IWMI
WORKING PAPER 144

An Overview of the Development Challenges and Constraints of the Niger Basin and Possible Intervention Strategies

Regassa E. Namara, Boubacar Barry, Eric S. Owusu and Andrew Ogilvie

International Water Management Institute

CGIAR Challenge Program on WATER & FOOD
Andes • Ganges • Limpopo • Mekong • Nile • Volta

Working Papers

The publications in this series record the work and thinking of IWMI researchers, and knowledge that the Institute's scientific management feels is worthy of documenting. This series will ensure that scientific data and other information gathered or prepared as a part of the research work of the Institute are recorded and referenced. Working Papers could include project reports, case studies, conference or workshop proceedings, discussion papers or reports on progress of research, country-specific research reports, monographs, etc. Working Papers may be copublished, by IWMI and partner organizations.

Although most of the reports are published by IWMI staff and their collaborators, we welcome contributions from others. Each report is reviewed internally by IWMI staff. The reports are published and distributed both in hard copy and electronically (www.iwmi.org) and where possible all data and analyses will be available as separate downloadable files. Reports may be copied freely and cited with due acknowledgment.

About IWMI

IWMI's mission is to improve the management of land and water resources for food, livelihoods and the environment. In serving this mission, IWMI concentrates on the integration of policies, technologies and management systems to achieve workable solutions to real problems—practical, relevant results in the field of irrigation and land and water resources.

IWMI Working Paper 144

An Overview of the Development Challenges and Constraints of the Niger Basin and Possible Intervention Strategies

Regassa E. Namara
Boubacar Barry
Eric S. Owusu
and
Andrew Ogilvie

International Water Management Institute

The authors: Regassa E. Namara is a Senior Economist at the Regional Office for Africa of the International Water Management Institute (IWMI) in Accra, Ghana; Boubacar Barry is Coordinator of the West African Science Service Center on Climate Change and Adapted Land Use (WASCAL) Project at the satellite office of IWMI in Ouagadougou, Burkina Faso; Eric S. Owusu is a Research Officer at the regional office for Africa of IWMI in Accra, Ghana; and Andrew Ogilvie is Deputy Project Leader, Niger Basin Focal Project, at the Institut de Recherche pour le Développement (IRD), Montpellier, France.

Namara, R.E.; Barry, B.; Owusu, E.S.; Ogilvie, A. 2011. *An overview of the development challenges and constraints of the Niger Basin and possible intervention strategies*. Colombo, Sri Lanka: International Water Management Institute. 34p. (IWMI Working Paper 144). doi: 10.5337/2011.206

/ river basin development / poverty / social aspects / climate change / agriculture sector / water governance / West Africa / Niger River Basin /

ISSN 2012-5763
ISBN 978-92-9090-742-8

Please direct inquiries and comments to: *IWMI-Publications@cgiar.org*

A free copy of this publication can be downloaded at www.iwmi.org/Publications/Working_Papers/index.aspx

Acknowledgements

The authors would like to thank Dr. Akiça Bahri, former Director of IWMI's Africa Program, who provided continuous support and encouragement. We are also grateful for the assistance provided by Kingsley Kurukulasuriya in editing the final draft of this paper.

Project

This research was conducted as part of the "Niger Basin Focal Project" (PN64) of the CGIAR Challenge Program on Water and Food (CPWF).

Collaborators

The following organizations collaborated in the research conducted for this report.

International Water Management Institute (IWMI)

Institut de Recherche pour le Développement (IRD), France

Donors

Funding for the research carried out in this report was provided by the following organizations, among others, through the CGIAR Challenge Program on Water and Food (CPWF).

UK Department for International Development (DFID)

International Fund for Agricultural Development (IFAD)

European Commission

The views expressed herein do not necessarily reflect the official opinion of DFID, IFAD and the European Commission.

Contents

Executive Summary

The Niger River Basin covers 7.5% of the African continent, and is shared between nine riparian countries. The basin countries can be categorized into water resources producers, consumers, both producers and consumers, and minimum contributors and consumers. As in the case for most transboundary rivers, upstream and downstream conflicts emanating from the development and utilization of the Niger River are inevitable and are expected to be intense, particularly given the escalating demands for water from the many uses and users. The basin is divided into four major sections, namely Upper Niger, Inland Delta, Middle Niger, and Lower Niger. But these divisions, though useful, are too generic to provide a complete understanding of biophysical, hydrological and socioeconomic processes impinging on the basin's water resources, and to provide intervention recommendations. On average, the basin's population is two-thirds (64%) rural and a significant part of the northern zones of the basin is unpopulated.

People in the basin are engaged in various livelihood strategies such as dry- and wet-season cropping systems, pastoral systems, crop-livestock systems, and fishing. The dry-season livelihood systems include *fadama* (lowland or inland valleys) farming, recession flood farming, agroforestry, irrigated rice farming and fishing. Wet-season livelihood systems center mostly on cereal cropping and transhumance. The major crops grown in the basin are yam, cassava, rice, groundnut, millet, sorghum, plantain, cocoa, maize, sugarcane, and cotton. Agriculture represents a large part of the gross domestic product (GDP) of the Niger River Basin with crop production alone contributing 25-35% of the basin's GDP, while livestock and fishery contribute 10-15% and 1-4%, respectively.

All countries of the Niger Basin suffer from chronic and acute poverty and are ranked 'poor' by most poverty indicators (Human Development Index [HDI]), child mortality, life expectancy, Social Vulnerability Index, etc.). Several structural (social and institutional) factors hold a large segment of the basin's population in the throes of poverty. Niger Basin's challenge is to break this vicious circle by using resources to generate sustainable growth that is favorable to the poor. Some of the prominent water-related challenges are degradation of land and water resources, climate change and variability, vulnerability to disasters, inefficiency and poor performance of agriculture (rain-fed and irrigation), competing demands between sectors and water users and inadequate investment in water infrastructure. At a wider level, inadequate public services, institutional and governance failure, high population growth and urbanization, poor macro-economic performance, and unemployment have also undermined the development of the basin. The severity of these challenges varies from location to location in the basin.

The basin's development goals and objectives originate as a response to the development challenges and are articulated in various policy documents such as the Niger Basin Shared Vision (NBA PADD), poverty reduction strategy papers, United Nations (UN) Millennium Development Goals (MDGs), and the New Partnership for Africa's Development (NEPAD), specifically the pillars 1, 2, 3 and 4 of the Comprehensive Africa Agriculture Development Programme (CAADP). The goals of the basin countries are eradicating extreme poverty and hunger; achieving universal primary education; promoting gender equality and empowerment of women; reducing child mortality; improving maternal health; combating Human Immunodeficiency Virus (HIV)/Acquired Immune Deficiency Syndrome (AIDS), malaria and other diseases; ensuring environmental sustainability; and developing a global partnership for development.

The specific development objectives of the basin countries are the following:

- Increase income, generate jobs, improve living standards, and alleviate poverty, especially among the poorest section of the population while at the same time safeguarding the environment including the sustainable management of the Niger Basin water resources.
- Improve access to health and education services, and increase life expectancy.
- Achieve political stability, good governance and an appropriate institutional framework.
- Improve the investment climate for private-sector development where infrastructure plays a decisive part.
- Develop infrastructures and the productive sector to ensure better productivity of factors of production and economic growth.
- Reduce food imports, boost agricultural exports through stabilization, intensification and expansion of agricultural production.

To realize the basin's development goals and objectives the following water-centered intervention clusters needed to be synergistically pursued.

- Ensuring right to secure access to water for the poor.
- Developing new infrastructure.
- Improving access to agricultural water management innovations.
- Strengthening Niger Basin's water governance.
- Upgrading rain-fed systems.
- Reducing the vulnerability of poor people to climate shocks and other hazards.
- Minimizing degradation of the terrestrial and aquatic ecosystems.
- Diversifying livelihood strategies.

INTRODUCTION

The Niger River Basin covers 7.5% of the continent spread across ten riparian countries. The part of the basin which extends into Algeria is hydrologically inactive and is therefore not taken into account (Figure 1). Accordingly, Algeria, unlike the other nine countries, is not part of the Niger Basin Authority (NBA). The basin countries can be categorized into four groups based on their level of contribution to water resources of the basin and level of dependence on the basin's water resources. Guinea, Cameroon and Benin are significant contributors while Mali and Niger are currently the major consumers of the basin's water resources. Nigeria consumes, and contributes significantly to, the basin's water resources. Ivory Coast, Burkina Faso and Chad are minimum contributors and consumers of the basin's water resources, partly due to the small proportion of the basin situated in these countries (Andersen et al. 2005).

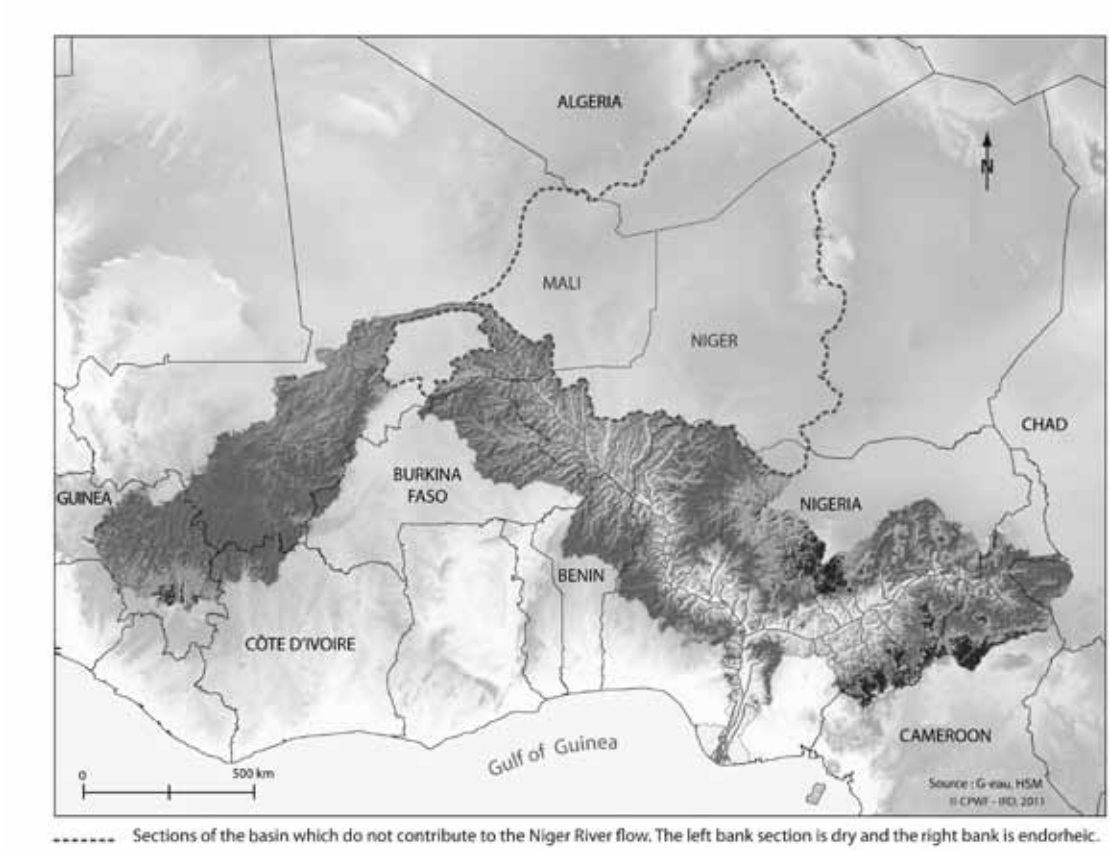

FIGURE 1. The Niger River Basin. *Source*: Clanet and Ogilvie 2009.

The availability of per capita renewable water resources of the basin is in decline due to a host of factors including increased cultivation and disappearance of natural vegetation, rainfall reduction related to climate change, and increasing human and livestock population (Wilby 2008). Precipitation was above the long-term mean from 1915 through the late 1930s, and the 1950s through 1960s, after which it was persistently below the long-term mean, with the largest negative anomalies in the early 1980s. The anomalies are with respect to the period 1900-2009 (Figure 2).

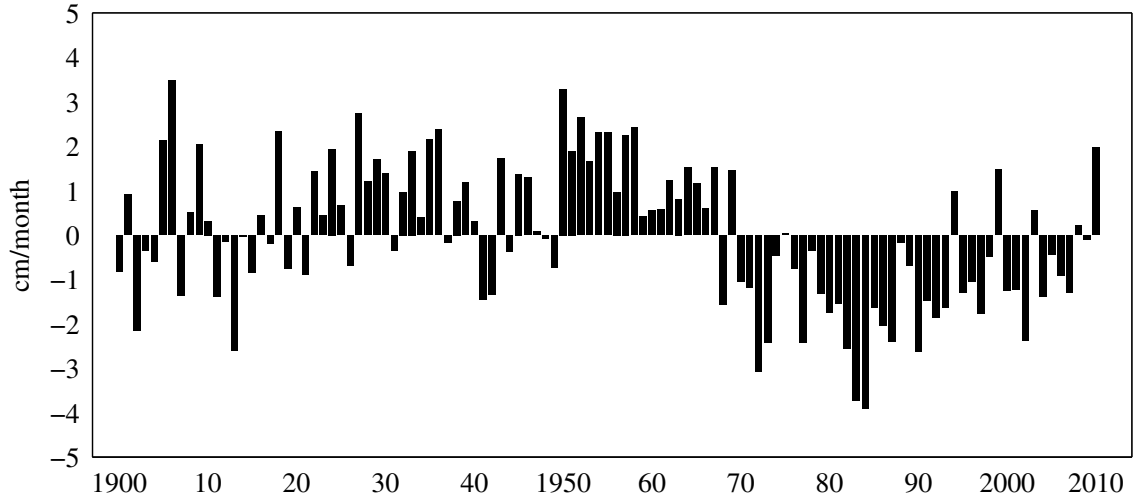

FIGURE 2. Sahel rainfall index (20-10N, 20W-10E), 1900–2010. *Source*: JISAO 2010.

The human population of the basin is about 100 million with an average annual growth rate which exceeds 3% (Ogilvie et al. 2010). It has an average population density of 50/square kilometer (km²). However, along the river course, where major cities are located, the population density often reaches higher than 200/km². A significant part of the northern zones of the basin is unpopulated. On average, the basin population is two-thirds rural. Though the level of urbanization may vary from country to country, urbanites constitute 40-70% of the basin population of Benin, Niger and Cameroon and 3-17% of the basin population of Ivory Coast, Mali and Guinea.

Niger River crosses four agroclimatic zones, namely humid tropical, dry tropical, semiarid and arid zones. Spatiotemporally, rainfall is much more variable, ranging from 4,000 millimeters (mm) in the Guinea Gulf to 200 mm in the Sahel (Diallo 2005). The basin has two distinct seasons, a rainy summer and a dry winter, except for Nigeria, which has four seasons. The monsoons occur from June to November with humid and unstable maritime equatorial air and relatively cool temperatures. The monsoons are longer and wetter in the southern part of the basin.

The interplay of climatic conditions together with a host of other physical, social and institutional factors has influenced the livelihood strategies found in the basin. These include: dry- and wet-season cropping, pastoral systems, crop-livestock systems, and fishing. The dry-season livelihood systems include fadama farming, recession flood farming, agroforestry, irrigated rice farming and fisheries. Wet-season livelihood systems rely predominantly on cereal cropping and transhumance. The major crops grown in the basin are yams, cassava, rice, groundnuts, millet, sorghum, plantains, cocoa beans, maize, sugarcane, and cotton. The basin's water resources are also used for transportation, trade, or even making bricks for homes. Agriculture represents a large part of the GDP of the Niger River Basin. Crop production alone accounts for 25-35% of the basin's GDP, livestock for 10-15% and fisheries for 1-4% (NBA 2007).

In line with the case for most international or transboundary rivers,[1] upstream and downstream conflicts emanating from the development and utilization of the Niger River are inevitable and are expected to be intense, particularly given the fast escalating demands for water for many uses and users. To facilitate efficient, sustainable and equitable development of the basin's water resources and design management interventions, it is necessary to classify the basin into manageable hydrological-socioeconomic units and visualize the interconnections among these units. Consequently, the basin is divided into four major sections, based on hydrological considerations. These are Upper Niger, Inland Delta, Middle Niger, and Lower Niger. But these divisions though useful are too generic to provide a complete understanding of biophysical, hydrological and socioeconomic processes impinging on the basin's water resources, and to guide the development of equitable and efficient policies, strategies, and interventions.

All of the Niger Basin countries are among the 30 poorest of the world and ranked very poor according to common poverty indicators (including child mortality, life expectancy, Social Vulnerability Index, etc.). Chad, Burkina Faso, Mali, and Niger are four of the poorest five with Niger being the last of 177 countries according to the United Nations Development Programme (UNDP) HDI (UNDP 2005). The proportion of people living below the poverty line (USD 1.25/day) is high across the basin and is especially acute in Burkina Faso (70.3%), Guinea (70.1%) and Niger (65.9%). The dynamics of poverty are complex and result from the interaction between structural causes, the biophysical environment, institutions and governance. Water quality is shown to have a significant impact on poverty, consistent with the negative impact of poor water and sanitation on human health. Improved agricultural water management (AWM) is also known to play a crucial role in poverty alleviation; however, it is not a sufficient condition, as reduced poverty depends on increased production that, in turn, depends on factors including land tenure, soil quality, fertilizer, machinery, storage, commercialization, etc. Interventions to reduce poverty must therefore attempt to account for the complex interactions between these many factors.

Irrigation is currently below its potential, as only about 0.9 million hectares (Mha) are currently irrigated out of 2.8 Mha. Nigeria, Mali and Niger possess the most area under irrigation, but there too it remains below the national potential (Table 1).

TABLE 1. Niger River Basin's irrigation potential and area under irrigation.

Country	Irrigation potential (ha)	Area under irrigation (ha)
Guinea	185,000	6,000
Ivory Coast	50,000	0
Mali	556,000	187,500
Burkina Faso	5,000	850
Benin	100,000	740
Niger	222,000	67,520
Cameroon	20,000	2,000
Nigeria	1,678,510	670,000
Niger Basin	2,816,510	924,610
Total	5,633,020	1,859,220

Source: FAO 1997.

[1]In this report, the words Niger River refer to surface water and groundwater flows, and the lakes and wetlands through which the river flows or passes. Moreover, in this report, the term 'international river' and 'transboundary river' are used interchangeably even though there is a long-standing debate over such terminologies. The Niger River can be considered as both an international and a transboundary river because the basin is situated within the borders of more than nine countries and crosses many intra-country administrative borders.

There is great potential to develop the transportation network of the Nile Basin to expand access to markets and commerce, and to increase labor flows. In many parts of the basin, inland navigation provides essential transport for people and goods. This potential is not fully exploited and existing navigational segments are underutilized. The transportation network can be improved to foster regional integration among and within the countries. Along the length of the Niger, navigation is possible for large flat-bottomed boats from the ocean throughout the entire year, and even farther upstream to Jebba (1,448 kilometers (km)) from August to February. Lake Kainji is navigable for 130 km. The Inland Delta is open to small fishing boats all year. In addition, several tributaries are navigable in high water, although when the water is low the channel in Lake Debo is not navigable. In general, the economic potential of the water resources of the Niger Basin, in the transport, agriculture, energy, industrial and domestic and sanitation sectors is not fully harnessed as yet due to the many challenges and constraints.

KEY DEVELOPMENT CHALLENGES AND CONSTRAINTS OF THE NIGER BASIN

A large segment of the population of the Niger Basin is in chronic poverty because of several structural factors. Additional development constraints and challenges threaten the vulnerability of the population across the basin. The nature and severity of these vary from location to location. The challenge of the Niger Basin is to use its many natural and human resources to generate sustainable growth and break free from poverty. Some of the prominent challenges facing the basin and its people are presented in the following sections.

Degradation of Land and Water Resources

The basin is endowed with a rich and diverse natural environment. The river has 36 families and nearly 250 species of freshwater fish, of which 20 are found nowhere else. Eleven of the 18 families of freshwater fish that are endemic to Africa are represented in the Niger River. The river's true delta in Nigeria contains West Africa's largest mangrove forest. But over the years people have reaped its riches with insufficient care for the livelihoods and well-being of future generations. The threats to livelihoods and ecosystems through deterioration in the natural resource base have been posed by a combination of human population growth, unsustainable resource use and development, and negative climatic conditions (NBA 2007). The environment is constantly deteriorating. Water, air, land, the forest, soils, climate, and the constituents of biodiversity, are elements whose optimal management is indispensable for ensuring some form of quality of life for the population.

The water bodies and infrastructure in the basin are silted due to natural and human causes such as intense rain episodes, low percentage of groundcover, steep slopes, deforestation, bush fires, overgrazing, and unsustainable agricultural methods. Moreover, the water bodies and infrastructure are polluted by waste from domestic users, industry, agriculture, handicrafts, mining, etc. Development has proceeded with no regard for waste management or pollution control. Cities have inadequate systems for the safe disposal and treatment of waste. As rural emigration to urban areas grows, the problem worsens. Environmental laws are inadequate and are not enforced. Aquatic plants such as water hyacinth and water lettuce are also proliferating water bodies and infrastructure.

The expansion of agricultural land has significantly contributed to the destruction of vegetation cover, and threatens streamflows and ecosystems (Diallo 2005). Land degradation is a major threat for land productivity and food production, which particularly affects the Sahel part of the basin.

The local fragile ecosystem is exposed to intense desertification and soil erosion. River flows in the basin are decreasing at the same time that fishing pressure is increasing, threatening the sustainability of the Niger's fisheries. The reduced water availability influences the livelihoods of those people living around the water, and many now live below the poverty line. The effects of deforestation and farming of fragile soils lead to sedimentation of river channels.

Population growth has led to the deforestation of watersheds, soil degradation and abusive cutting of the mangroves. Deforestation of watersheds causes the filling of lakes. Forests are used to meet the additional income, food or survival needs of the riparian populations of the forests, particularly during periods of shortage. Forests are also the main source of traditional pharmaceutical products. Pressure on resources and aggressions on the environment continue to be potential threats on the preservation of biodiversity. Nearly all households use wood/charcoal as the main cooking fuel. Electricity and kerosene are not used much by households contributing to the increasing deforestation of the basin. In rural areas, women are responsible for fetching wood, and they are forced to cover increasingly long distances to obtain daily supplies.

Deforestation and desertification are progressing unrelentingly. In Niger alone, natural forests have reduced from about 16 Mha in 1982 to about 5 Mha in 2006. In Ivory Coast, the area of dense forest, which was 12 Mha in 1960, had dwindled to 2.802 Mha by 2007, representing a loss of over 75% of the forest in less than half a century. A quarter of Nigeria's land was once covered by forest. Today just half of the forests remain, but the potential for their future exploitation is extremely limited. The advanced degradation of the forests has resulted from a combination of several factors namely extensive agriculture based on shifting cultivation and burning; a mining approach to forestry; cutting of wood for cooking; clandestine infiltration into classified forests, and national parks and reserves; hunting; livestock rearing; and frequent bush fires. In Ivory Coast alone, degradation resulting from farming activities affects about 40-50% of the forest area. This pressure on land has negative impacts not only on the rural lands but also on classified forests. Deforestation has been followed by erosion and desertification in some areas.

Climate Change and Climate Variability

The basin shows great climatological variability. Mean annual rainfall decreases northward from more than 4,100 mm in the south to less than 20 mm in Timbuktu. The fraction of the annual volume of discharge flowing past Mopti lost to evaporation may exceed 50% in some years. Most of the lakes are located in areas where rainfall is between 100 and 400 mm annually. Climate change and variability have brought a profound deterioration of traditional livelihood options. It leads notably to cereal and fodder shortages whose consequences are famine for the populations and the death of thousands of animals and trees, as was the case following the disastrous droughts in Niger in 1974 and 1984.

The climatic conditions of the Niger Basin follow medium-term cycles which have been deteriorating since the 1960s. The basin has witnessed several successive periods of low rainfall, which endangered agro-silvo-pastoral production, leading to long-term degradation of the environment and living conditions of the populations. There is evidence that the duration of the rainy season and rainfall volumes are reducing, resulting in hydrological deficits. In some parts of the basin (e.g., Niger), rainfall is spatiotemporally very irregular, and the number of days of annual rainfall varies widely. Recurrent periods of drought accompanied by reduced rainfall constitute the key characteristic of the current climate. Studies on climate variability in West Africa show a significant decrease in both the amount of annual rainfall and the onset and duration of the rainy season (L'Hôte and Mahé 1996 in Andersen et al. 2005). Associated climatic threats include severe

low flows, and water and soil erosion of rangelands. For instance, several watercourses dried up during the low flow period 1983-1985, necessitating the careful hydrological reexamination of several planned irrigation dam construction projects (PNUD 1990).

However, West Africa's climate change scenarios, particularly rainfall-related climate projections, are highly uncertain. Recent tests have shown the limited capacity of models to forecast West Africa's climate. For instance, the models predict the start of the rainy season 1-2 months earlier than the dates currently observed. A comparison of the observed Sahelian climate (1961-1990) with climates simulated by six general circulation models recommended by the Intergovernmental Panel on Climate Change (IPCC) illustrates the anomalies. Contrary to the real situation, the models show a marked rainy season almost throughout the year, along with a considerable bias (140-215 mm/year [yr]) in annual aggregate rainfall estimates as compared to the observed data.

There has been a substantial reduction in rainfall in West Africa over the last 50 years, with a clear break between 1968 and 1972. The reduction is extremely clear in the Sahel, with the highly deficient periods of 1972-73 and 1982-84 and in 1997. This trend has taken the form of a 200-km downward slide in isohyets towards the South, i.e., an aridification of the area's climate. The reduced rainfall observed in previous decades may however not continue, as from the mid-1990s, a return to increased rainfall has been noted, in particular in the Sahel. The decreased rainfall since the 1970s resulted in a drop in the streamflow of the rivers. The Niger River's streamflow fell by 30% between 1971 and 1989 and that of nearby rivers such as the Senegal and the Gambia fell by almost 60%. The flow reduction observed was locally greater than the drop in rainfall levels, notably in the Upper Niger Basin, where the reduced rainfall has a significant impact on groundwater recharge and related baseflow. Along with climatic factors, anthropic changes such as land use changes and increased withdrawals also have a significant impact on water resources in the basin (Niasse 2005).

West African farming is directly correlated to weather hazards. By 2100, estimated farm-sector losses due to climatic change and variability will reduce the regional GDP by 2-4%. Pastoral and rain-fed agropastoral areas will undoubtedly be the most affected by climatic variations. Food crops, mainly focused on cereal production in Sahelian countries, depend on the rainy season's characteristics, along with other climatic and environmental factors. Case studies undertaken in Burkina Faso, Mali, Niger and Senegal have come up with divergent results as to the impact of climatic changes. The average yield of millet and sorghum is likely to fall by 15 to 25% in Burkina Faso and Niger by 2080. These crops should be less vulnerable to temperature variations lower than 2 °C and to slight rainfall variations (± 10%). Conversely, irrigated and rain-fed rice yields are predicted to increase. Indeed a rise in the atmospheric concentration of CO_2 (fertilizer effect) and a moderate increase in temperature would lead to a 10-25% increase in cereal yields in the Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS) countries' irrigated areas and a 2-10% increase in rain-fed rice, assuming a sufficient water supply.

Along with cereal production, livestock farming plays an important role in all Sahelian countries. It contributes up to 10-15% of the GDP in Burkina Faso, Chad, Mali and Niger. Migratory pastoralism remains a production mode adapted to some Sahel-Saharan ecosystems, but has undergone significant transformations due to population growth and climatic variations. One of the significant innovations occurring in the Sahel over the last decades has been the birth and popularization of agro-pastoralism, i.e., the combination of crop farming and livestock breeding. This new livelihood strategy adopted by farmers and shepherds aims to limit the risks associated with the uncertain climate. Crop farming helps shepherds limit the purchase of cereals during the lean period, while crop farmers diversify their activities and capitalize on their income by investing in cattle. The 1973/74 and 1984/85 droughts

changed the spatial dynamics of migratory herding and pasturelands in the Sahel. The case of Fula breeders in the Dallol Bosso area (Niger) is noteworthy as it led many breeders to find refuge farther south in Benin and Nigeria where they sometimes settled.

Poor Performance of Existing Water Infrastructure

The main challenge facing the water sector in the rural area is poor use of the existing capacity of infrastructure. During 1997-2000, the productivity of the water sector was as low as 35%, which means that, for every 100 liters of water provided the sector recovers only 35 liters. The sector is characterized by weak internal management and a high rate of fraud, which limit the business performance of the companies that manage the system. The situation with the irrigation infrastructure is similar, as the collective management of irrigation water and maintenance of structures generate difficulties. The Office Du Niger, which was originally conceived to irrigate a million hectares, is currently only exploited on 100,000 ha due to poor planning and operation. Since the 1960s, in Nigeria, several large-scale irrigation schemes have been developed on the Niger and some of its tributaries, but many of these have not been adequately maintained. The costs of not taking full advantage of irrigated potential are high, and food import bills are rising rapidly.

Inadequate Investment in Water Infrastructure

At the basin level, around 6 km^3/yr are withdrawn from the river for agriculture, which ratio is low compared to the overall water availability of the basin (180 km^3/yr outflow in the Niger Delta, Nigeria). Nevertheless this value also hides important spatiotemporal variations. Indeed, in the Upper Niger for instance, the Markala Dam for the Office du Niger withdraws 5% of wet-season flows but this rises to 80% in the dry season. While there is scope for additional dams and irrigation projects, it is important when designing future projects to closely consider the impact on low flows. These additional infrastructures will also be required to increase their efficiency, in order to reduce their impact on downstream users.

Traditional rain-fed agriculture has until now succeeded in catering to the growing demand in cereals but as population rises and rainfall variability increases, irrigation will increasingly become a vital component of the livelihood strategies of rural communities. In some basin countries such as Mali and Niger the reduced flow of the Niger River has already led to a reduction in the land available for traditional irrigation. River banks and lakes are traditionally cultivated as water recedes. In Mali alone, up to 80,000 ha had been cultivated this way, assuring livelihoods to a population of some 250,000. The poor hydrological conditions of past years have reduced this area to around 15,000 ha. Similarly, up to 170,000 ha of floating rice, sustaining 500,000 people, were cultivated along the Niger, while in recent years the surface area under floating rice has shrunk to around 50,000 ha, partly because pre-flood rains often no longer attain the 140 mm benchmark, and partly because the inundated area has shrunk, thus restricting the area fit for rice cultivation.

The irregular rainfall, the difficult hydrogeological context of some regions, and the excessive depths to access the most productive aquifers are natural constraints which limit the development of irrigation. Expansion is therefore based on strategic dam construction, which can provide the necessary water storage across the whole basin. Currently, there are several planned dam construction projects. However, the implementations of these multipurpose dams often stall due to financial and economic constraints. Drought and reduced water availability have forced rural communities to migrate south to more humid conditions increasing pressure on the remaining floodplains and

wetlands. With this migration, traditional resource management has given way to survival needs that are ecologically unsustainable and lead to declining biodiversity and productivity of natural habitats. Irrigation may improve water availability for upstream users in arid areas, but will also inevitably increase the pressure on downstream ecosystems. Navigation and hydropower problems may also arise if more water is abstracted for agricultural purposes (JICA 1993). Competition over scarce water resources will increasingly become a source of tension between users and between countries. The heads of States of the basin countries have acknowledged the danger of unilateral planning and are committed to pursue a regional dialogue and seek support for cooperative and sustainable Integrated Water Resources Management (IWRM) of the Niger Basin.

Inadequate Public Services

The inadequate provision of public services also undermines efforts to reduce poverty in the basin. Inadequate infrastructure slows down the development of production capacities and access to basic social services.

Low education coverage

The low level of literacy and education affects the quality of human capital and overall factor productivity, possibilities of access to employment and income-generating activities, as well as the hygiene, health and environmental behavior of the populations. The educational system is dysfunctional, as there is a lack of sufficiently qualified graduates to meet the needs of the countries. In some basin countries, educational establishments are in decay, strikes are common, teachers go unpaid for months and corruption has become rampant. Poverty incidence is shown to progressively decline as the level of education increases, but a considerable percentage of children still do not have access to primary education. The education coverage is superior in urban areas where most economic activities, which demand qualified manpower, are located. There are sharp gender disparities in education, and despite recent improvements the boys' literacy rate has remained much higher than that of girls, due to sociocultural constraints. The financial burden of education also weighs highly on the poor; though education may be free, parents must typically pay for schoolbooks, uniforms or even school benches. In Guinea, the poorest quintile devotes 11.8% of its nonfood spending on the education of children registered in public schools. In comparison, the richest quintile devotes only 3% of its nonfood spending on education. All these factors undermine access to education and make it difficult to achieve poverty-reduction indicators.

Poor health services and conditions

Many poor people have no access to health services. In case of illness, poor people consult first of all traditional healers or practice self-medication instead of consulting modern health personnel. This situation reflects the lack of, or the long distance separating them from, health centers and the high cost of modern health services. There are disparities in access to health services along many angles of societal divisions, namely poverty status, gender, geographic location, etc. Consultation rates among poor households are considerably lower than the national average. Women from the poorest section of the population are attended less frequently by qualified health professionals. Infant and child mortality levels in rural areas remain high, with up to 25% of live births not reaching the age of 5. Respiratory diseases, water-related diseases including malaria and diarrhea and poor nutrition are the major causes of child mortality and morbidity.

In Burkina Faso, Ivory Coast and Nigeria the proportion of individuals with AIDS is considerable. In Nigeria, HIV/AIDS has become a major health and also social problem. There is a growing feminization of the pandemia and, for instance, in Ivory Coast, the rate is 6.4% for women compared to 2.9% for men. The economic poles of the countries including the major cities are the most affected zones. HIV/AIDS also threatens the basin's productivity and economy, with an already observable impact on some key sectors, notably health, education, agriculture and defense. In Nigeria, HIV seroprevalence in agro-industries is close to 17%. A significant proportion of hospital beds are occupied by AIDS patients, and the average period of hospital stays are on the rise. The number of children infected or affected by HIV/AIDS is high. Nearly 90% of infected children are infected through their mothers during pregnancy, delivery or breastfeeding.

Inadequate energy supply

The Niger River Basin has enormous hydroelectric power potential but little has been done to exploit it so far. Electricity ensures the well-being of the population and constitutes a key asset for competitiveness and development. There is significant urban-rural disparity in electricity coverage. In rural areas, smaller proportions of households have individual electricity meters, and poor people usually use a group meter. In the towns too, the supply of electricity is irregular and subject to frequent outage or cuts and the electricity services are not widespread. Among the basin countries, only Ivory Coast has managed to have a wide electricity coverage, which is ensured by six hydroelectric and three thermal power stations. Since 1994, the surplus of electricity production is exported via interconnection of the national grid with other countries in the basin, namely Benin, Burkina Faso, Mali and Togo. The very low rate of access to modern energy services has considerable influence on the quality of life of households.

The energy situation of the Niger Basin is characterized by low energy consumption per inhabitant, a major part of which comes from biomass. The major energy sources in order of importance are biomass, hydrocarbons and electricity. As the supply of modern fuels is not widespread, firewood and charcoal are the main fuels used by households for cooking. For instance in Niger, forests provide about 87% of the national energy requirements, as well as 97% of household energy consumption. Rural energy supply, particularly rural electrification, is usually planned for lighting. No consideration is given to the productive use of electricity in rural areas, particularly for agriculture.

Low domestic water supply and sanitation coverage

Human settlements in most parts of the Niger Basin are characterized by a lack or insufficiency of sanitation services, whether for the removal of wastewater, or for the elimination of solid waste. Very few towns have master plans for sanitation services, and much less for sanitation systems. The wastewater and sanitation have always been relegated to the background in national investment programs. One of the direct results of this is the degradation of the natural environment and negative impacts on the health of the population. Despite the implementation of numerous projects, access to drinking water and hygiene remains problematic in rural areas. Borehole wells are the main supply source of drinking water for households throughout the basin, particularly in the rural, and therefore the poor, areas. Huge efforts have to be exerted in many localities, where the number of clean water points per thousand inhabitants is close to zero.

Households that have no sanitation systems are among the poorest. For instance, in Ivory Coast, while the poverty rate is only 10.8% among households with water closet (WC) toilets, it is 44.8% among those that use pit latrines and 67.9% in households without any WC. Similarly, the population having access to potable water is less poor than that using other sources of water supply. For instance, again in Ivory Coast, the poverty rate is 18.9% or 23.3% among population groups having a private or public standpipe. On the other hand, the rate is 49.9% among those using water from wells and 53.0% among those consuming surface water.

The use of water for drinking from traditional unprotected sources such as wells, marshes, ponds, etc., results in outbreak of deadly waterborne diseases, notably diarrhea, cholera, onchocerciasis, bilharzias, guinea worm, etc. At the social level, this situation leads to social unrests, strikes and acts of hooliganism with regard to potable water supply facilities. The long time spent on the chores of women, girls and children in fetching water results in a decline in admission rates, especially of young girls to schools and on time available for homework of those who already attend schools. The time spent fetching water or falling ill due to poor quality of water, sanitation and hygiene leads to a drop in agricultural productivity and, consequently, in economic growth.

Poor transportation and communication services

The population in the Niger Basin faces real difficulties as a result of poor transportation services. It takes households several minutes or hours to reach the nearest public transportation services and these are particularly scarce in rural areas. Often, private taxis have replaced public transport, which is ineffective. The transport sector has a structuring effect on other sectors of activity, and if smooth, may greatly enhance the well-being of the population. It opens up rural areas, enhances access to education, health services and markets which boost the competitiveness of the national economy, triggers private investments, and increases the integration of the country in the regional and international economy. Poor people have less access to transport. For example, in Guinea, the average time required to reach a health center and a food market is nearly 1.8 times greater for the poorest 20% of households than for the richest 20%.

Although there are slight differences, the road density of member countries of the Niger Basin is low. For instance, in Guinea, the road density is 2.9 km/100 km^2 compared to 6-10 km/100 km^2 in other sub-Saharan countries. Only small sections of the road network are asphalted and un-asphalted roads pose accessibility problems, especially in the forest region due to the high rainfall and spongy, porous soils. Large countries such as Niger and Mali have very large expanses of land with low population density and face serious challenges in terms of providing not only adequate affordable transport but also other economic and social infrastructures (schools, hospitals, etc.). Furthermore, many of the basin countries are far from maritime embarking points. For instance, Niamey is located 1,060 km away from Cotonou's port, and Zinder is 1,510 km away from Lagos. The absence of railways, the low navigability of the Niger River and inadequate airport facilities make domestic and external transport dependent mainly on road transport (95%). The landlocked position of many of the basin countries constitutes a serious handicap for the import of inputs and capital goods, as well as for exports. Finally, existing roads are also badly damaged and poorly maintained, as the average speed observed on existing roads is typically limited to not more than 35 km/h for 4-wheel drive vehicles.

In this situation, where the road infrastructure is poorly developed and where the major towns are subject to major congestion, telephones could compensate for existing shortcomings and help improve economic activity. Indeed, transportation and telephones are, to a certain extent, interchangeable goods. Access to local area network (LAN) telephones remains poor but the rapidly

growing introduction of mobile phones may improve the situation. Communication systems, among other things, can help circulate information on markets and weather information to warn of risks. Access to postal services is only possible on foot for the majority of the poor. Less than 1% of the poor have an Internet connection at home.

Poor Performance of the Agriculture Sector

Agriculture in the basin relies predominantly on subsistence farming. Extents of farms are generally small and shared. For instance in Guinea, although the average size of plots held by households is 9.8 ha, it is in fact exaggerated by a small proportion of relatively big farmers. Half of all agricultural operations are less than 2 ha each in size and two-thirds are less than 3 ha each. Although almost all farming households have a manual tool (machete, hoe, rake, wheelbarrow, etc.), only slightly more than one in ten have a tool pulled by an animal or a mechanical tool. Therefore, it is not surprising to find that these farming operations declare an extremely low level of productive capital.

Nonetheless, agriculture accounts for a substantial proportion of the GDP of Niger Basin countries. Even in Nigeria, despite the dominant role of the petroleum sector as the major foreign exchange earner, agriculture remains the mainstay of the economy. It is the largest nonoil export earner, the largest employer of labor, and a key contributor to wealth creation and poverty alleviation. Over the past 25 years, total cereal production has succeeded in meeting the increased demand in the basin. However, the rate of growth in agricultural production may not be sufficient to keep pace with the needs of a rapidly growing population, and the changing diets (more kilocalories [kcal], more meat). In certain countries, this has already resulted in a progressive increase in import bills for food and industrial raw materials (ECOWAS 2005). Likewise, in many countries, national rice production is insufficient to cover the growing demand for this staple crop and cannot compete with the low cost of imported Asian rice (Figure 3).

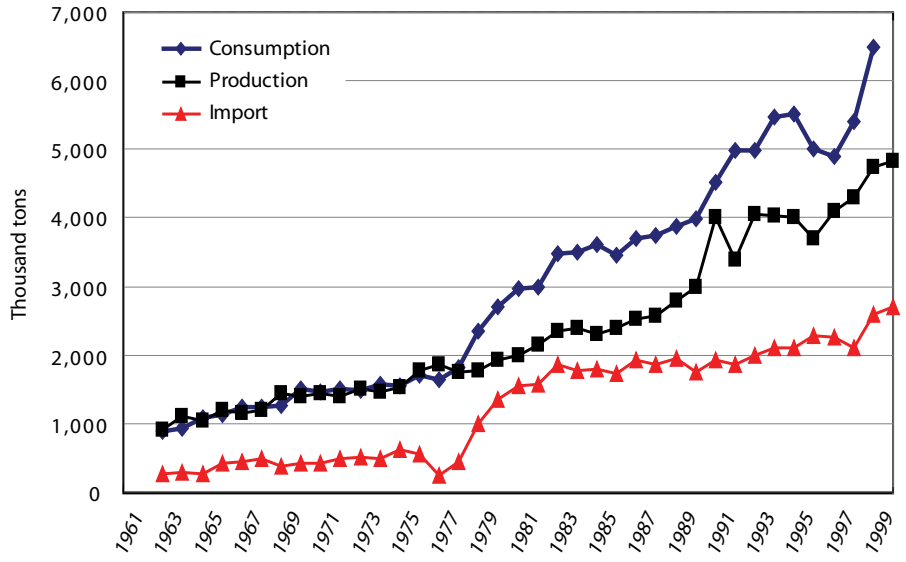

FIGURE 3. Rice consumption, production and import trends in West Africa. *Source*: WARDA 2000.

With the economy being highly dependent on agriculture, it remains vulnerable to unstable climatic conditions. It is also based on archaic and inefficient production methods, which result in the food production sector employing 85% of the labor force, 90% of whom are women. Except for irrigated rice, the production system has not experienced any major improvement (Figure 4). It is basically carried out by small-scale farmers using rudimentary material and registers very low yields.

Rain-fed production accounts for the bulk of the basin's agricultural production, but it is prone to vagaries of weather such as droughts. Crop production mainly comprises millet, sorghum, rice, *fonio* (millet), maize, yam, cassava, plantain, groundnut, sesame, sorrel, onion, sweet sedge, cotton, cowpea, *souchet* (tiger nut), and vegetables, most of which are for self-consumption.

In some countries/localities, food production shows some improvement thanks to an increase in the cultivated areas and not its intensification (IMF 2008a, 2008b, 2008c, 2008d, 2008e). This presents a great challenge to the reduction of poverty in rural areas. In conclusion, the various crop yields are low and fluctuating because of the low level of fertilization, reduction of fallow period and extension of farmlands into marginal and environmentally sensitive areas, the low technological level of current production systems, and the small size of the parcels (between 0.25 and 0.5 ha/ family) which does not allow for economically profitable farming and post-harvest losses.

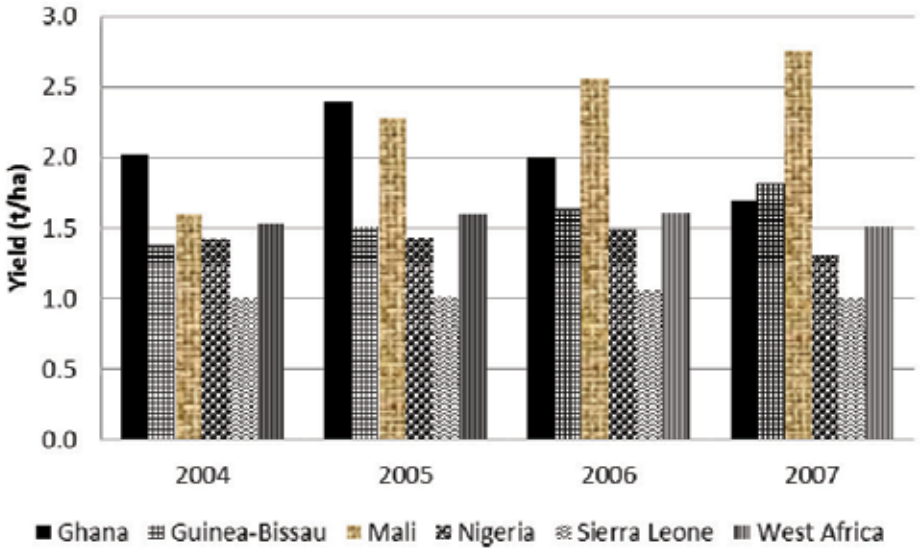

Figure 4. Paddy yield during the years 2004 to 2007 in West Africa.

The predominance of agriculture in the economy and its dependence on climatic factors lead to volatile and erratic economic growth, thereby affecting its sustainability. For instance, in Niger, abundant rainfall can trigger double-digit growth rates (as in 1998), while rainfall shortages generally coincide with economic recession (as in 2004).

The livestock population comprises camels, cattle, donkeys, goats, horses, poultry and sheep. Milk and by-products constitute the main food for a substantial proportion of the population, and an important supplementary food for the remaining majority. Hides and skins were important sources of foreign currency for many of the basin countries in 2003. This production potential is high in terms of quantity and quality, especially as it concerns small ruminants. However, the livestock exploitation rate remains relatively low. Average milk production per cow is estimated between 1

and 2 liters/day, which is far below the increasing domestic demand, and Niger Basin countries have become importers of dairy products. In Niger alone, imports of powdered milk stood at about Communauté Financière Africaine Franc (CFAF)[2] 5 billion (nearly USD 2.26 million). The low capacity of storage facilities and modern slaughterhouses has contributed to this situation. Livestock feeding and access to water pose serious problems. The problem of watering livestock is acute in pastoral areas, particularly during the 9 months of the dry season, and also due to the fluctuating and unstable fodder resources.

Fisheries and aquaculture are carried out on many water bodies in the Niger Basin occupying an important place in the economy of the basin countries. Fish is the main source of animal protein for many consumers. Many varieties of fish are found in the Niger River and its tributaries. However, the actual annual catch is less than half of what it used to be, because both the area under water and the total available volume have been reduced. Production equipment for industrial fisheries and traditional fishing has degraded compromising competitiveness of the sector.

In summary, the main challenges of the agriculture sector are the following:

- Continued dependence on rain-fed agriculture.
- Unfavorable land tenure system.
- Inefficiencies in financial and marketing services.
- Decline in political commitment to agricultural and rural development and inadequate incentive framework and pervasive distortions in the macro-economy.
- Rapid shift of the population from rural to urban areas and the shift in consumption patterns from local to imported food items.
- The generalized aging of the plantations of coffee, cocoa, oil palm and coconut trees.
- The inadequate use and low mastery of modern farming techniques.

Institutions and Policies

In the basin, civil society on the whole is relatively weak and inexperienced. It does not yet have all the basic capacities in the areas of organization, communication, financial management and defense of its interests to play a role as a true partner of the government. Macroeconomic policy has been highly circumscribed by inefficient, volatile, and unsustainable public-sector spending and by unusually high volatility of major macroeconomic aggregates. During the last 3 decades, the economic policies have significantly changed with direct and indirect effects on the basin countries' social and economic conditions. Chief among these changes were the policy reforms and structural adjustment programs that have eliminated many public agricultural support programs, creating a vacuum that has not yet been filled by the private sector. Consequently, farmers faced more difficult access to inputs and higher input costs. Input use has stagnated or declined, yet higher population and less land for expansion of cultivation make it vital to increase the productivity of already cultivated land through adoption of intensive agricultural production techniques. Too little investment is occurring in inputs and land improvements that maintain soil fertility, control erosion, and improve water availability. The dilemma is how to ensure such investments are financially and economically profitable and affordable.

[2] Current rate: USD 1 = CFAF 443.

The inflation rate in many of the basin countries is higher than the 3% ceiling set by Western Africa Economic and Monetary Union. The inflationary pressure can largely be explained by weak supply due to poor agricultural production. Imports are rising, due to the growing demand for food products and intermediary and capital goods for infrastructural projects, which widen the trade deficit. In Niger, the revenue balance continued to benefit from the debt relief granted under the Heavily Indebted Poor Countries (HIPC) Initiative of the International Monetary Fund (IMF) and World Bank. Year-on-year inflation, meanwhile, rose from 5.4% in 2002 to 39.1% in 2006. In Mali, the average inflation rate was 1.9% over the 2002-2005 period, thereby remaining below the tolerable level of 3%. In Burkina Faso, the general price level increased moderately in 2006 compared to 2005. Inflation is well controlled in Burkina Faso. In Cameroon, this growth was accompanied by a 5.1% rise in prices as measured by the consumer price index, as against 2% in 2005.

Finances at all levels of the government are in poor shape. The poor have less access to credit than the nonpoor. Hence, to meet their liquidity needs, the population generally resorts to parents, friends and acquaintances, and remittances. Indeed, loans between individuals represent 80% of loans granted to the poor and 67% of loans granted to the nonpoor. Taking into account the loans granted within the system of tontines, this proportion increases to 86% among the poor and 71% among the non-poor.

There is limited institutional and organizational capacity to deal with development challenges. The available institutions are technically ill-equipped to monitor, control and evaluate the basin's water resources. The notable institutions with competence to conduct activities which directly or indirectly contribute to the improvements of the living conditions of the basin population include NBA, CILSS, and Le Centre pour l'agriculture, la recherche hydraulique et météorologique (AGRHYMET), etc. NBA deals with activities such as monitoring and management of water resources, protection of ecosystems, the coordination of national policies in all those areas, and finally the integrated development of the Niger River Basin. AGRHYMET, rather, focuses on food security, monitoring of the environment and training of nationals of CILSS member countries in agro-hydrometeorology. Recently, these institutions agreed to develop synergies so as to valorize their scientific, technical and human achievements and avoid duplication.

Problems of governance generally translate into poor economic performance, persistent institutional and legal obstacles, low professional and organizational capacity and widespread corruption. The weaknesses in judicial and security systems are factors that hinder the development of the private sector (e.g., Guinea, Ivory Coast, Nigeria and Niger). There is difficulty in mobilizing private investment. Businesses wishing to operate face many constraints, including poor infrastructure; inadequate physical security; corruption; weak enforcement of contracts; the high cost of finance; poorly defined property rights; and unstable macroeconomic policies, especially fiscal and trade policy. These factors have deterred foreign entrepreneurs from investing and induced many people to take their money and skills abroad. The economic structure of the basin countries remains highly undiversified. In many of the basin countries, the main challenges are, on the one hand, maintaining and consolidating social peace and, on the other, reviving economic and social development. Public-sector mismanagement and corrupt governance (e.g., Nigeria, Guinea, and Niger) have encouraged many people to seek inappropriate ways of sharing the national income such as through violence. Corruption seems to be, institutionalized; government was widely regarded as a provider of large contracts, distributed by officers in power to people wealthy enough to buy their influence. Over time, the judiciary became intimidated, as the rich and powerful manipulated laws and regulations to their advantage. They are strengthened by evidence of weak institutions. As a result, implementation failures are persistent (IMF 2005, 2009). The judiciary system suffers from other difficulties of access

of the population to justice due to high cost of the services. It is marked by the excessive slowness in the consideration and issue of deeds and considerable delays in the execution of decisions.

There is a weak statistical information system for the preparation, monitoring and evaluation of policies, projects and programs. The culture of monitoring-evaluation is not deeply rooted in the management modes of public affairs. This situation favors illegal enrichment, and increased corruption in all its forms. The poor management of public resources and the shortcomings of the institutional, legal, and regulatory framework are major constraints of economic development and social cohesion. Moreover, cohabitation and mutual acceptance between people of diverse origins have collapsed because of the strong pressure on jobs and natural resources, notably land and water. The erosion of social cohesion accentuated a number of conflicts. Issues related to landownership cause intercommunity and intra-community conflicts. Land disputes have been aggravated due to a surge in the demand for land/water from unemployed young people due to the economic crisis in other sectors. It has contributed to the deterioration of the confidence between the communities and favored social divisions through conflicts between generations and sociopolitical crises. Conflicts for control of natural resources have spread to stretches of lagoon, river and lake waters where tensions are often rife between fishermen from elsewhere and the locality.

Difficulties in the promotion of women and gender mainstreaming into policies are also major constraints. Beliefs and values affect the position of women in society, limiting access by girls to quality education and by women to employment; and thereby reducing the country's human capital potential.

Rampant Poverty and Inequality

Poverty generates multifaceted effects at the individual and collective levels. It exacerbates inequalities of access to opportunities and outputs and destroys the integrity of families, households or communities and lead to their deviancy. Poverty brings about psychological stress: it breeds not only humiliation and loss of self-pride, but also some skepticism, despair and passivity. In countries such as Mali, the level of poverty was reduced from 68.3% in 2001 to 59.2% in 2005. However, the level of this reduction is not commensurate with the desired target due to poor control of population growth, inadequate growth rate of the economy, unequal distribution of the fruits of growth, and limited access to basic services. Similarly, in Niger, the economic growth rate of 3.9%/yr on average between 2002 and 2006 is not enough to reduce poverty significantly and put Niger on track towards achievement of the MDGs. Furthermore, the high population growth rate of 3.3%, which is one of the highest in the world, limits performance, particularly in the basic social sectors, by each day increasing the demand for infrastructure and resources.

In Burkina Faso, macroeconomic and poverty simulations indicate a lowering of the incidence of poverty, from 46.4% in 2003 to 40.8% in 2006. The cumulative effects of economic growth observed in 2003 (8%), 2004 (4.6%), 2005 (7.1%), and 2006 (6.4%), contributed to a reduction of the total incidence of poverty. One also observes a tendency to a more marked decrease of the incidence of poverty in rural areas (- 5.4 points) than in urban areas (- 3.6 points) between 2003 and 2006. In Burkina Faso, simulations have shown that, ceteris paribus, a 1% increase in real GDP in 2006 led to a 0.6% in poverty reduction. In Ivory Coast, the economy virtually stagnated, whereas the population continued to increase at a rate close to 3%; as a result, the average real income, rather, declined in the recent period. Eventually, poverty increased by 10 points between 2002 and 2008. In Ivory Coast, today, one out of every two persons is poor compared to one out of ten in 1985 and the number of poor has been multiplied by 10 in the space of a generation. Poverty has, therefore, increased in a steady trend, going from 10.0% in 1985 to 36.8% in 1995 and

to 33.6% in 1998 before increasing further to 38.4% in 2002 and eventually to 48.9% in 2008. In Guinea, the poverty rate increased from 49% in 2002 to 62.45% in 2008 in rural areas as against 24.5% and 29.45%, respectively, over the same period in urban areas. For decades, Nigeria has struggled to improve socioeconomic conditions, which have declined despite increasing revenue from crude oil. The growing incidence and the dynamics of poverty in Nigeria have stratified and polarized Nigerian society between the haves and the have-nots, between the north and the south, and between the educated and the uneducated.

The proportion of the poor working in the agriculture sector is high. The proportions of the poor in the other sectors are relatively smaller. One of the characteristics of poverty in the basin is the very high concentration of income. For instance, households in the first quintile (20% poorest) have only a less than 10% share of total consumption. At the other extreme, households in the fifth quintile (20% richest) account for about 50% of total consumption.

A generic analysis of poverty reveals major disparities to the detriment of women. Analyses show that, ceteris paribus, a household headed by a woman runs greater risk of having a lower standard of living than one headed by a man. Women are also disadvantaged in terms of working time, due to the combination of family and professional activities. Women who farm have a work load that ranges from 15 to 17 hours a day. Women's work is made still harder by a lack of equipment, a low level of transformation of food products and the distance from water points and sources of firewood.

Poverty is more prevalent in the dry savannah where agriculture provides scarce returns. This agroecological factor is accompanied by insufficient or even nonexistent socioeconomic infrastructure and poor endowment of qualified human resources. Social conditions in the Niger Basin present a startling paradox: despite a rich endowment of natural and human resources, most of the basin's population is poor.

High Population Growth and Rural Urban Migration

Rapid population growth makes the Niger Basin one of the areas with the highest fertility rate in the world. Indeed, due to low levels of income and capital stock, rapid population growth is a major constraint on economic growth, because the net per capita savings rates are not enough to allow for capital accumulation. Furthermore, the poor populations, in rural or peri-urban areas with very large families, very often have the lowest resources and consequently cannot afford adequate health and educational services, as well as drinking water or sanitation. In these areas, poverty increases and becomes a self-sustained phenomenon.

The Niger Basin harbors countries such as Nigeria, whose urbanization rate (about 5.3% a year) is one of the fastest in the world. This situation leads to urban unemployment and its attendant problems of slums, crime, and high sociopolitical tensions. Population pressure coupled with lack of employment in the rural sector is causing massive rural-urban migration. These poor people are usually concentrated in the suburbs of the cities. In Niger, the larger the household size, the higher the proportion of poor people, particularly in urban areas. The percentage of poor people in households of more than 13 persons is four times higher than in households with less than three persons. Furthermore, households with a larger number of children, have higher probability of being poor because each additional child reduces the share of food for consumption.

POTENTIAL INTERVENTIONS

Many of the basin countries envision being modern, civil, democratic, well-governed countries founded on a dynamic, diversified and sustainable economy, harmoniously distributed on the national territories. They strive to become prosperous, equitable and respectful of ethics, united, peaceful and committed to African integration. The development visions, goals and objectives of basin countries parallel the development challenges described in the previous section and are articulated in various documents such as the Niger Basin Shared Vision, Poverty Reduction Strategy Papers, UN MDGs and the NEPAD/CAADP program (pillars 1, 2, 3 and 4).

Many of the basin countries have adopted all or most of the UN MDGs and have reflected them in their Poverty Reduction Strategy Papers. The core objective is to increase income, improve living standards (i.e., access to health care, drinking water, decent housing, sanitation, education, etc.) and alleviate poverty. They strive to attain food security through producing the bulk of food products on national territory. Sustainable management of water resources of the Niger Basin may significantly contribute to the attainment of these objectives.

To achieve the development missions, goals and objectives of the Niger Basin countries, priority intervention areas that may help remove the identified development constraints and challenges have been identified. The interventions use water as an entry point for poverty alleviation, food security, and economic growth in the basin. Synergy in the implementation of these interventions should help to effectively fight against poverty.

Ensuring the Right to Secure Access to Water for the Poor

Securing water access through better policies and institutions

The rising demand for limited water resources of the Niger Basin makes sharing and prioritization of use unavoidable. Local norms and rules generally guarantee that everyone has equitable access to water. However, formal water legislation and priority setting under scarcity can often only weakly protect the poor (Derham et al. 2005). An equitable pro-poor water allocation arrangement guarantees acceptable minimum quantities of water for all and sets rules for the few who want to claim any surplus (van Koppen et al. 2002). Another important way to increase the security of local water rights is to assign the rights to collectives rather than to individuals (Boelens and Hoogendam 2002). Although not recognized by formal legal frameworks, rights to water are often claimed on the basis of landownership. Thus, where land distribution is skewed against the poor, water is also likely to be unevenly distributed. Land with a water source tends to have a higher value than land without one, making landownership-based rights to water even more inaccessible to the poor.

Developing infrastructure

In the basin, the justification for development and investment is evident as the ‘great’ river holds tremendous potential. At the moment, water resources in the Niger Basin may be abundant except in specific sections such as the Sahel. But the desert margin is expanding; climate change is impacting on both the absolute quantity and distribution of rainfall; urbanization, industrialization, and human and livestock population are threatening the quality of the available water thus reducing the overall available water for productive and consumptive use. Moreover, there is a backlog of investment needs in water infrastructure. This need is reflected in various national, regional and continental

programs and policies. Thus infrastructure to utilize the basin water resources to increase wealth and alleviate poverty while preserving the quality of water resources is required more than ever. These infrastructures include multipurpose dams that extend the area equipped for irrigation, increase energy production through expanded hydropower generation and increase fish production. Irrigation is both the highest consumer of water and an excellent way of gearing up development because it helps create wealth and employment and makes an important contribution to issues like food security. Increase in energy production through expanded hydropower generation, particularly in the rural setting, would have multifarious beneficial socioeconomic impacts such as inducing a whole set of farm, off-farm, and nonfarm economic activities thus diversifying livelihoods, and triggering the development of services, businesses, and productive sectors other than agriculture. It also enhances the development of groundwater-based agricultural economy as observed in many South and East Asian countries and expands private smallholder irrigation systems through enhancing the adoption of electric powered pumps for abstracting water.

Surface water/groundwater transfers are considerable in the Niger Basin. Thus, investment in infrastructure that facilitates the conjunctive uses of surface and subsurface water resources is generally recommended as part of an integrated water resources management.

Improving access to innovations in AWM

Due to technical innovations some of the technologies for lifting, channeling, and distributing water from various sources (e.g., reservoirs or dams, rivers, streams, lakes, and aquifers), such as small motorized pumps (powered by different energy sources including fuel, solar, wind, electricity and human), micro-sprinklers, drips, etc., are brought within the financial reach of many smallholder farmers. Small-scale localized water management systems, which are based on the adoption of these technologies, are generally more suited to the needs of the poor. Examples of successful programs based on individual or group ownership of AWM technologies are many but the *fadama* development projects in Nigeria are exemplary. These systems are spreading within the basin supported by the government and nongovernmental organizations (NGOs). Some of the promising technologies are:

- Low-cost drip and sprinkler systems.
- Low-cost water storage systems.
- Small motorized pump-based irrigation systems, etc.

Empowering People to Better Use Niger Basin's Water Resources and Infrastructure

Strengthening Niger Basin's water governance

Cooperative strategic interventions in the Niger Basin are much needed if lasting benefits are to be attained and felt by all. There are two aspects that need to be addressed: the protection of the Niger Basin water as a natural resource, and the development and management of water infrastructure in the basin at present and in the future. As a transboundary river, Niger requires cross-basin legal and regulatory mechanisms with clear implementation and enforcement pathways. There is already an established basin institution in the form of the NBA. What is needed is to strengthen its capacity and create conditions that are favorable for enforcement of laws and regulations pinpointed in NBA's documents. Recognizing that the root cause of many water problems is related to poor water governance, there has been a wide call for reform. Common elements in such reform initiatives

are decentralized decision making involving institutionalization of user participation, assignment of private property or extensive use rights to water, and greater reliance on market mechanisms to ensure the most cost-effective allocation and management of scarce water resources. The water-sector reforms, however, have been constrained in many countries by various factors, among which are internal resistance from executives of institutions, the lack of political will, political instability, and dependence on development partners to find the resources for reforms.

Governance of the Niger Basin water as a natural resource requires the following:

- Synchronization of institutional structures of water including water laws, water policies and water administration, project selection criteria, water pricing and cost recovery policies, and user participatory and privatization policy.
- Streamlining of the water laws of the basin countries clearly defining intergovernmental responsibility, water rights (including informal/micro-local water rights) and clarifying accountability.
- Improving the basin water administration through standardization or synchronization of organizational and managerial structures including regulatory apparatus and conflict resolution mechanisms of basin member countries.
- Improving gender equality. In many cases, water resource policies and programs have proven detrimental to women's land and water rights and, therefore, to their sustainable management and use (Castillo et al. 2007).
- Strengthening the voice of the poor in decisions affecting their well-being. One way to tackle this is to craft and support institutions and processes that have the ability to speak upward from the village level to higher levels and to make the voices of the poor heard. However, having the right to voice opinions is not the same as having the power to set the agenda. It proposes special programs targeting people who have the weakest political voice and who are most vulnerable to the ravages of poverty.

Improving productivity of existing water infrastructure

The limited available agricultural water infrastructures in the Niger Basin are poorly maintained, operated and utilized owing to complex economic, institutional, administrative, managerial, and policy failures, which need proper diagnosis to formulate corrective interventions and strategies to enhance productivity and sustainability of existing water infrastructure. Below is a menu of interventions that may be implemented to enhance the productivity of existing infrastructure.

Recognizing multiple-use of water infrastructure. A promising pathway to using water more effectively for poverty reduction and gender equity is a multiple-use water services approach, which takes poor women and men's multiple water needs as the starting point. This approach recognizes that when rural communities construct their own wells, village tanks, household storage, and other water infrastructure they typically do so for multiple uses. Multi-functionality, flexibility, and the tapping of conjunctive water sources enable poor people to accommodate a range of water needs, to attenuate the negative effect of seasonal variation, and to spread risks and cope with extreme events.

Livestock-rearing, fishing, and aquaculture activities represent a significant share of farm production in most farming systems of the basin and are significant sources of cash income and nutrition for households with small landholdings. Integrating these livelihood systems into existing water infrastructure is an effective way to improve their productivity. There are numerous

small dams or reservoirs in the basin functioning well below their design potential in terms of their economic contribution to rural people. Supporting or developing fish-farming and better management of fish stocks will contribute to improvement in productivity.

Strengthening water infrastructure governance and management. Many of the existing water infrastructure be it hydro-dams or irrigation systems are underutilized. In most cases, the structures are operating at about 50% capacity. Improvements in water infrastructure governance are also one way of improving the performance of the systems. Infrastructure governance is a broad term that includes institutions, organizations and policies. The solutions to the problems also require redressing the technical, biophysical, economic, social, and institutional anomalies. Some of the suggested technical and institutional interventions include the following:

- Rehabilitating existing irrigation schemes to increase and secure agricultural productivity.
- Reducing the sources of pollution of water resources.
- Improving the safety, efficiency and effectiveness of the facilities.
- Prolonging the life span of infrastructure through preventive measures of dam silting and integrated catchment area development.
- Managing degraded ecosystems while providing incentives to communities through income-generation activities.
- Strengthening water user associations (WUAs), participation in infrastructural management, water allocation and distribution decisions.
- Designing and implementing socially just cost-recovery policy that takes the users' ability and willingness to pay as the main parameter and that targets the operation and maintenance (O&M) cost of the infrastructure. The cost recovery policy must embrace transparency in the determination of user fees, relating fees to the level of water consumed.
- Using water pricing as a mechanism of improving water resources use efficiency, not as a mere cost recovery tool.
- Improving water administration through decentralization of management and responsibilities but avoiding dispersal of organizational responsibilities, and improving functional linkages among water organizations.

Linking farmers to input and output markets. One way of improving the productivity and performance of irrigation infrastructure is by improving the profitability of irrigated agricultural production systems through improving the functioning of input and output markets. The functioning of input and output markets is crucial to improve input access and reduce the unit cost of inputs to farmers and access reasonable output prices. An increase in market access can be partly facilitated through developing and extending navigation systems. But one main problem is that infrastructural developments in the Niger Basin such as dams are usually designed with little or no consideration of the impact of water abstraction on navigation downstream. Rehabilitation of both damaged locks at existing dams and junction canals to bypass certain stretches that are inaccessible by boat is necessary. Improve locks and/or links to permit sailing in parts of the river where navigation is currently impossible.

Some specific recommended actions are the following:

- Improve a) the coordination of input and output marketing systems, and b) incentives for private-sector involvement.

- Improve access to production areas, particularly through dirt roads, rural telephony and electrification.
- Support producer organizations and collective infrastructures.
- Improve food storage facilities to enhance the capacity of the food-reserve program as a step towards achieving food security.
- Promote joint venture, private-sector-managed, multi-commodity development and marketing companies to guarantee remunerative prices for farmers, stabilize consumer prices, and provide alternative markets for farm produce.
- Encourage out-grower systems: one opportunity for reducing marketing and production risk for smallholders will be to attach them with nuclear farmers in the form of the out-grower system. These days, private investors are knocking on the doors of Niger Basin states in search of land/water for investment. These investors usually have elaborate or well-researched production and marketing plans and are usually targeting export markets and can, therefore, serve as a nucleus for the struggling smallholders.

Promoting crop diversification. Crop diversification is a key to the sustainability of the livelihoods of poor people, but smallholders face significant constraints to diversifying their enterprises. For instance, despite the high global demand for fruits and vegetables, poor farmers are not benefiting from the production of such crops. In the national development plans, there is a tendency to consign smallholders to the production of staple crops, reserving production of high-value, cash and exportable crops for large-scale or commercial farmers. Crop diversification usually, but not always, requires changes in the design of existing irrigation infrastructure, as most past designs are suited to main staple crops such as rice. When an irrigation scheme experiences monocropping, particularly of staple cereal crops, several problems arise, such as nutrient mining, pest and diseases outbreak, low output prices, decreased farm income, and reduced farmers' incentive. Crop diversification greatly improves farm income and enhances farmers' ability to share the cost of rehabilitation, and O&M of irrigation systems.

Linking farmers to extension and financial services. Irrigated agriculture is a relatively knowledge- and capital-intensive venture. Because of the infancy of the irrigation sector development, support services, particularly in the area of extension advice, and financing services are not well developed. Research-based best agronomic, water management, and crop protection practices are hugely required for profitable irrigated farming. These practices ought to be disseminated to farmers through various channels including the radio, television, publications (e.g., pamphlets, leaflets, manuals, etc.), and adopting individual and group extension systems, which are often missing. It is also important to develop or encourage the availability of rural finance, not just credit services as usually done by governments and NGOs. The credit services should be promoted alongside with saving opportunities. Irrigators must be encouraged to save when there is abundant cash, following a bumper harvest or increased income.

Genetic improvement of crops. Irrigation allows farmers to overcome drought or moisture stress, which is one of the endemic production risks in the Niger Basin, particularly in the Sahel Zone. The removal of this risk often opens the way for farmers to adopt high-yielding crop varieties. The yield elasticity of local crop varieties under irrigated systems is significantly inferior to that of modern high-yielding varieties (Wood et al. 2004). Improved crop varieties will help boost agricultural productivity and tackle poverty head on. Thus, research on crop breeding should focus on breeding, screening and disseminating varieties responsive to water and other inputs such as fertilizer.

Improvements in on-farm water management. On-farm water management can be defined as the manipulation of water within the borders of an individual farm, a farming plot or field. It starts at the farm gate and ends at the disposal point of drainage water. The main components of on-farm water management are soil and water conservation, water application practices, drainage, soil amelioration and agronomy. It encompasses the management of all water used for crop production purposes including precipitation and water applied through irrigation. It also includes practices and tools to improve site conditions such as land leveling and crop-protection practices. All these have to be done within the context of the socioeconomic environment of the community and the farmers' personal situations. It generally seeks to optimize the soil-water-plant relationship to achieve a yield of desired product. The main aim of on-farm water management is to minimize water input while maximizing output or at least without compromising output to optimize profits. The farmers' incentive for minimizing water input varies by irrigation system typology. For instance, in public irrigation systems farmers have less incentive to adopt water saving practices as compared to those owning irrigation facilities. Improved on-farm water management practices increase the productivity of fertilizer and improved seed and encourage complementary farm-level investments.

Upgrading Rain-fed Systems

The bulk of the Niger Basin population depends on rain-fed agriculture. Thus, a modest productivity improvement in the rain-fed system would have a broader and deeper poverty reduction and food security outreach. One of the limiting factors of production in rain-fed systems is soil-moisture stress. In fact, efforts to breed and introduce improved crop varieties in rain-fed systems have not resulted in the desired outcome owing to failure of the introduced varieties under the moisture-stressed rain-fed agricultural systems (see Box 1).

Box 1.

Significance of AWM: Some empirical evidence.

Niger

In Niger, the performance of agriculture and other economic sectors is extremely vulnerable to erratic and declining rainfall and periodic droughts. Since 1970, Niger has experienced 13 years of deficit cereal production; in half of those years, the country was forced to import one-third of its food requirements. To counter these problems, the Government of Niger and donor agencies have sought to increase agricultural productivity by improving research and extension capacity for three of Niger's most important crops: millet, sorghum and cowpea. From 1986 to 1990, 68% of Niger's public outlays for agricultural research and 58% of its researchers were devoted to these three crops. In addition, since 1976, the United States Agency for International Development (USAID) has invested more than USD 22 million in research projects for these three crops, through the Institut National de la Recherche Agronomique du Niger (INRAN). In spite of increased investments in research and extension, cowpea yields increased by only 0.2% annually between 1961 and 1990, and sorghum and millet yields decreased by 0.7% and 2.7%/yr, respectively. The newly released varieties could not compete with local land varieties, which were developed through thousands of years of natural selection. Several factors contribute to the limited impact of research and extension in Niger. The risks that climate create for agricultural cultivation mean that the scope for

major increases in productivity from crop production research is limited. High-input varietal technology is unlikely to be adopted on a large scale because of the difficulty in obtaining yield increases substantial enough to make inputs profitable in the extremely dry climate. There was a visible underinvestment in water management.

Mali

Over the last 50 years, Mali has experienced a revolution in rice production in areas that benefited from access to irrigation water (i.e., areas served by the *Office du Niger*). The paddy yield jumped from as low as 1 tonne/ha to as high as 7 tonnes/ha (Aw and Diemer 2005), due to a series of interventions, including the rehabilitation of plots, improved practices, reduced surface areas to favor intensification (3-5 ha) as well as the devaluation of the CFAF which increased market prices and stimulated farmers (Ogilvie et al. 2010). Meanwhile the productivity of the rain-fed rice cultivation has not shown any remarkable improvement and remains close to 1 tonne/ha on average. The experience of *Office du Niger* testifies the importance of integrated AWM (i.e., technical and also political interventions) in enhancing productivity.

Interventions suggested below may help attenuate the effect of drought and boost productivity in rain-fed farming systems of the Niger Basin, which are as follows:

- Rainwater harvesting.
- Improving on-farm water management through adopting/adapting soil and water conservation practices such as mulching, ridging, and minimum or zero tillage, etc.
- Developing moisture-stress-tolerant crop varieties through both conventional (if possible) and unconventional crop breeding approaches.
- Integrating crop and livestock production practices.
- Encouraging the adoption of agroforestry practices.

Reducing the Vulnerability of Poor People to Climate Shocks and Other Hazards

Climate change and climate variability, floods and droughts contribute to vulnerability and deepening of poverty, particularly among already poor people. These shocks and hazards also impinge on the overall economic gamut of the basin countries, particularly for those heavily reliant on agriculture. Thus, efforts are required to enhance the knowledge and prevention of natural risks and the impacts of the phenomenon of climate change. An enhanced mitigation strategy of flood and drought management, and well-established early warning systems and storage options will help reduce the devastating impacts of floods. The specific strategies include: reduction in flood risk through development and dissemination of information management systems, mitigation of drought risk through development of new water storage systems and improvement of storage management during low water flow periods, adoption of water saving strategies, reduction of greenhouse gases, developing hydrological forecasting tools, ensuring minimum discharges during low water periods, adoption of adaptive social and economic infrastructure, improving coverage of precipitation-gauge stations and capacity-building through staff training in climatology, seasonal forecasting and agro-meteorology.

Ending Degradation of the Terrestrial and Aquatic Ecosystems

The prevalence of extensive low-productivity rain-fed agriculture such as those based on the slash-and-burn cultivation systems are threatening terrestrial ecosystems resulting in significant loss of biodiversity and soil. The deterioration of the terrestrial ecosystem has also an impact on the overall availability of water. To control desertification and reverse the trend towards depletion of environmental resources, efforts have to be made in the area of reforestation, land reclamation, development of natural forests and protected areas, as well as development of community forestry and agroforestry. This should be complemented by improving rural people's access to alternative energy sources such as hydroelectric power, which contributes to ecosystem conservation through reduced pressure on forest resources. Hydroelectricity is also a factor of integration and regional stability as well as a strong trading potential for the member countries of the basin in terms of the benefits to be shared.

The specific intervention areas include watershed management (integrated development and protection of catchment areas), erosion and sedimentation control, carbon finance mechanism, preservation of the resources of aquatic environments including the management of wetlands, prevention of water pollution, reforestation, restoration of degraded areas and habitats (through preventive and curative actions), improved soil and water conservation methods, recovering and sustaining depleted fisheries, reducing land and sea-based pollution and improving water quality, etc. The technical interventions enumerated above work better, if complemented by actions in the area of policies and institutions. The benefits spill over to the sustainability of water infrastructure through, for instance, reduction of siltation of the infrastructures and the hydro-graphic network in the basin, enhancing their performance and sustainability. An improvement in environmental management, especially in the Fouta Djallon watershed and the Inland Delta will lead to significant benefits for the overall sustainability of the water resources of the basin.

Diversifying Rural Livelihoods

Water is an important input into many other livelihood processes, not just agriculture. Development of economic activities related to water resources (e.g., tourism), but not depending on investments in large-scale infrastructure, increases wealth and alleviates poverty while preserving natural resources. Thus, support is needed to realize the eco-touristic potential of the Niger Basin. Programs that enhance job creation and/or the employability of the basin's rural population are particularly important. The actions should be aimed at strengthening human capacities, promoting access of the poor to educational and health services, and drinking water and sanitation infrastructures. Supporting small and medium-size enterprises will help create jobs. Moreover, integrated rural development programs to stem the flow of migration from rural to urban areas are necessary.

REFERENCES

Andersen, I.; Dione, O.; Jarosewich-Holder, M.; Olivry, J-C. 2005. *The Niger river basin: A vision for sustainable management*. Washington, DC: World Bank.

Aw, D.; Diemer, G. 2005. *Making a large irrigation scheme work: A case study from Mali. Directions in development*. Washington, DC: World Bank.

Boelens, R.; Hoogendam, P., eds. 2002. *Water rights and empowerment*. Assen, the Netherlands: Van Gorcum Publishers, 260p.

Castillo, G.; Namara, R.; Munk Ravnborg, H.; Hanjra, M.; Smith, L.; Hussein, M. 2007. Reversing the flow: Agricultural water management pathways for poverty reduction. Chapter 4. In *Water for food, water for life: A comprehensive assessment of water management in agriculture*, ed., Molden, D. London: Earthscan; Colombo: International Water Management Institute.

Clanet, J.-C.; Ogilvie, A. 2009. *Basin focal project Niger*. CPWF Project Report series. Colombo, Sri Lanka: CGIAR Challenge Program on Water and Food (CPWF). 124p.

Diallo, O.S. 2005. Water erosion and silting in the Niger river basin in the context of watershed management. Proceedings of the African Regional Workshop Nairobi, Kenya 8-10 October, 2003. Rome: Food and Agriculture Organization of the United Nations (FAO).

Derham, B.; Hellum, A.; Sithole, P. 2005. Intersections of human rights and customs: A livelihood perspective on water laws. In *African water laws: Plural legislative frameworks for rural water management in Africa*, ed. van Koppen, B.; Butterworth, J.A.; Juma, I. Proceedings of a workshop held in Johannesburg, South Africa, 26–28 January 2005. Pretoria: International Water Management Institute.

ECOWAS (Economic Community of West African States). 2005. *2006-2010 Regional action plan for the implementation of the ECOWAS agricultural policy (ECOWAP) and the Comprehensive Africa Agriculture Development Programme (CAADP) in West Africa*. Abuja, Nigeria: ECOWAS.

FAO (Food and Agriculture Organization of the United Nations). 1997. Irrigation potential in Africa: A basin approach. *Land and Water Bulletin* 4.

IMF (International Monetary Fund). 2005. *Nigeria: Poverty reduction strategy paper*. National Economic Empowerment and Development Strategy. IMF Country Report No. 05/433. Washington, DC.

IMF. 2008a. *Guinea: Poverty reduction strategy paper*. IMF Country Report No. 08/7. Washington, DC.

IMF. 2008b. *Mali: Poverty reduction strategy paper.* IMF Country Report No. 08/121. Washington, DC.

IMF. 2008c. *Niger: Poverty reduction strategy paper*. IMF Country Report No. 08/149. Washington, DC.

IMF. 2008d. *Burkina Faso:* P*overty reduction strategy paper*. IMF Country Report No. 08/212. Washington, DC.

IMF. 2008e. *Cameroon: Poverty reduction strategy paper—Progress report.* IMF Country Report No. 08/1. Washington, DC.

IMF. 2009. *Cote d'ivoire: Poverty reduction strategy paper*. IMF Country Report No. 09/156. Washington, DC.

JICA (Japan International Cooperation Agency). 1993. *The study on the national water resources master plan*. Nigeria: Federal Ministry of Agriculture, Water Resources and Rural Development.

JISAO (Joint Institute for the Study of the Atmosphere and Ocean). 2010. Mean Sahel precipitation anomalies. Available at http://jisao.washington.edu/data/sahel/ (accessed on February 10, 2011).

L'Hôte, Y.; Mahé, G. 1996. *Afrique de l'ouest et Centrale*. *Carte des precipitations moyennes annuelles (période 1951–1989)*. Paris: Office de la Recherche Scientifique et Technique d'Outre-Mer (ORSTOM).

Niasse, M. 2005. Climate-induced water conflict risks in West Africa: Recognizing and coping with increasing climate impacts on shared watercourses. Paper presented in an international workshop on human security and climate change. Holmen Fjord Hotel, Asker, near Oslo, 21–23 June 2005.

NBA (Niger Basin Authority). 2007. *Project implementation document*. Report 43582. Niamey, Niger: NBA.

Ogilvie, A.; Mahé, G.; Ward, J.; Serpantié, G.; Lemoalle, J.; Morand, P.; Barbier, B.; Diop, A.T.; Caron, A.; Namara, R.E.; Kaczan, D.; Lukasiewicz, A.; Paturel, J.E.; Lienou, G.; Clanet, J.-C. 2010. Water, agriculture and poverty in the Niger river basin. *Water International* 35(5): 594-622.

PNUD (Programme des Nations Unies pour le Développment). 1990. *Schéma directeur de la mise en valeur des ressources en eau du Mali.* Projet PNUD/UNDTCD MLI/84/005. New York: United Nations Development Programme (UNDP).

UNDP (United Nations Development Programme). 2005. Human Development Report 2005. Available at http://hdr.undp.org/en/media/HDR05_complete.pdf (accessed on October 24, 2009).

van Koppen, B.; Parthasarathy, R.; Safiliou, C. 2002. *Poverty dimensions of irrigation management transfer in large-scale canal irrigation in Andhra Pradesh and Gujarat, India*. Colombo, Sri Lanka: International Water Management Institute (IWMI). 31p. (IWMI Research Report 61).

WARDA (West Africa Rice Development Association). 2000. *Rice production and consumption in West Africa*. Available at www.unep.ch/etb/events/events2002/05AprilAgri/warda.pdf

Wilby, R. 2008. *A review of recent trends and projected climate changes for Niger, West Africa: Informing climate change adaptation and water resources management policies*. A Technical Brief for Tearfund.

Wood, S.; You, L.; Zhang, X. 2004. Spatial patterns of crop yields in Latin American and the Caribbean. *Cuadernos de Economia* 41(124): 361-381.

IWMI Working Papers

144. *An Overview of the Development Challenges and Constraints of the Niger Basin and Possible Intervention Strategies*. Regassa E. Namara, Boubacar Barry, Eric S. Owusu and Andrew Ogilvie. 2011.

143 *A Comparative Analysis of the Technical Efficiency of Rain-fed and Smallholder Irrigation in Ethiopia.* Godswill Makombe, Regassa Namara, Fitsum Hagos, Seleshi Bekele Awulachew, Mekonnen Ayana and Deborah Bossio. 2011.

142 *Typology of Irrigation Systems in Ghana*. Regassa E. Namara, Leah Horowitz, Shashidhara Kolavalli, Gordana Kranjac-Berisavljevic, Busia Nambu Dawuni and Boubacar Barry. 2010.

141 *A Case for Pipelining Water Distribution in the Narmada Irrigation System in Gujarat, India*. Tushaar Shah, Sunderrajan Krishnan, Pullabhotla Hemant, Shilp Verma, Ashish Chandra and Chillerege Sudhir. 2010.

140 *Inventory of Water Storage Types in the Blue Nile and Volta River Basins*. Robyn Johnston and Matthew McCartney. 2010.

139 *Climate Change Impacts and Adaptation in Nepal*. Ryan Bartlett, Luna Bharati, Dhruba Pant, Heather Hosterman and Peter McCornick. 2010.

138 *Synthesis of IWMI Work in Nepal.* Dhruba Pant and Madar Samad. 2010.

137 *Multiple Sources of Water for Multiple Purposes in Northeast Thailand.* Frits Penning de Vries and Sawaeng Ruaysoongnern. 2010.

136 *Health Impacts of Small Reservoirs in Burkina Faso.* Eline Boelee, Philippe Cecchi and André Koné. 2009.

135 *From Mesopotamia to the Third Millennium: The Historical Trajectory of Water Development and Use in the Karkheh River Basin, Iran.* Sara Marjanizadeh, Asad Sarwar Qureshi, Hugh Turral and Parviz Talebzadeh. 2009.

134 *Assessing the Economic Impact of Redistributing Water within a Catchment: A Case Study of the Musi Catchment in the Krishna Basin in India.* Brian Davidson, Petra Hellegers and Madar Samad. 2009.

133 *Livestock and Water Interactions in Mixed Crop-Livestock Farming Systems of Sub-Saharan Africa: Interventions for Improved Productivity.* Katrien Descheemaeker, Tilahun Amede and Amare Haileslassie. 2009.

Related Publications

Abernethy, C. L.; Sally, H.; Lonsway, K.; Maman, C. 2000. ***Farmer-based financing of operations in the Niger Valley irrigation schemes***. Colombo, Sri Lanka: International Water Management Institute (IWMI). 41p. (IWMI Research Report 037)

www.iwmi.org/Publications/IWMI_Research_Reports/PDF/Pub037/Report37.pdf

Boelee, E.; Cecchi, P.; Kone, A. 2009. ***Health impacts of small reservoirs in Burkina Faso***. Colombo, Sri Lanka: International Water Management Institute (IWMI). 40p. (IWMI Working Paper 136)

www.iwmi.org/Publications/Working_Papers/working/wp136.pdf

Oweis, T.; Hachum, A.; Kijne, J. 1999. ***Water harvesting and supplemental irrigation for improved water use efficiency in dry areas***. Colombo, Sri Lanka: International Water Management Institute (IWMI). 47p. (SWIM paper 7)

www.iwmi.org/Publications/SWIM_Papers/PDFs/Swim07.pdf

Purkey, D.R.; Vermillion, D. 1995. ***Lift irrigation in West Africa: Challenges for sustainable local management***. Colombo, Sri Lanka: International Irrigation Management Institute (IIMI). 57p. (IIMI Working Paper 33)

http://publications.iwmi.org/pdf/H_16109i.pdf

van Koppen, B.; Namara, R.; Safilios-Rothschild, C. 2005. ***Reducing poverty through investments in agricultural water management.*** Colombo, Sri Lanka: International Water Management Institute (IWMI) 82p. (IWMI Working Paper 101)

www.iwmi.org/Publications/Working_Papers/working/WOR101.pdf

Postal Address
P O Box 2075
Colombo
Sri Lanka

Location
127 Sunil Mawatha
Pelawatta
Battaramulla
Sri Lanka

Telephone
+94-11 2880000

Fax
+94-11 2786854

E-mail
iwmi@cgiar.org

Website
www.iwmi.org

IWMI
International
Water Management
Institute

ISSN 2012-5763
ISBN 978-92-9090-742-8