ghana (WRC), Acacia Water, Both ENDS, and the Institute for Environmental Studies (IVM).

2. AREA DESCRIPTION

2.1 Physical environment

The Dayi river is located in the Volta Region, east of Lake Volta. The river runs from the Akwapim mountains, along the Ghanaian-Togolese border and into Lake Volta (Figure 1). The catchment is a flat valley surrounded by mountain ranges with heights ranging from 300 to 1000 m. The valley is about 60 km long and about 20 km wide at its broadest part. The catchment covers an area of approximately 2180 km2: the main part is located in Ghana, with around 422 km2 being in Togo. Rainfall in the basin has decreased in recent years. At Kpandu station, at the lower end of the basin (Figure 1), rainfall has decreased from 1400 to 600 mm/yr in the period between 1985 and 2006. At Hohoe, more upstream in the valley, rainfall fell from 1700 to 1500 mm/yr over the same period, with the largest change in the 1970s and 1980s. The Dayi river and some tributaries in the eastern part are perennial, and contain some spectacular waterfalls. The subsoil consists mainly of old sedimentary rocks, including shales and quartzites, together with volcanic rocks.

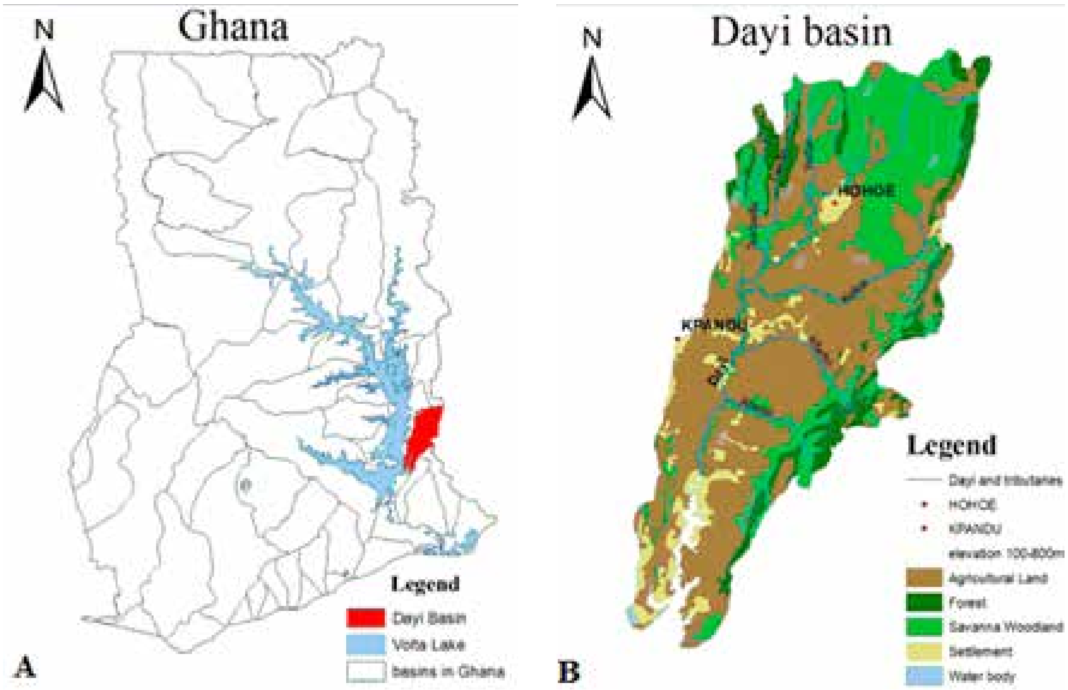


Figure 2 1A. Location of the Dayi River Basin (red) in Ghana.
Figure 2.1B. Land use in the Dayi Basin (WRC, 2009)

The rocks are covered by a weathering layer and younger unconsolidated deposits in the form of loams, sands and gravels line the major rivers. The area's vegetation reflects rainfall distribution and altitude and can be divided into three zones: moist semi-deciduous forest; savannah and mountain vegetation. Moist semi-deciduous forest once existed on the lower slopes of the highlands, but crop cultivation has reduced this to secondary forest. Patches of wooded savannah can also be found.

2.2 Socio-economic situation

2.2.1 General characteristics

The Volta Region has a population density of 80 persons per km2 and a population growth of 1.9%. The region has some urban centres, such as Ho and Hohoe, but is largely dominated by traditional communities. Around seventy percent of the regional population lives in rural areas (GSS, 2005). Unemployment rates are 7-8%, but 83% of the economically active population works in the informal private sector. In total, around 80% of the economically active population is self-employed, and because the population is rather young (41% is aged 0-14 years), there is a high dependency ratio: 92 dependents for every 100 working people (Alfa et al., 2009).

Although it is rural, the Dayi Basin is a relatively densely populated area (123 persons/km2; Groen et al., 2008). The main city in the area is Hohoe. The main economic activities are subsistence and some cash crop farming.

There are two medium sized communal irrigation schemes (15 to 30 farmers, each covering about 10 to 20 acres). One is at Kpandu, which has an intake from Lake Volta and sprinkler irrigation. The system is run by the Irrigation Development Authority (IDA). The other one is at Ve Koleonu, where water is lifted from the Dayi River, distributed via lined channels and brought to the fields by furrow irrigation. The system, funded by the World Bank, was never finished and is now operated by the farmers' group.

2.2.2 Socio-economic survey

In May and June 2009 IVM carried out a socio-economic field survey. Five villages were selected, based upon their representativeness for the three distinct ecological zones within the basin.

The villages included in the survey are neatly spread out along the Dayi River, and represent the upstream, midstream and downstream areas (Figure 2.1). The villages of Have and Woadze represent the mountainous upstream area. Koloenu represents the mid-stream transitional savannah, where the forests have been largely cleared and turned into large-scale arable land. Kukurantumi and Abrani represent the downstream forested area. Information was collected from 109 respondents from the five villages for the study (Pauw et al., 2009).

A typical household has one male and one female member, and two to four children. Most respondents see themselves as farmers, although there are many (47%) who have other sources of income, such as processing food, selling fish and eggs, selling livestock, or a pension. In general the downstream households have the lowest level of socio-economic development level, while midstream households show the highest. Although all the villages are connected to the mains water grid, only 30% of them use piped water as their main source of domestic water. The rest fetch water (for free) from the rivers.

Only 4% of the total agricultural land being used (excluding fallow land) is irrigated. Thirty-one respondents (just over 20%), grow irrigated crops., Nearly all the harvest from irrigated land is sold commercially. The most important irrigated crops are okra, aubergines and peppers. The majority of respondents grow rain-fed crops such as cassava (80 %) and maize (77%). About 15% of the harvest of rain-fed crops is used for own consumption and the rest is brought to market. Beans, rice and peanuts are almost exclusively produced by the midstream households, who also grow most of the maize. The more drought-resistant crops of cassava, yam and cocoyam are grown more frequently by the upstream and downstream communities. The midstream households grow the widest variety of different crops, their harvests have the highest value and their revenues are the highest. The highest revenues are from drought-sensitive vegetables such as okra, tomatoes, aubergines and pepper.

A majority of respondents stated that their incomes had decreased over the past five years. Market prices for their crops have fluctuated, but generally decreased, while the price of seeds, pesticides and inorganic fertilisers has increased. Some people have fallen ill (because of poor health or age) and have found it difficult to maintain their living standards.

2.2.3 Vulnerability and adaptation to climate change

Respondents identified five climate-related hazards (heat, rainfall variability, drought, prolonged dry season and floods) and claimed that the first three were the most important. They saw these hazards as leading to a lack of water, failing harvests and the subsequent outmigration of youth. Increased hunger, however, was seen as the worst consequence of climate-related hazards (by 85% of respondents). The respondents considered themselves to be vulnerable to climate-related hazards and afraid of future hazards.

Government documents do show some interest in climate change adaptation but have a more traditional vision of development, which is sectoral and not well integrated. However, these documents do recognise the interrelation between deforestation and soil degradation and the importance of irrigation.

These same topics were also mentioned by the respondents, both in the 'open' and the 'closed' questions in the survey. Reforestation, prevention of land degradation, irrigation and planting of tree crops were seen as good ways to offset the negative effects of climate-related hazards. These measures can be used by individuals and communities. Crop diversification was also seen as a successful measure for coping with climate-related hazards.

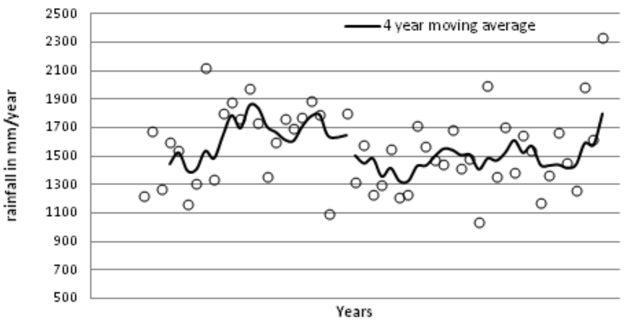
There was a significant correlation between respondents' motivation to adopt adaptation measures and their experience in farming and the costs of adaptation. Richer farmers appeared more motivated to adapt than the poorer ones. In general it can be concluded that the farmers are relatively well aware of, and sensitive to, the impacts of climate-related hazards.

It was also noted that local people's perceptions of the interconnections between local environmental problems and climate change is not always correct. Many local respondents think (incorrectly) that deforestation is a cause of climate change. However they are right in seeing that there are links between the two. Reforestation can be a useful adaptive measure, because it prevents erosion during heavy rainfall or slows down runoff. Once erosion has taken place less water may infiltrate into the soil, leading to floods and reduced base flows.

3. CHANGES IN CLIMATE AND HYDROLOGY

3.1 Climate and climate change

Ghana has a tropical climate with a dry season from December to April and a bimodal wet season that shows peaks in June and September (Figure 4). Average rainfall varies from 1100 to 2000 mm/yr. Potential evaporation is around 1500 mm/yr. Variations in yearly rainfall have a large impact on groundwater recharge and river base flow, which also shows inter-annual variations. Presently base flow is around 1 to 2 m^3/s at Hohoe and increases to about 6 m^3/s at Gbefi, further downstream.



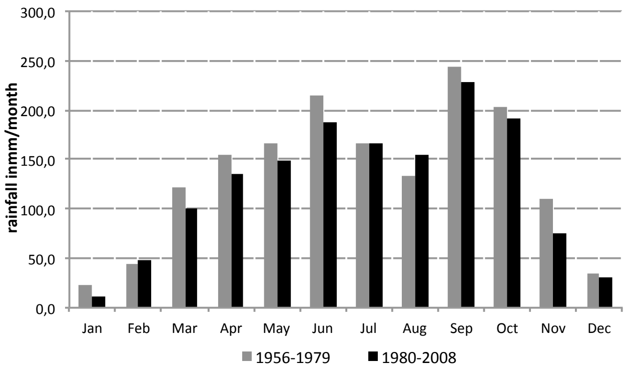


Figure 3-1 Annual rainfall at Hohoe

Figure 3-2 Average monthly rainfall at Hohoe

The socio-economic study (Pauw et al., 2009) and discussions during various missions made it clear that the population in the Dayi River Basin is well aware of climate and environmental change (deforestation). They state that rainfall has decreased over the past decades and has become less reliable. The first rainy season starts later and the late rainy season ends earlier. As a result, two cropping periods are no longer possible. Farmers are dependent on the rains in April and May to plant their seedlings.

Many rivers and springs are no longer perennial. The local population believes that deforestation during recent decades is the cause of the decrease in rainfall and river base flow and the cessation of spring flows. In their perception, reforestation would bring more rain.

The facts largely support the observations of the local population, but the causality is different. Rainfall data show that annual rainfall at Hohoe changed from approximately 1700 mm/year in 1975 to 1400 mm/year at present (Figure 3-1). Early and late rains have decreased (Figure 3-2). In Ghana as a whole, lower annual rainfall due to longer dry seasons, has led to more and more tributaries and main rivers drying up quickly, reducing the availability of surface and groundwater for an increasing population (Alfa et al., 2009).

Mean annual daily temperature has increased by 1°C in the period 1961-2000 (and is projected to increase by a further 2.5-3.0 °C by 2050). A recent projection from the Netherlands Climate Assistance Programme (NCAP, 2011) indicates a further decline in rainfall and a shortening of the rainy season, in combination with increasing temperatures throughout the year (Figure 3-3). Yet temperature trends as a whole indicate an increase of rainfall in Ghana during the rainy season (Pauw et al., 2009).

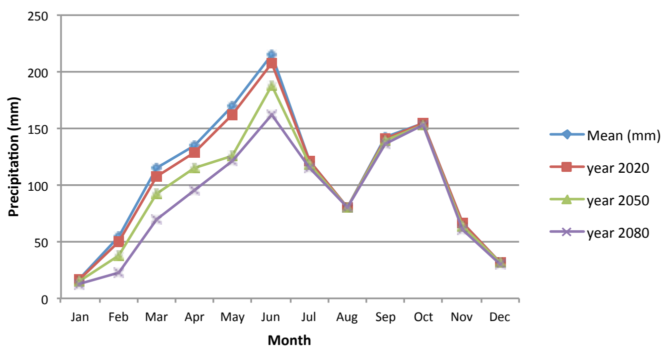


Figure 3-3 Monthly rainfall for Ghana as a whole, predicted by NCAP (2011)

There is a discussion as to whether these observed changes are part of climate change or part of the variability of the West African rainfall regime. Another point of discussion regarding these trends and the causes of climate change is the difference between people's perceptions and scientific knowledge. It is clear however that rainfall patterns are changing. To understand the possible effects of this on river base flows, daily rainfall records were input into a rainfall-runoff model of the Dayi River, to simulate the runoff pattern under future climate scenarios. The Vrije Universiteit of Amsterdam (VUA) has developed a tropical rainfall generator, which uses historical rainfall data from several locations and a temperature rise based on different climate scenarios to create a new dataset, validated by using nearest neighbour re-sampling procedures (Buishand & Brandsma, 2001). For Ghana, a scenario with a temperature rise of 30C over the coming 75 years was used. This resulted in three time series of 25 years each, showing likely temperatures and precipitation at the present (average 1971- 1996), in 2040 (2028 – 2053) and in 2080 (2068-2093).

The rainfall generator shows an average overall increase in yearly rainfall in 2040 and 2080 (Figure 3-4). This increase will mainly occur in the months of March and April and from August to November (Figure 3-5). For September and October precipitation in the 2040 scenario is lower than in the 2080 scenario.

	Average Rainfall/Year (mm)	Average Yearly Temerature (°C)	Average Sum of Simulated Discharge (mm)
Present	1520	26.9	413
2040	1548	27.3	397
2080	1666	27.8	490

Table 2 Average sum of precipitation and average of temperature for 25 year periods representing the present situation, 2040 and 2080

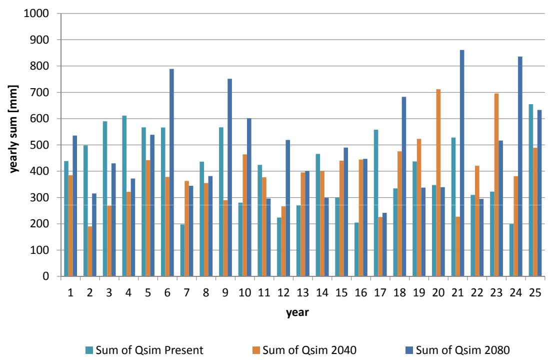


Figure 3-4 Predicted yearly average temperature and total precipitation (from the weather generator).

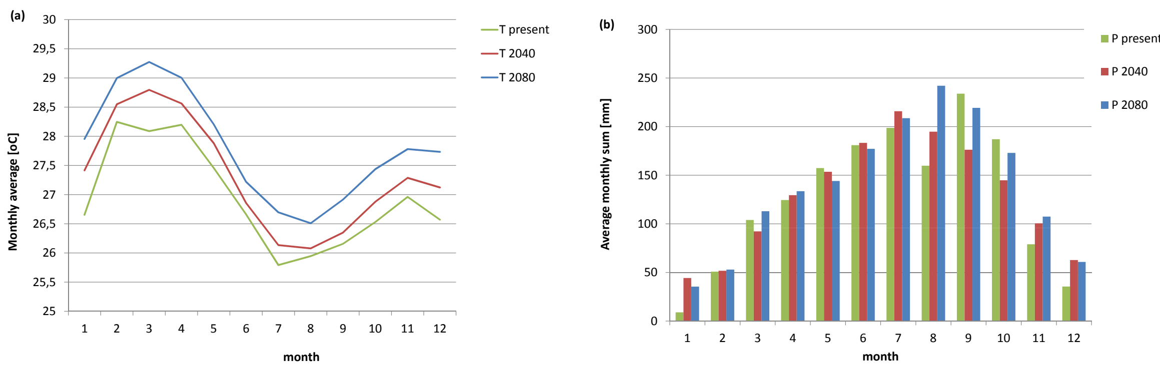


Figure 3-5a & 3-5b Monthly average temperature and average monthly precipitation for the present situation, 2040 and 2080.

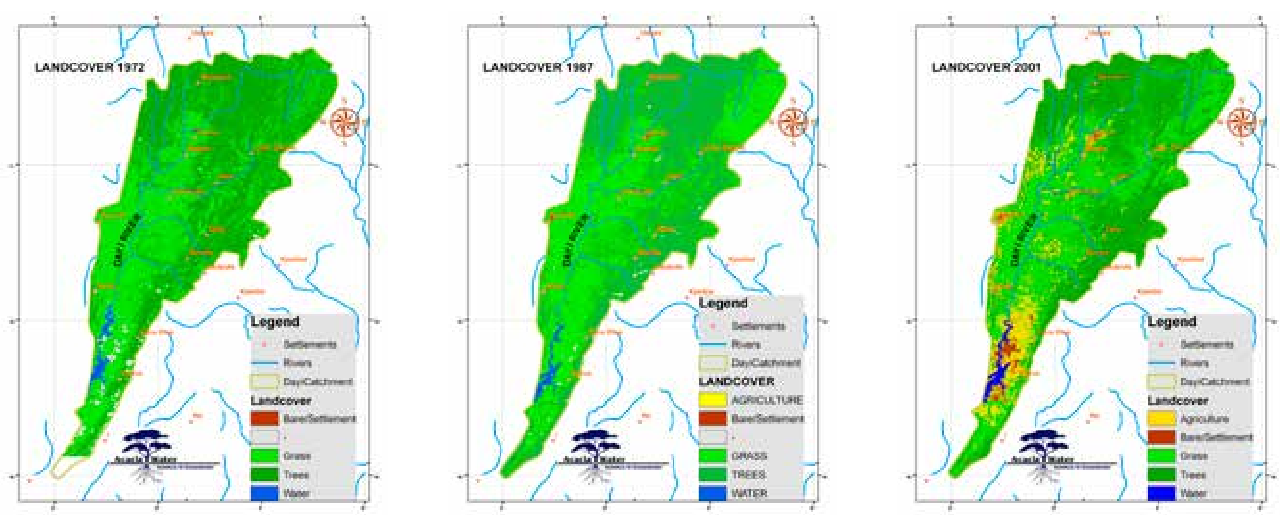


Figure 3-6 Interpreted land cover temporal changes based on LANDSAT images

3.2 Land use change

The local population states that there has been much deforestation in recent decades A spatial and temporal analysis of land cover was carried out to test this. LANDSAT (satellite) images show that deforestation has intensified since 1987. However large-scale erosion is not visible and deforestation does not seem to have had a large impact on river flows and the local climate.

It is clear that there was a remarkable increase in agriculture land use between 1987 and 2001, especially in the areas close to the lake (Figure 3-6). There has also been an increase in bare patches (which could have been fallow land at the image capture time) and settlement areas. The LANDSAT images also show that the forest/grass ratio seems to have decreased from 1972 to 2001. However, there is no visible effect on the size of the lake itself over this period.

LANDSAT NDVI indexes, which are an indication of vegetation presence and characteristics, are more or less stable over the years. Apparently the deforestation has been largely compensated for by secondary forests and dense cropping patterns.

There are steep slopes close to the ridge boundaries and on the headwater side of the catchment area. Agriculture has spread over much of the catchment and since 2001 has also taken place on steep slopes. The presence of settlements close to such areas can be seen as evidence of the spread of agriculture, due to the economic pressure faced by farming communities.

3.3 Hydrological scenario studies

3.3.1 Hydrology – general

The path followed by the Dayi River is indicated in Figure 3-6. The river flows from Togo to Lake Volta. The tributaries also originate in the higher elevated areas and join the Dayi rier at different parts of its path. Because of these confluences, the discharge of the Dayi river increases towards the south. In 2004 base flow at Gbefi was 4 to 5 times more than the base flow at Hohoe (Beyen and Rutgrink, 2010).

3.3.2 Rainfall runoff model

During October and November 2009 a field study was carried out on the runoff behaviour of the Dayi River (Beyen & Rutgrink, 2010). Based on observations and existing data on daily runoff, rainfall, temperature and potential evapotranspiration, a rainfall-runoff model was made for the catchment upstream of Hohoe. The model was made with the HBV code, which simulates catchment response (Seibert, 2005). The model was calibrated by comparing simulated and measured discharge (Figure 3-8) for different periods, for which both daily precipitation and daily runoff were available. Catchment parameters were optimised by calibration, using Monte Carlo runs (Beyen & Rutgrink, 2010).

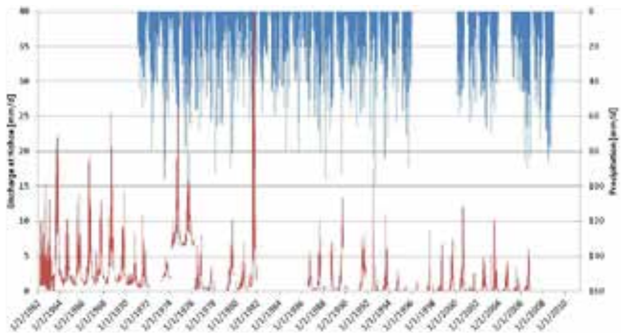


Figure 3-8 Precipitation (blue) and discharge (red) data for Hohoe

There are quite a few gaps in the dataset, which also shows some unrealistically high values for discharge (e.g. for 1974 to 1977). There are only 5 periods with complete data for rainfall and runoff. Figure 3-8 shows that base flows before 1972 were considerably higher than those after 1976.
Figure 3-9 presents average rainfall and temperature data for the last four decades. Note that the relatively high rainfall in the period 2001 – 2008 is the result of increased rainfall in the last 3 years. The increasing temperatures are also apparent in this figure.

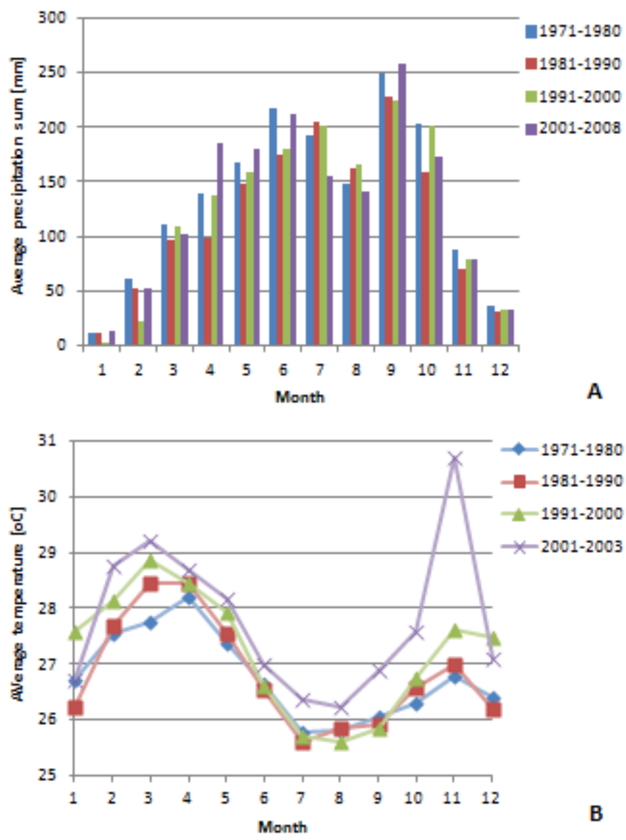


Figure 3-9 Observed average sum of precipitation (A) and average temperature (B)

Calibration for the five periods resulted in efficiencies varying from 0.3 and 0.84. The period of 1986 – 1987 gave the best results. The more recent periods were difficult to calibrate, especially with respect to base flows during the dry season. This might be an indication of upstream use of river water,

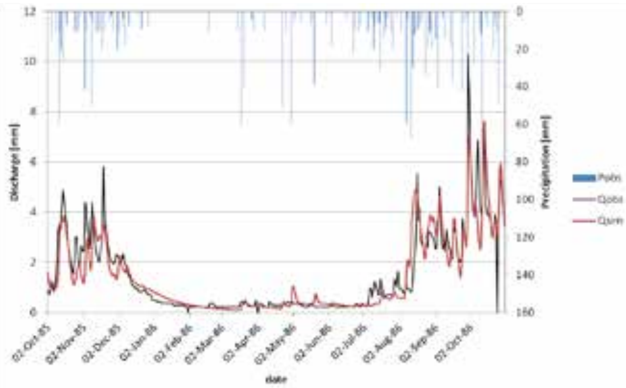


Figure 3-10 Observed precipitation (mm), observed and simulated discharge (mm) for the 1986-1987 run.

but this has not been verified. After 1980 the base flow seems to be lower. For the 2000 – 2002 and 2005 – 2006 runs the model was not able to simulate the base flow (often zero).

3.3.3 Runoff for various climate scenarios

The rainfall runoff model calibrated for the 1986 – 1987 data was used to simulate runoff for different climate projections. The purpose of these scenario runs was to study possible future base flows. The base flow in the dry season is the main source of water and limits the potential for expanding irrigated agriculture.

Simulations with the HBV model were carried out for periods of 25 years for the present situation (1971-1996, the 2040and the 2080 climate (see Table 2 for details).

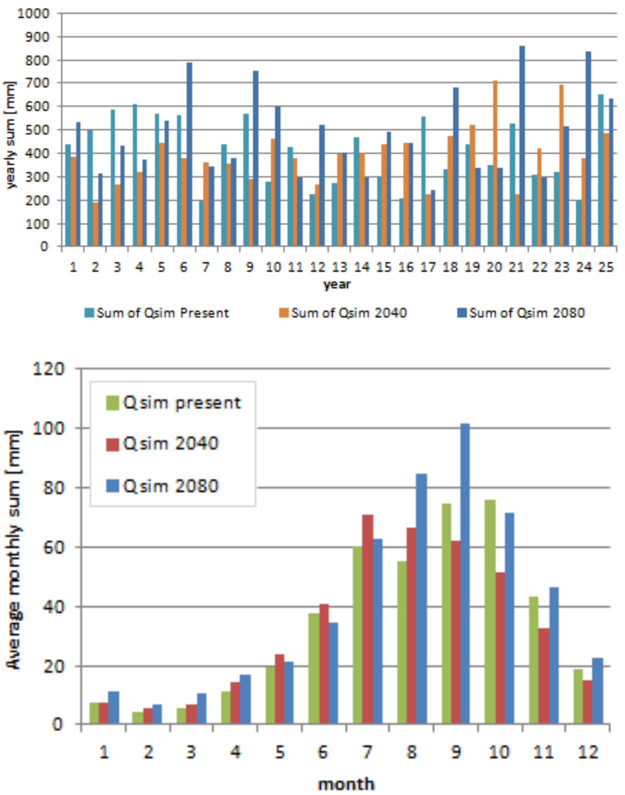


Figure 3-11 Yearly sum and monthly sum of simulated discharge for the present situation, 2040 and 2080.

The results show that the impacts of climate change will depend on a combination of temperature and precipitation. The increase in rainfall is not always high enough to compensate for the increase in evapotranspiration caused by a rise in temperature. In the 2040 scenario the, river discharges are lower the wet months (September to December) than at present, but they then rise above the present values by the year 2080. River discharges in August seem to increase continuously throughout the period. In July and the preceding dry months the situation remains more or less stable. Given the uncertainty of the climate and runoff simulations we conclude that there is no evidence that the present base flows will change much in the future.

3.3.4 Adaption strategies

Several adaptation measures were developed within the project. Before implementing measures in the field, the effects of these measures were evaluated under current and projected climatic conditions. For this evaluation the WEAP model was used (www.weap21.org) using the current basic water-related characteristics of the basin and their interrelations. This included specifications of supply, demand and the resource base, including information on dams and reservoirs. To assess the possible effects of climate change, the results of the weather generator and two SRES scenarios were used. Two adaptation strategies were evaluated: business as usual (BAU) and the construction of a weir at Hohoe (blue and green in Table 4). It was assumed that irrigation would be practiced under both scenarios.

Table 4 shows that water demand will not be fully met from mid-December until the end of February, The unmet demand of the reference scenario is higher than under the A2, B1 and weather generator scenarios. The unmet demand is also higher under the ‘strong irrigation’ scenario, under both the A2 and weather generator scenarios. The maximum shortage is approximately 200 cubic metres on 31 January in the A2-strong irrigation scenario.

The main results of this analysis are that unmet water demands will be very high in the BAU scenario (without a weir). There are already unmet water demands and these will increase in the future. The Hohoe weir would have a buffering effect on water levels and would greatly reduce unmet water demands under current and projected climatic circumstances. This will have beneficial effects in both situations Based on the analysis under different climate projections, it is not expected that climate change will be a major hurdle for irrigation development in the upper and middle catchment of the Dayi River if the proposed weir near Hohoe is constructed. The total irrigation needs will remain minimal compared with the water demand of Hohoe town. Given the uncertainties, this irrigation will be beneficial adaptive measure.

Average demand site coverage (%) over the period 15 November 2011- 28 February 2050								
Part of Dayi Demand site	West Kpando Livestock	Upper			East		Middle	
		New Baika	Hohoe domestic	Ve Koloenu	Ho livestock	Ho irri devt	Vakpo	Afeyi Irri devt 2
Reference without weir	66.7	72.8	72.8	77.1	52.2	n.a.	77.1	n.a.
>A2	87.3	84.2	84.2	90.3	77.0	n.a.	90.3	n.a.
>> Strong irrigation	84.7	84.2	84.1	89.7	76.6	70.6	89.7	82.9
>Weather generator	86.7	88.5	88.4	91.4	72.2	n.a.	91.4	n.a.
>>strong irrigation	84.5	88.4	88.3	91.1	71.9	67.1	91.1	83.7
Reference with weir	68.8	99.9	100	100	52.2	n.a.	100	n.a.
>B1	88.5	99.9	100	100	77.8	n.a.	100	n.a
>A2	89.5	100	100	100	77.0	n.a.	100	n.a.
>>strong irrigation	87.3	100	100	100	76.6	70.6	100	92.3
>Weather generator	88.3	99.9	100	100	72.2	n.a.	100	n.a.
>>strong irrigation	85.6	99.9	100	100	71.9	67.1	100	92.3

Table 4 Average demand site coverage (%) for eight demand sites in the four sub Dayi catchments, over the period 2010-2050. (Pauw & Boateng, 2011).

4. LOCAL INTERVENTIONS

4.1 Irrigation and agroforestry

The Woadze Model is an environmentally friendly approach to agriculture, developed by the Development Institute. It was used in the ADAPTS project as a way to reduce the vulnerability of communities in the Dayi River Basin (DRB) by counteracting the effects of climate change through the sustainable management of natural resources (forests, river basin, biodiversity, soil and water).

The Woadze model adopts an integrated river basin management (IRBM) approach that focuses on conservation, soil and water management. It aims to improve communities' livelihood security by encouraging farmers to change from rain fed to irrigation agriculture. Several principles were considered when developing the 'Woadze Agricultural Model'.

This is an integrated approach, ensuring conservation, ensuring environmental protection, adhering to issues of sustainability, community-led, generation of public goods, enabling more secure livelihoods

Box 1 The Woadze zonal model.

In establishing the project on the ground, the Woadze model delineated five clearly demarcated zones, from the river bed upwards.

1. ***Buffer Zone.*** A no-cultivation zone of around 30-50m width along the river bank. This zone was planted with the same (protective) species that can already be found along the river banks.
2. ***A zone for checking erosion/land degradation.*** Using Vertiver grass as a secondary buffer zone.
3. ***Agroforestry zone.*** This consisted of a mixture of timber and non-timber species. The plants/crops in this mixture are determined by the profile of the area and farmers' preferences . The project worked in three different ecological zones: upper stream (high forest); middle stream (savannah woodland) and downstream (forest and savannah). Plants/ crops were planted according to this ecology and farmers' preferences.
4. ***Cultivation area/production zone.*** This is the zone for vegetable production and other high-value crops using regular irrigation.
5. ***Fire belt.*** This is a preventive measure against wild bush fires.

The different technologies and management systems were discussed with the stakeholders, who also made site visits to see different technologies in operation. The farmers involved in the ADAPTS project chose to work with sprinkler irrigation. The system consists of a central pump, which lifts water from the river and pumps it under high pressure to the sprinklers via pipes and feeders. The advantage of this method is that the land does not need to be levelled (as in case of gravity irrigation). All the irrigation command areas were located along the Dayi River and were cleared of all trees and graded, apart from the uncultivated buffer, vertiver grass and agroforestry zones along the river bank. Trees with a direct economic value (fruits, timber, moringa) were planted in places where the buffer zone needed reforestation.

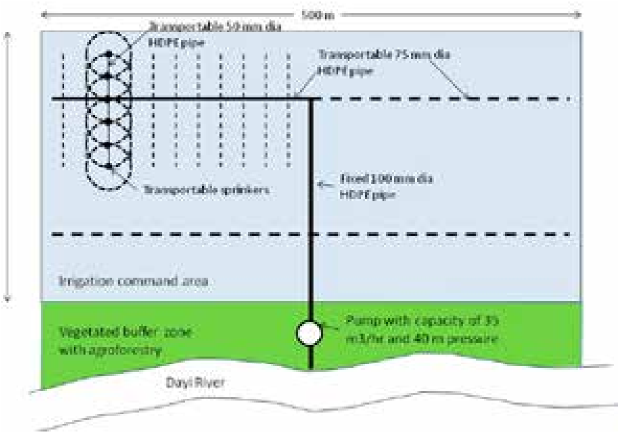


Figure 4-1 Sprinkler system

Before construction, surveys were undertaken of selected sites in the communities. They were demarcated for documentation purposes and the soils at the sites were evaluated to determine their nutrient status. Crops were selected for production according to their suitability to the soil. Six groups were selected to participate in a number of training workshops and field visits to improve their skills base. These covered the following areas.

- Nursery establishment and management
- Tree planting skills
- Group formation and development
- Financial management and book keeping
- Procedures for vegetable production for export markets
- Irrigation system installation and management.

The project provided all the inputs and equipment needed for farm operations to the groups. The groups are managed by elected leaders and a project officer was always available within the communities to give technical advice and support. Inputs were supplied to the groups through their leaders with the members decided on how these are to be distributed.

4.2 Marketing

Introduction

Marketing is an essential element within the project. One of the central elements of the programme was to equip the farmer groups with the skills and resources to be able to successfully engage with market outlets. This meant that the farmer groups have to take into account the current market position of Dayi Basin, which has changed from a market economy in the first half of the twentieth century towards a degree of self-sufficiency in the second half of the 20th century. New markets were not developed again until after the year 2000.

Before 2000

In the first half of the twentieth century the economy of the Dayi Basin and the city of Hohoe became an important commercial centre for cocoa. . Other important tree crops were oil palm and plantain, although it is unclear if the area was ever self-sufficient in these crops. In the seventies and eighties the cocoa economy started to stagnate and lapsed into a severe crisis. The Dayi area became dominated by the cultivation of annual crops, mostly for consumption in the area. There was a significant spread in cassava cultivation by women and this has grown to become a market crop of some importance. In 2010 it was reported that wholesalers from Accra were buying cassava from Ho market.

After 2000

Since 2000, irrigated vegetable growing has been developed at some locations in the Dayi Basin. Most of these have been top-down designed schemes which did not meet their intended goals (for instance the schemes at Kpandu and Ve Koleone). One farmers' group, who started with such a scheme but now works independently from the agency that instigated it, has managed to become suppliers of okra, aubergines and peppers to the market at Ho.

In 2008 the Woadze farmer group was producing for the market at Ho, The harvest of 2009 failed due to a breakdown of the pump and diseases. The harvests of 2010 and 2011 were a success, but we do not know where their market outlets were. The replicability of these pilots may be constrained by the limited availability of water in Dayi River (elaborated on below). Other products that are sold on small scale are moringa, pineapple, mango, citrus fruits and cashew nuts.

4.3 The costs and benefits of the schemes

To date three irrigation and agroforestry schemes, following the Woadze model, have been implemented. The investment costs of these schemes are shown below in Table 5.

The average costs per scheme amounted to 24,800 Euro. These costs covered the costs of preparing the land and supplying materials, alongside intensive training on operating the irrigation system, farming practices and capacity building. We believe that, the prices of the irrigation equipment can be reduced in the future by dealing directly with the suppliers in the future. The training costs can also be reduced, as farmers have now organised themselves and can now advise each other. The project team expects that total costs for future schemes can be reduced to 20,000 Euro or less.

Cost item	Budgeted costs		Actual costs	
	GHS	EUR	GHS	EUR
Land development	22,800	12,128	26,328	14,004
Irrigation system & installation	39,400	20,957	54,039	28,744
Buffer zone & agroforestry	8,450	4,495	8,150	4,335
Production materials			2,580	1,372
Man hours (DI) for organisation	32,752	17,421	48,576	25,838
Total investment costs	103,402	55,001	139,673	74,294
Investment costs/scheme	34,467	18,334	46,558	24,765
Investment costs/ scheme excl. DI costs	23,550	12,527	30,366	16,152

Table 5 Investment costs of ADAPTS schemes

Items	Unit	Quantity	Unit costs	Amount	
			GHS	GHS	EUR
Costs					
Pre - planting costs					
Land preparation(ploughing)	Acre	1	100	100	53
Seed	Acre	1	280	280	149
Sub-Total				380	202
Planting Costs					
Transplanting	Acre	1	40	40	21
Fertilisers	Bag	6	52	312	166
Fertiliser application	Times	3	10	30	16
Spraying	Times	10	5	50	27
Chemicals (fungicides, insecticides, herbicides)	Acre	1	50	50	27
Weeding	Times	5	30	150	80
Sub-total				632	336
Other costs					
Harvesting cost	Box	1100	1.2	1,320	702
Fuel	Month	6	60	360	191
Maintenance of system/ group dues	Month	6	30	180	96
Wages for farmers	Month	6	100	600	319
Loan servicing per season	Season	1	500	500	266
Sub-total				2,960	1,574
Total Cost of production per season				**3,972**	**2,113**
Revenue from harvesting	Box	1100	6	**6,600**	**3,511**
Gross profits per acre				**2,628**	**1,398**

Table 6 Costs and benefits per acre for pepper farming

The ADAPTS project supplied the funds to cover the investment costs of the schemes. However, because the costs were higher than expected it was only possible to implement three schemes instead of the anticipated six. For reasons of solidarity and in order to make this local action economically profitable, the ADAPTS team and the beneficiary farmers' groups decided to convert the grants into interest-free loans with a pay-back period of three years. This will enable the groups who missed out from the initial programme to benefit in the coming years.

The costs and benefits of growing pepper are presented in Table 6. All the costs are included, including the yearly down payment on the ADAPTS loan and the labour input by the farmers themselves (as salary). The pepper is not offered to the local market but sold to an exporter. With a gross profit of 2600 GHS or 1400 Euro per acre, pepper growing is obviously quite profitable. Our calculations use a conservative estimate of 6 GHS per box although prices can sometimes reach 7 GHS per box.

Similar cost benefit analyses have also been carried out for other vegetables, which are currently sold to local market women and traders. For aubergines and okra these analyses result in profits of 1262 GHS (671 Euro) and 934 GHS (497 Euro) per acre, respectively. The price of vegetables fluctuates strongly between the rainy and dry season. Farm gate prices for aubergines fluctuates between 5 and 30 GHS per box, while for okra the range is from 5 to 20 GHS per box. In the cost benefit analyses conservative estimates of 10 and 8 GHC per box have been applied for the two crops respectively.

4.4 Development of the farmers' groups

In addition to developing agricultural activities and marketing skills the project also aimed to build up organisational competence among the participating farmers' groups. This section briefly looks at how these groups have evolved. The Kpandu farmer group has reached a good level of organisation and has built up considerable marketing power. They only sell their products at one place, enforcing transparency, and obliging buyers to bid against each other - which guarantees high prices. In 2010 the group was involved in negotiations with GIDA on expanding the irrigation facilities.

The farmers' group in Ho is now the most important supplier of fresh vegetables to the city and their success is directly dependant on the irrigation facility. Delivery of their products to market is sometimes hampered by the lack of a permanent road. The group has a formal membership structure, with an elected leader. Members pay a fee which apart from membership of the association, covers the cost of maintaining the pump and canals, and allows rent to be paid to absentee land owners. Most of the labour is provided by the households, which limits any inequalities. Men do have some degree of dominance, but females play a key role in hiring labour and marketing.

5. GOVERNANCE AND POLICIES

5.1 Introduction

In Ghana it is often difficult to coordinate the sectoral policies and governance institutions that influence natural resource use. The coordination of decisions over agricultural land, forests and water often leaves much to be desired. The ADAPTS project provided a useful opportunity and a good approach to coordinate the activities of different stakeholders and organisations enabling them to work together harmoniously at the local level at the Dayi River Basin within one institution (the Dayi Basin Board). This was done through involving government agencies, traditional authorities and farmers' organisations in discussions designed to build consensus on the sustainable use of resources in the Dayi Basin. This process also led to the empowerment of farmer groups.

5.2 Stakeholder engagement

Farmer groups were given several training courses to ensure that they could actively participate in resource management in the basin and engage government agencies meaningfully from an informed position. These courses included resource mapping and monitoring using participatory rural appraisal (PRA) methods. Other empowerment training courses included participatory climate change and vulnerability assessment, leadership and organisational development skills and governance and policy advocacy skills. (These trainings were in addition to the technical trainings detailed in section 4.1) This resulted in an elaborate structure involving the individual farmers, and a network of the communities participating in the ADAPTS project in the Dayi River Basin

5.3 The Dayi River Basin Board and Management Plan

The national Water Resources Commission (WRC) expressed an interest in developing a river basin plan for Dayi, the first such plan in a rural area, and the first one to include climate change and adaptation. All the important stakeholders in the basin were invited to attend a meeting, including district governments, traditional leaders and farmers, women and youth organisations and were asked to nominate a board. Two places were allocated to civil society stakeholders (one from DI and the other from a farmers' association). This was an important step, as other boards previously established by the WRC had little or no civil society or local representation and were driven in a top-down fashion from Accra.

The Dayi Basin Board (DBB) was officially inaugurated in July 2010. It has a consultative and advisory role in relation to the management of the Dayi River Basin's water resources. The Board also has a Basin Officer, an ex-officio member appointed by the WRC to manage the Board's Secretariat.

The WRC has elaborated the present River Basin Management Plan (RBMP for the Dayi River Basin as part of its mandate to "*propose comprehensive plans for utilisation, conservation, development and improvement of water resources*". [1] The RBMP drew on a number of dedicated assessment studies (guided by a strategic environmental assessment - SEA) and reviews, which informed the priorities within the plan. A number of consultative meetings and workshops took place while preparing the plan, involving the DBB members as well as District Assemblies and their planning officers. The RBMP for the Dayi River Basin addresses the basin-wide water management issues that need to be addressed to achieve the sustainable management of the Basin's water resources in the future. As such, they provide a framework for local water management planning.

In parallel with the technical assessments and the analysis of the water resource-related challenges, a consultative process was carried out with the involvement of "grass roots" basin-based stakeholders. This aimed to capture local perceptions about water resource management, climate change issues and vulnerable communities and to identify possible actions to address these issues and problems. A series of workshops were organised at Hohoe in 2009, 2010 and 2011 where local people's views on these issues were collated. The strategic environmental assessment (SEA) process offered a participatory platform for thorough public discussions, often in workshop settings.

The Dayi River Basin Plan was the first such plan in Ghana to take climate change into account, utilising elaborate and seasonally specific information on rainfall patterns and water runoff. It was also the first RBMP to include local stakeholders in its development. Local people were involved in several consultation rounds and representatives of local stakeholders are also members of the basin board.

In instituting water resource management mechanisms that involve adaptation to climate change, the RBMP adopted ADAPTS' approach of making vulnerable communities more resilient and better able to adapt to the impacts of climate change.

5.4 Dialogue and upscaling

The ADAPTS project has caught the attention of high-level government officials, such as the sector Minister and the chairman of the WRC. The Deputy Minister has requested that another pilot project following the ADAPTS approach is implemented elsewhere in the country to see if this approach is viable in other basins. He was also impressed with the involvement of local actors and CSOs and the inclusion of climate adaptation measures in the development of the RBMP and has indicated that this may be made obligatory when developing RBMPs in the future.

In addition ADAPTS has been invited to several platforms and meetings where it has given presentations on its work in the Dayi River Basin and its role in contributing to the DRMB. These meetings have been well attended by officials from government agencies and ministries. At one meeting, organised by the WRC, the Deputy Minister of Water Resources, Works and Housing and the Chairman of WRC were present. At the meeting it was unanimously decided that the WRC should adopt ADAPTS' approach for elaborating Integrated Water Resource Management (IWRM) action plans.

5.5 Replication

To share the lessons and results of the pilot, farmers from different communities in the project regularly visit other. Farmers from different groups have been teaching the other groups about cultivating particular crops, since some of the communities specialise in particular crops. These sessions led the project groups in the various communities to form a broader network dubbed the 'ADAPTS Farmers Network'. Network leaders have been selected from the various groups. This follows the same approach as the learning between ADAPTS counterparts of different countries.

1. *Water Resources Commission (WRC) Act No. 522 of 1996*

6. SUMMARY AND CONCLUSIONS

The ADAPTS programme in Ghana can be considered successful in terms of increasing farmers' capacity to adapt to climate change and in incorporating climate and social concerns into water management policy. Almost all of the targets defined in the proposal have been achieved. The only major difference between the plan and its implementation is that due to budget constraints, only three communities were supplied with irrigation schemes. The schemes were more expensive than anticipated in the planning phase. These three farmer groups with irrigation schemes are now seeing the positive effects, and because they feel solidarity with the groups that did not receive an irrigation scheme, have agreed to turn the project grant into a loan, that will start up a revolving fund for financing schemes in New Baika, Lolobi Kumasi or Ve Koleunu. The Development Institute will be the coordinator of this. The future will learn if the returns of the irrigation scheme will be sufficient to pay back the total project grant.

With regard to water policy: in 1998 The Ghanaian government set about decentralising water management throughout the country. The idea was to create separate water boards to manage individual river basins. At the start of the ADAPTS project, there were three boards with River Basin Management Plans (RBMP) in operation in Ghana. Working closely with the WRC, ADAPTS helped to create a new water board and develop a RBMP in the Dayi Basin. ADAPTS's bottom-up approach, which stresses the empowerment of local water stakeholders, was officially incorporated in the WRC's strategy for decentralising water management. The formation of the Dayi River Basin Board was the first time this approach had been used in Ghana and the new RBMP was the first in the country to be created using a stakeholder consultation approach.[2] During the development of the plan, meetings and workshops were held between government officials, NGOs, and civil society groups, ensuring that all had input into the plan's creation and are represented in the Basin Board. In addition, it is also the first plan to include future hydrological circumstances, such as climate change and adaptation measures in its design. As such, it should contribute to better water management in the basin in the future. Furthermore, the government is keen to upscale this approach to other basins in the country.

Runoff records show that river base flows have decreased by some 80 % since the 1970s. This is attributed to the decrease in rainfall throughout this period. By assessing the effect of irrigation schemes on the flow of water, the project has contributed to exploring the amount of water that can be used for irrigation without affecting downstream uses. ADAPTS also used information from global circulation models to assess the limits under possible future climatic circumstances. This has shown how practical models can be made for climate change and adaptation and how they can assist with making plans and decisions.

The ADAPTS project also aimed to help farming communities to establish sustainable communal irrigation schemes to supplement rain-fed agricultural production during the monsoon season. This was achieved in Woadze, Vakpo and Gbefi. After a workshop where the farmers went on a field visits to sites employing different types of irrigation, it was agreed to proceed with sprinkler systems. Such a system is easily maintainable and consists of removable parts. Pumps on the banks of the river bring water under high pressure to the sprinklers in the adjacent fields using removable pipes. Licenses for such irrigations systems must be obtained under the RBMP to avoid any negative impacts on downstream users (under current and future circumstances). The ADAPTS project provided technical and agronomical assistance and the construction funds on a 3 year loan basis. At present three groups comprising a total of 45 farmers are employing this method. These farmers have organised themselves in the ADAPTS Farmers' Association. The success of the new irrigation schemes can be measured in the increased output of cash crops being produced in the areas. The primary income earner for most farmers is peppers. While previously their products were mainly sold on local markets, the ADAPTS Farmers' Association has found buyers that are interested to export their peppers to the UK and the Netherlands and the first harvest has been sold. However, there are some start up issues with receiving payments of the traders, which hamper the investments for the next growing season. The coming years will be crucial to establish a stable joint trade, which will help to improve the livelihoods.

The loan instalments will go to help finance the creation and implementation of further irrigation schemes in New Baika, Lolobi Kumasi and Ve Koleunu, that were left out due to a lack of initial funding.

The success of the programme has led the Ministry of Water Resources Works and Housing and the Water Resources Commission of Ghana to adopt communal irrigation combined with river basin management as an essential part of the new national water policy (National Conference of Water and Climate Change, Accra, May 2011; IWRM action plan of WRC, November, 2011).

2. At the writing of this report the RBMP was awaiting final approval from the central government.

The project in Ghana has also developed different datasets and models to assess potential climate change in the region and its effect on hydrology. The "weather generator", which generated daily rainfall and temperature records for future climate scenarios, is particularly innovative. These tools can be used as generic analytical methods for planning and managing water in tropical river basins, with scarce data.

Two main lessons have been learned from the ADAPTS Ghana programme. First is that increased solidarity among farmers and the willingness to work and invest together as a group can lead to substantial benefits for individual households and communities. Prior to the project, most farmers in the area operated independently, relying on the rain as their main source of water. Implementing an irrigation scheme, a potential benefit for all, required farmers to band together to help negotiate its future design and use. This exercise led to the creation of farmers' groups that collectively manage their water resources. Moreover, they also now manage the sale, export and profit from their crops and have achieved considerable market power. While water policy now explicitly supports the use of irrigation, such schemes are expensive and for the most part do not operate on the individual level. If future irrigation schemes are to be successful they first require the creation of farmers' organisations that can have access to credit to finance their schemes. Provided that the schemes are profitable, the proceeds can go to repay their loan and/or finance new schemes. This dynamic is already established in the project's pilot area.

The second lesson learned from the project, as is shown by the new RBMP and water board, is that consultations and dialogue between government, stakeholders and knowledge institutes can lead to a more inclusive and robust water policy that is better geared to adapting to the impacts of climate change.

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