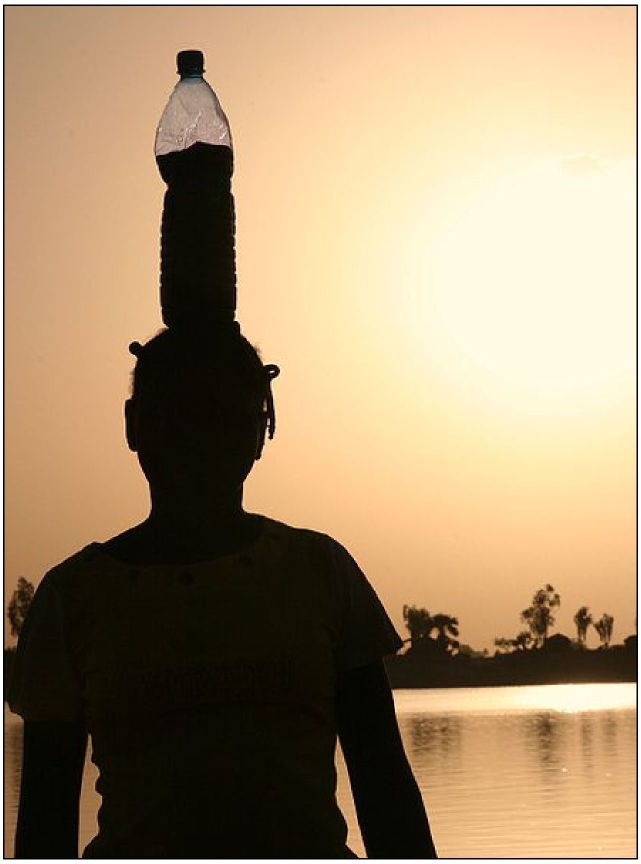
Adaptation to Climate Change in the Upper and Middle Niger River Basin



River Basin Snapshot

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Stefan Zeeb

Head of Division
Competence Center Water and Waste Management

Content

Note: Title picture by Ferdinand Reus; Wikimedia Commons (2008a)

Executive Summary

The Niger River Basin Snapshot: assessing the needs for adaptation to climate change and variability in a West African river basin. This basin snapshot aims at assessing historical trends and future projections in water availability in the context of climate change and variability in comparison with impacts on the water balance that are directly caused by human activities in the basin. It also assesses efforts by local communities to adapt to climate change and variability, as well as support by government and donors for adaptation. Finally, it assesses the scope for no regret measures and possible new measures for adaptation. This snapshot is part of a series of basin snapshots in developing countries carried out by KfW on behalf of the German Ministry of Economic Cooperation and Development (BMZ).

Several West African economies depend on the Niger. With a surface area of 2.27 million km^2 shared by 10 countries and a population of almost 100 million the Niger Basin is one of the most important river basins in Africa. It supports large-scale irrigation, fisheries and livestock herding, provides drinking water, generates hydropower and allows navigation. This basin snapshot is limited to the four countries of the upper and middle Niger Basin countries (Burkina Faso, Guinea, Mali and Niger) where German development cooperation is particularly active and where climate-induced changes to the hydrological regime are expected to be more severe than in the lower Niger basin which benefits from ample water resources. The upper and middle Niger basin has about 20 million inhabitants, of which about 8 million each live in Mali and Niger.

The Niger is the principal river of West Africa, featuring diverse environmental and climatic areas. The Niger has a flow of 32.5 km^3 per year (average 1970-1998) in Koulikoro, Mali which is half the average flow of the Rhine River at its outlet. The flow is characterized by strong variations between the wet and dry seasons. The source of the Niger is located in the mountains of Guinea in an area with very high rainfall. It then flows northeast through areas with declining rainfall, passing through the Inner Delta in the Sahel. The Inner Delta in Mali, an area that is larger than the German state of Hesse, acts like a sponge and holds back flood waters from the wet season slowly releasing it during the dry season. The river then turns southwest, passing through Niger's capital Niamey, and then reaches again areas of much higher rainfall until it discharges to the sea through the Niger delta. The upper and middle Niger has seen little regulation through dams. The largest dam in this part of the basin, with a storage capacity corresponding to 7 % of the river's flow, is on the Sankarani River, a tributary of the Niger in Southern Mali. However, three large dams – one each in Guinea, Mali and Niger - are planned or under construction, primarily for hydropower, increasing the storage capacity to about half of the of river flow. Currently agriculture is by far the largest water-using sector accounting for about 90% of water use, and agriculture – which is still primarily rain-fed - contributes to about 80% of employment.

Historical hydrologic trends are inconsistent. As mentioned above, rainfall, runoff (defined as rainfall minus evapotranspiration) and river discharge fluctuate significantly between seasons (by a factor of almost 1:100). In addition, both average and dry season river flows have fluctuated considerably between years. For example, the average discharge of the river at Koulikoro in Mali in 1982-1993 has been only 45% of the discharge in 1951-1970, a period of high flows. However, in 1994-2008 it increased again to 67% of that level. It is thus difficult to assess what exactly constitutes a "normal" river flow. Also, it is next to impossible to ascertain to what extent the greenhouse effect has had an impact or not on the decrease of rainfall and river flow from the early 1970s to the early 1990s, nor to what extent it has caused its rebound since then. In particular in the Sahel, changes in land cover cause desertification with a strong impact on hydrology. For instance, soil crusting leads to reduced infiltration and increased runoff.

Future projections on hydrology are uncertain. The IPCC relies in its reports on 20 general circulation models (GCMs), comparing projections for temperature and hydrological variables for the period 2030 - 2049 with historical figures for 1980-1999. It should be noted that, in the case of the upper and middle Niger, this historical period has been characterized by unusually low rainfall and river flows. An analysis of six locations in the upper and middle Niger basin using the World Bank's climate change knowledge tool shows that projections by the 20 models are not consistent concerning the direction of change (increase or decrease) in rainfall and runoff. The tool does not project changes in river discharge. It would thus be premature to make investment plans on the basis of either lower or higher water availability in the upper and middle Niger basin.

Human activities with direct environmental impacts and population growth play a decisive role. While the direction and magnitude of the hydrologic regime in the upper and middle Niger basin remain highly uncertain, there is greater certainty concerning other environmental trends caused directly by human activity in the basin. In the 50-year period considered by the climate models, the population of the basin is likely to increase by about 250% from about 8 million in 1999 to more than 20 million in 2049 assuming a slowdown in birth rates. Even if one assumes that only half of the increased population (about 9 million people) will depend on agriculture, fisheries and livestock, this will put tremendous pressure on already stressed natural resources. For example, it would increase water abstraction by about 6 km^3 per year. This impact compares to the impact of climate change, which – in an assumed worst case of a 20% reduction in river flows compared to the low average flow of 1970-1998 – would correspond to 6.5 km^3.

Locals have a long adaptation experience. Local communities have adapted to climate variability for centuries. In addition, they had to adapt to a significant decline in water availability from the early 1970s to the early 1990s. They have done so in different ways: At the local level, a study in Niger showed that local communities have developed fairly limited coping techniques, such as new fishing techniques and the watering of animals at the river when pools run dry. At the regional level, they have responded to the long-term decline of water availability by increasingly migrating to cities. However, it is uncertain to what extent migration has been affected by climate change and variability and by other economic factors. It is also not clear if the rebound in water availability since the mid-1990s has slowed down migration or has reduced or reversed adaptation efforts by communities.

Governments and donors support development and adaptation. The governments of Guinea, Mali, Niger and Burkina Faso have provided significant financial and technical assistance for rural development over the past decades, including for efforts to adapt to increasing environmental stress and desertification. While it is beyond the scope of this basin snapshot to assess the effectiveness of these measures, it should be stressed that the nature of these measures is not different from measures to adapt to climate change and variability.

All four countries have adopted National Adaptation Programs for Action (NAPAs) in 2006-07 including 71 projects with a total estimated value of US$64 million (excluding Niger, whose plan does not include an estimate of the value of the projects). The NAPAs include future climate projections without addressing uncertainties. Implementation of the NAPAs has been sketchy.

Recommendations: no regret measures and targeted support for adaptation. There is ample scope for "no regret measures" in the upper and middle Niger Basin that make sense whether the climate becomes drier, wetter or remains constant. These measures include for instance the promotion of efficient irrigation methods, improving transboundary river basin management and improving the use of meteorological information. The best way to adapt to climate change and variability in the middle and upper Niger basin given the uncertainty of climate projections is to increase support for such no regret measures.

Part one: Water resources and Climate

The first part concentrates on the geographic and economic background and gives an introduction of past and future climate developments in the region including their relevance and the reliability of predictions. This includes both climate change, defined as the long term change of mean climate values and climate variability, the deviation of climate variables from the average, visible through extreme weather conditions like droughts.[1]

The Niger River Basin

With a length of 4,200 km, the Niger River is the third longest river in Africa after the Nile and the Congo River. The Niger traverses four countries, two of which (Niger and Nigeria) are named after it. The river basin covers 2.27 million km² and is shared by ten countries, namely Algeria, Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Guinea, Mali, Niger and Nigeria. However, the active drainage area is less than half of the basin and excludes Algeria.

Geography

The Niger crosses areas with different climatic characteristics. A large part of the river basin is located in the Sahel, a semiarid area between the Sahara desert and the Sudanian savannas. Due to the topographical and hydrological characteristics, the river is often divided into four sub basins: the Upper Niger Basin, the Central Delta, the Middle Niger Basin and the Lower Niger Basin.

Figure 1. Map of the Niger River Basin, showing the four sub basins; source: own map based on Wikimedia commons 2006; position of isohyet (approximation): Descroix et al. 2009, p. 91; sub basin borders: World Bank 2005, p. 71

[1] For a detailed definition please refer to Annex 4: Glossary of terms

Climatic zone	***Precipitation p.a.***	***Length of rainy season***	***Countries***
Sahelian/sub desert zone	250-750 mm	3-4 months	Mali, Niger
Sudanian zone	750-1,500 mm	5-7 months	Guinea, Mali, Niger, Nigeria

Table 1. Niger River Climatic Zones; source: derived from Laë et al. 2003, p. 5

The present paper concentrates on the former three sub basins. In order to keep the snapshot character of the study, it is mostly limited to the four countries Burkina Faso, Guinea, Niger and Mali.[2] As shown in table 2, these four countries together have about 20 million inhabitants in the basin, while the majority of people is located in the Lower Niger Basin which is not part of this study.[3]

	Benin	***Burkina Faso***	***Cameroon***	***Chad***	***Côte d'Ivoire***	***Guinea***	***Mali***	***Niger***	***Nigeria***
Population	6.75	10.7	14.9	8.3	15.4	17.1	10.6	10.7	114
Population in river basin	1.95	2.12	4.46	0.08	0.8	1.6	7.8	8.3	67.6

Table 2. Population of the countries of the Niger River Basin (2004, in million); source: World Bank 2004, p. 2-3

The source of the Niger is located close to the *Fouta Djallon* Mountains in the South of Guinea at an altitude of approximately 800 m. With more than 2,000 mm per year,[4] the area receives a high amount of rainfall. The river flows northeast through the Upper Niger Basin. Several tributaries provide additional water, until the Niger enters the Inner Delta in Mali. During the rainy season, the delta forms a large flood plain of 20,000 to 30,000 km²,[5] facilitating the cultivation of rice, cotton and wheat as well as cattle herding and fishing.[6] The size of the flooded area is subject to strong annual variations, depending on the discharge of the Upper basin.[7] A large part of the water is lost in the delta due to evaporation and seepage.[8] According to the FAO, almost two thirds of the water is lost in the Inner Delta.[9] Zwarts et al. suggest a water loss of one third.[10]

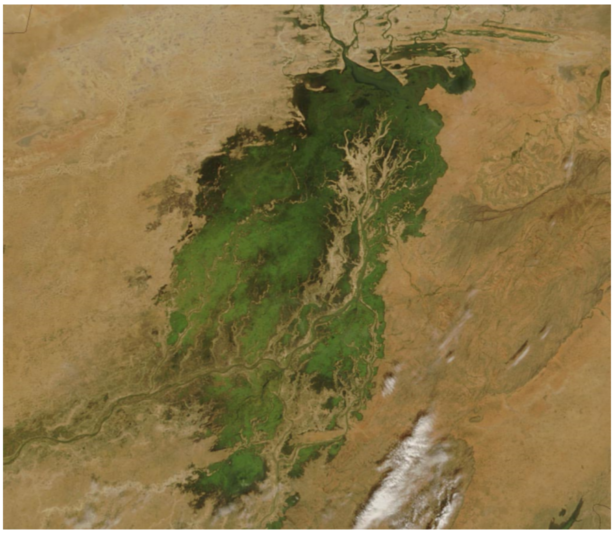

Figure 2. Satellite image of the Niger Inland Delta; source: Wikimedia Commons 2008b

[2] Algeria, Benin and Cote d'Ivoire are excluded although part of the three sub basins is located inside them.
[3] UNEP 2005, p. 36
[4] Schuol et al 2008, p. 33
[5] NBA et al. 2002, p. 8
[6] Laë et al. 2003, p. 200
[7] In 1984, the inundated area was only 9,500 km² (UNEP 2005, p. 37)
[8] Olomoda 2002, p. 209
[9] FAO 1997

After the Inner Delta, the Niger reaches the fringes of the Sahara desert and turns southwards, passing Niamey, the capital of Niger. Further downstream, the Niger River enters Nigeria and receives water from large tributaries. It flows into the Atlantic Ocean at the Gulf of Guinea.[11] The Niger and its sub basins are shown in figure 1. Table 1 gives an overview of the Sudanian and Sahelian climate zones.

The river facilitates hydropower generation, irrigated agriculture, fishing and navigation and is a crucial factor for the economy in West Africa. Hence, variations in the river flow have an immense impact on the people who depend on it.

Water storage

The natural flow of the Niger River has been increasingly regulated by the construction of dams with the objective to generate hydropower and to store and use water for irrigation.[12] However, there is still room for increasing energy production through the construction of further dams. The World Bank estimates that 30,000 gigawatt hours could be generated in the Niger River and its tributaries, but only 6,000 have been developed so far.[13] This figure includes Nigeria, by far the biggest producer. However, the impacts of the construction of new dams might also be harmful. For instance, the Inland Delta depends on floods from the Upper Niger. Flooded areas might play an important role in groundwater formation. Artificial reservoirs might also lead to a decreasing flow of the river, resulting in increased evaporation and sedimentation. In addition, water hyacinths might proliferate in standing waters. Therefore, all impacts should be carefully considered before new reservoirs are constructed.

In Nigeria, 22% of the total energy is generated at the Kainji and Jebba dams.[14] Mali constructed four dams, i.e. the Sélingué dam on the tributary Sankarani which is mainly used for hydropower, the Sotuba dam which serves a small hydropower plant, a dam in Markala, which provides water for an irrigated area controlled by the *Office du Niger* and Talo dam which provides water for rice irrigation. The Djenne dam is currently under construction. Talo and Djenne dams are located on the Bani River, the main tributary of the Niger which contributes to the more than 40% of its discharge.

Zwarts et al. assessed the share of water which is withdrawn at the dams and compare it to the average discharge of the Niger and its tributaries from 1970 to 1998 with the following results: 0.83 km^3 per year compared to a flow of 8.9 km^3 or 9.3% of the water is withdrawn from the Sankarani at Sélingué. The water withdrawn from the Niger River for irrigation at Markala amounts to 2.69 km^3 or 8.3% of the 32.5 km^3 measured in Koulikoro. In dry years, this figure increases to 15% and in wet years it is reduced to 4%. Compared to this, the impact of the Sotuba dam (0.22 km^3) and the amount which according to the authors is withdrawn in the Inner delta for irrigation (0.21 km^3) are small. Concerning seasonal impacts, the authors write that the peak flood is reduced and the flow in the dry season is higher, due

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[10] Zwarts et al. 2005, p. 33
[11] UNEP 2005, p. 37
[12] UNEP 2005, p. 37
[13] World Bank 2005, p. 58
[14] NBA et al. 2002, p. 9

to the water storage function of the Sélingué dam. In the dry season, the water release at Sélingué exceeds the water intake at Markala.[15]

A new dam is under construction in Taoussa/Tossaye, downstream of the Inner Delta.[16] In Guinea, a dam is planned at the Niandan tributary. The dam's capacity would almost be three times as big as the biggest existing one in Sélingué (Mali) and therefore have a considerable impact on water availability in the Inner Delta.[17] In Niger, the Kandadji dam is currently under construction, about 180 km upstream of Niamey. The construction is expected to be completed in 2013. The dam will reduce Niger's dependency on Nigerian electricity, part of which is generated through large dams in the Lower Niger Basin. Part of the financing comes from the Islamic Development Bank, the OPEC Fund for International Development, the African Development Bank, the Saudi Development Fund and the Niger Basin Authority.[18] Annex 1 shows a table with the major characteristics of all dams.

Agriculture

Agriculture contributes a very high share to the national GDP and employment of all selected countries. The vast majority of agricultural activities are rain-fed and not irrigated. As shown in table 3, less than 5% of the cultivated area was equipped for irrigation in 2002. According to UNEP, West Africa's rain-fed agriculture is primarily used for self-sufficient nutrition, based on food crops like millet, corn and sorghum.[19]

However, irrigated agriculture usually accounts for a higher share in the GDP and employment compared to the share in cultivated area. In the irrigated area of the *Office du Niger* in Mali, about 590,000 tons of rice and 303,000 tons of sugar cane are produced per year.[20] As shown in annex 1, water is abstracted from the Niger and its contributories and used for irrigation at all listed dams.

	Burkina Faso	***Guinea***	***Mali***	***Niger***
Contribution of agriculture to GDP	29%	24%	45%	39%
Share of labor in agricultural sector	90%	76%	80%	90%
Share of water used by agricultural sector	86%	90%	90%	95%
Share of cultivated area equipped for irrigation (2002)	0.5%	4.4%	4.9%	0.5%

Table 3. Relevance of agriculture in Burkina Faso, Guinea, Mali and Niger; sources: Agricultural water use: CIA 2010; share of irrigation: FAO 2010b

Navigation

In many areas, the Niger River is used for navigation, depending on time and location. Between Guinea and Mali however, there is no commercial traffic. From August to January, the Niger is navigable from Koulikoro to Gao. The Inland Delta is navigable for small fishing boats throughout the year. In the wet season, boats are the most popular transport method in

[15] Zwarts et al. 2005, p. 32-35
[16] For more information on dams in the Upper Niger Basin, refer to Zwarts et al. 2005
[17] Zwarts et al., 2005
[18] Wikimedia Foundation 2010
[19] UNEP 2005, p. 30; Awaiss and Humphrey, p. 42
[20] World Bank 2005, p. 6

the delta.[21] Mopti on the Bani tributary serves as main port in the Inland Delta. Downstream of the delta, navigation on the Niger is limited until Timbuktu. From Timbuktu to Niamey, navigation is possible, although difficult in some parts due to rocks and rapids.[22]

Livestock and Fishing

It was estimated that in the Inner Delta alone, about two million cattle and four million sheep and goats graze the floodplains each year just after the flooding.[23] Small scale fishery is practiced along the whole basin. It is the Inner Delta, where fishing is a considerable commercial sector. About one third of the rural population inside the delta depends on fishery. However, the amount of fish varies considerably due to the spatial variation of the flooded area. Large floods provide about three times more fish than small floods.[24] According to the *Operation Pêche Mopti* (OPM), the fish production in the Inner Delta ranged from 54,000 to 133,000 tonnes between 1967 and 2001.[25]

Water quality

Information on water and soil pollution is poor.[26] However, threats to water quality seem to be limited at present in the Upper and Middle Basins and the Inner Delta. According to the Niger Basin Authority (NBA), mining activities and deforestation are practiced in the *Fouta Djallon* area in Guinea, leading to pollution and sedimentation of the river bed.[27] Gold and diamonds are exploited in the Upper and the Middle Basin, often in a traditional way with negative impacts on the environment, e.g. through open holes or the diversion of water ways. In the same areas, small scale industrial activities combined with a lack of water treatment and waste control threaten the river water quality.[28]

Agricultural pollution through fertilizers and pesticides is low. However, cases of eutrophication have been reported.[29] The lack of sanitation infrastructure along the river basin is another factor leading to the degradation of water quality.[30] In addition, the decreasing flow has a direct impact on water quality, since it reduces the river's sediment transport ability.[31] Besides climate change, land use has been identified as a critical factor with large direct environmental and hydrological impacts which are further described below.

Vulnerability and Relevance of Climate Change and Variability

Countries located in the Niger River Basin are particularly vulnerable to climate change and variability due to several factors. In particular the countries located in the Sahel depend on water from the river.[32] In fact, most of the issues which contribute to the strong vulnerability are more urgent for the development of the countries than climate change itself. Approaches

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[21] Zwarts et al. 2005, p. 236
[22] World Bank 2005, p. 19-20
[23] Zwarts et al. 2005, p. 110; World Bank 2005, p. 6; Laë et al. 2003, p. 4
[24] Zwarts et al. 2005, p. 91
[25] Zwarts et al. 2005, p. 99
[26] NBA et al. 2002, p. 62
[27] NBA et al. 2002, p. 8
[28] NBA et al. 2002, p. 20
[29] NBA et al. 2002, p. 62
[30] World Bank 2005, p. 67
[31] UNEP 2005, p. 37
[32] IUCN 2004, p. 11

addressing them can lead to increased resilience and can be classified as adaptation to climate change and variability.

Strong poverty reduces the countries' adaptive capacity (i.e. ability to cope with climatic threats). All countries in the river basin are classified as developing countries, six of them as Least Developed Countries (LDCs) by the United Nations, including Guinea, Burkina Faso, Mali and Niger.

Dependence on agriculture: A large share of the national economies depends on agriculture and cattle-breeding.[33] The vulnerability is further increased by the fact that most of the agriculture is rain-fed (see table 3). The dependence on agriculture became visible after a massive drought in 1984, when the GDP of Mali and Niger fell by 9 and 18 percent, respectively.[34]

Demographics: Moreover, rapid population growth and urbanization cause increased pressure on water resources. The population growth rate ranges from 2.6% to 3.7% per year. Migration to urban areas is expected to further increase water demand.[35] However, infrastructure including water and sanitation systems is poorly developed. Table 4 shows some national key figures concerning population and infrastructure.

	Burkina Faso	***Guinea***	***Mali***	***Niger***
Population (in million)	15.8	10	13.5	15.3
Population growth	3.1%	2.6%	2.6%	3.7%
Population in the Niger River Basin (in million)	2.1	1.6	7.8	8.3
Annual rate of urbanization (average: 2005-2010)	5%	3.5%	4.8%	4%
GDP per capita (USD) (2009 est.)	1,200	1,100	1,100	700
Access to improved water supply (2006)	72%	70%	60%	42%
Access to improved sanitation (2006)	13%	19%	45%	7%

Table 4. Population and water use in Burkina Faso, Guinea, Mali and Niger; sources: Population, population growth, urbanization and GDP: CIA 2010; connection rates: WHO/UNICEF 2008

Land use makes the countries even more vulnerable. Changes in land use and resulting changes in land cover have an important impact on water resources in the basin. In the Sahelian part of Niger, the share of cultivated land increased from 10% in the 1950s to almost 80% today.[36] Furthermore, deforestation is practised along the river basin. Wood is used as an important source of energy, while access to electricity is insufficient.[37] In addition, traditional manmade, accidental or natural bush fires contribute to deforestation.[38] Both developments cause increasing runoff, withdrawing water resources from land.

To mention some positive developments: through the increasing water storage construction projects, flood control will be improved. As shown below, institutional aspects like transboundary organizations, research and sector reform made considerable progress during the last years. In addition, foreign financial and technical assistance support the

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[33] Awaiss and Humphrey, p. 56
[34] UNEP 2006, p. 11
[35] UNEP 2005, p. 30
[36] Cappelaëre et al. 2006, cited in Descroix et al. 2009, p. 92
[37] World Bank 2005, p. 67; Awaiss and Humphrey, p. 52
[38] NBA et al 2002. P. 46

communitites in improving their adaptation to climate change. In particular in the Sahel zone, people can make use of their long experience with weather events.

Climate Change and Variability

Hydrological data

In 1984, 65 hydrological Data Collection Platforms (DCPs) were installed along the river under NBA's *Hydroniger* Project. For this project, the NBA received assistance by the United Nations Development Program (UNDP), the Organization of Petroleum Exporting Countries (OPEC) and the European Economic Community (EEC). The World Meteorological Organization (WMO) acted as a supervisor for the project. In 2005, the World Bank reported that only 15 of these stations were operational.[39] In addition to these stations, the NBA has installed new DCPs in 1996 under the Niger *HYCOS* project, a regional implementation of the WMO's World Hydrological Cycle Observing System (WHYCOS).[40] Moreover, hydrological data is produced by National Hydrological Services in several member states, partly since the early 20th century.[41]

Even though the dissemination of data is part of the projects and the HYCOS project included the establishment of a regional web site,[42] it is difficult to obtain hydrological data from the river basin. Although the NBA web site includes a direct data access portal with data from all HYCOS stations, it was not possible to get the data online.[43]

Historical Trends

The basin has experienced strong climate change and climate variability. Seasonal and annual changes in rainfall and runoff have forced people to adapt to different climatic conditions at all times. As mentioned above, the region is characterized by a wet season and a dry season, the latter being significantly longer in the Sahel zone. Desertification is increasing towards the south of the Sahara desert, evidenced by the move of rainfall areas. It is difficult if not impossible to separate the developments which are caused by climate change from those which are directly caused by people, e.g. man made deserts through a change of land use.

Rainfall

The seasonal pattern and amount of rainfall in all areas depend on the latitude and position of the Intertropical Convergence Zone (ITCZ), which migrates between north and south during the year.[44] Compared to the period from 1951 to 1969, isohyetal lines shifted about 150 to 250 km southward in the period from 1970 to 1988 (figure 3).[45]

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[39] World Bank 2005, p. 127
[40] World Bank 2005, p. 128
[41] Olomoda, p. 2
[42] World Bank 2005, p. 128
[43] The data access portal URL is http://nigerhycos.abn.ne/user-anon/htm/
[44] UNEP 2005, p. 32
[45] World Bank 2005, p. 27

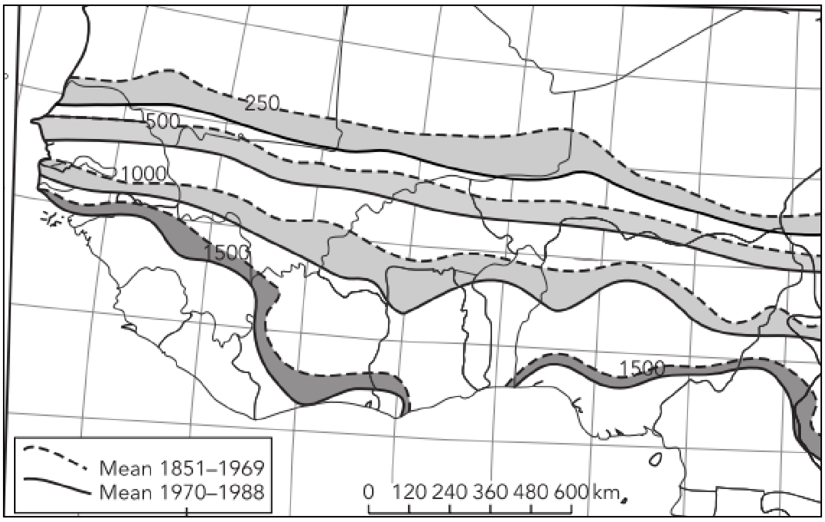

Figure 3. Move of isohyets to the South; source: World Bank 2005, p. 28

Similarly, Olomoda found that the 200 mm isohyetal line shifted 100 km southward when comparing the average of the years 1950-1967 to the period 1968-1995. When analysing the rainfall data of the 20th century, a remarkable break becomes visible in 1970, with a wet period before and a dry period after that year. Since the 1990s however, rainfall has slightly increased at least in the Central Sahel.

Data are available at the monthly level for the meteorological stations in Koulikoro and Niamey. The development of the accumulated annual amount of rainfall is similar in both locations. After a wet period during the 1950s and 1960s, a decrease in rainfall starts in the 1970s and intensifies in the 1980s. Since the mid of the 1990s, rainfall increases again (figure 4).

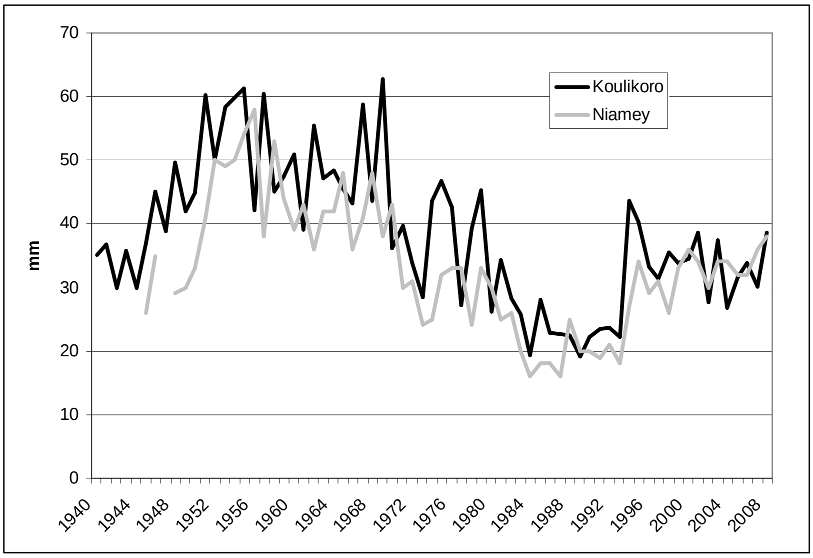

Figure 4. Accumulated annual rainfall in mm in Koulikoro and Niamey; source: NBA 2010

It should however be noted that these data do not necessarily mean that the 1970s and 1980s were particularly dry. It is also possible that the 1950s and 1960s were very wet decades deviating from the decadal average. In the 1970s, the situation might just have returned to normal conditions.[46]

Discharge

According to Olomoda, the Niger River has been affected by extreme low flows "since the past five decades" with a completely dry river in Niamey in 1985.[47] Comparing the data from the stations at Koulikoro in the Upper Niger, Mopti at the Nantaka contributory in the Inner Delta and Niamey in the Middle Niger over the last decades, four periods can be distinguished. There is one wet period from 1951 to 1970, one intermediate period from 1971 to 1981 with average discharge, a very dry period from 1982 to 1993, followed by another average discharge period from 1994 to 2008. The low river flow during the 1980s coincides with a great drought in West Africa, known as *La Grande Sécheresse*. Table 5 shows the average annual discharge during these periods and figure 5 gives a more detailed view.

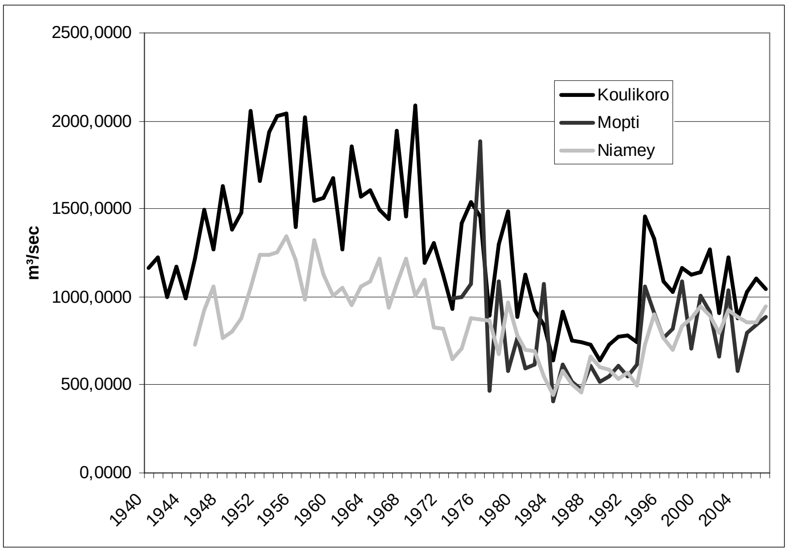

Figure 5. Average annual discharge in m³/sec for the Niger River at Koulikoro and Niamey and Mopti-Nantaka; source: NBA 2010

	1951-1970	*1971-1981*	*1982-1993*	*1994-2008*
Koulikoro	1691	1224	767	1137
Mopti-Nantaka	N.A.	938	595	823
Niamey	1124	793	556	860

Table 5. Average annual discharge during several periods in m³/sec; source: NBA 2010

It is important to mention that the annual average can only show long-term climate change trends, but the flow of the Niger varies considerably during the year. For instance, the average discharge in 1984, the dry driest year recorded in Koulikoro was 636 m³/sec. However, during the dry season from January to June, the flow was not exceptionally dry.

Figure 6 shows the seasonal variations through hydrographs in Koulikoro for the driest year recorded (1984), the wettest year (1969) and the most recent year available, 2008. It becomes clear that the annual average does not necessarily represent droughts and

[46] Personal communication 2010

47 Olomoda, p. 1

abundance. In fact, in the figure the year with the highest annual average is also the year with the lowest monthly minimum, with only 62 m³/sec in May.

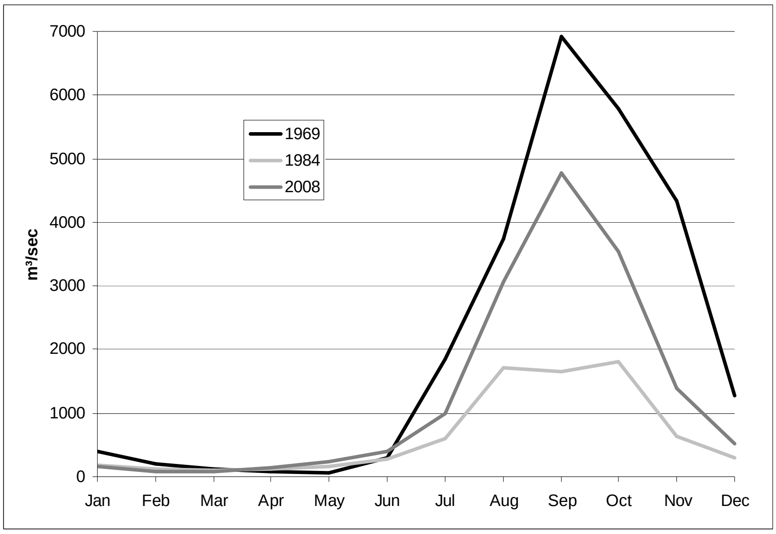

Figure 6. Hydrograph for three selected years in Koulikoro; source: NBA 2010

The hardest droughts become visible when analysing the annual minimum monthly average discharge, as shown in figure 7 for Koulikoro and Niamey. Similar to the mean annual discharge, certain periods become visible.

In both locations, two peaks were recorded in 1955 (Koulikoro: 198 m³/sec in April; Niamey: 292 m³/sec in July) and 1958 (Koulikoro: 139 m³/sec in April; Niamey: 301 m³/sec in June). A dry period starts in 1973. This period lasts until 1981 in Koulikoro and ten years longer in Niamey. During this period, the discharge was never higher than 41 m³/sec in Koulikoro and 35 m³/sec in Niamey. Three times, in June 1974, June 1981 and May 1985, the monthly average discharge dropped to only 5 m³/sec in Niamey, which practically renders the term *river* inadequate. Three days in July of 1974 and (concordant with Olomoda's statement) most time of June 1985, the Niger was completely dry in Niamey with a discharge of 0 m³/sec. In Koulikoro, the minimum monthly discharge was recorded in May 1973 with 19 m³/sec. The development of the two stations over the years is relatively similar until 1981. Afterwards, the level is partly considerably higher in Koulikoro. The reasons for that are not clear, but might be related to water withdrawal between the two stations.

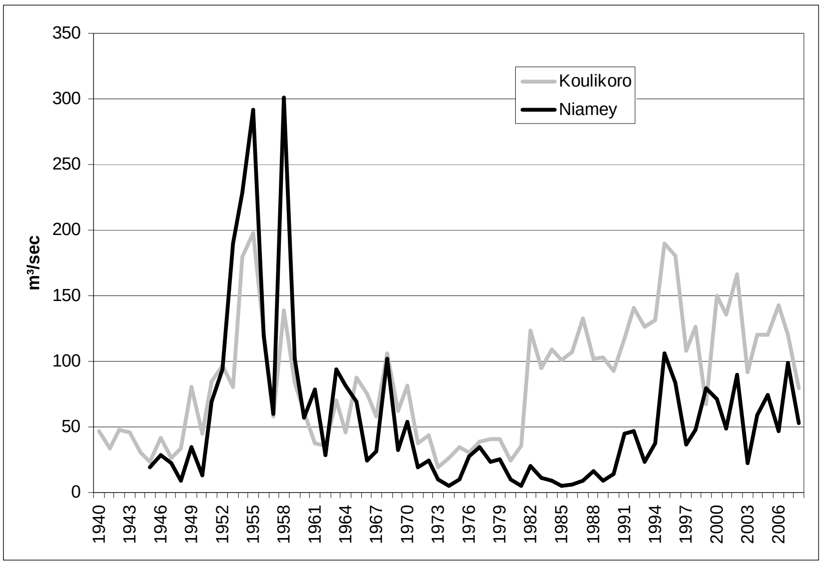

Figure 7. Minimum monthly discharge in Koulikoro and Niamey per year; source: NBA 2010

Runoff

According to scientific literature on hydrology, runoff has increased in the Sahel Zone since the 1970s.[48] When it comes to the causes for this development, it is difficult to separate direct human impact from climate change. On one hand, the climate became more arid, leading to increasing desertification. On the other hand, people have increased agricultural production in the Sahel for decades, removing grass, bushes and small trees which were already rare. This led to an impermeable crust which appeared as top layer of the soil with poor water holding capacity, increasing runoff. The impact of these significant changes in land cover exceeds the increasing evaporation rates caused by higher temperatures and even the reduction in rainfall.[49] Comparing similar areas with different population density, Mahé and Paturel found indications suggesting that direct human impacts are more relevant for the change in runoff than climate changes.[50]

On the contrary, in areas with Sudanian climate runoff has decreased during the last century, even though changes in land cover are similar to those in Sahelian areas.[51] This might be related to the role which groundwater has in Sudanian areas with respect to runoff. Consecutive dry years do not only lead to less surface water, but also to a decreasing groundwater table. This in turn increases seepage and reduces runoff.[52] It is important to mention that in both areas, the hydrological circumstances with impacts on runoff are highly complex and it is extremely difficult to understand and explain them, even among hydrologists.

Impacts of climate change

Regardless of the cause, a change in rainfall frequency and intensity and discharge like in the second half of the 20th century has important impacts on water resources in the highly

[48] Mahé and Paturel 2009
[49] Mahé and Paturel 2009; Descroix et al. 2009
[50] Mahé and Paturel 2009, p. 543
[51] World Bank 2005, p. 28
[52] Descroix et al. 2009

vulnerable economies.[53] This includes the direct impacts of a reduction in water supply and crop yields. In the following, some other main effects are briefly described.

Shrinking natural wetlands: As mentioned above, the size of the Inland Delta depends on the discharge of the Niger River and varies considerably. A reduction of wetlands leads in turn to a decrease in species diversity, including fish.[54]

Degradation of water quality: Increased runoff caused by torrential rainfall often transports solids, leading to increased siltation in the watercourses.[55] This has been the case in Niger particularly concerning the Niger River.[56]

Decline of groundwater level: Less rainfall and increased runoff reduce groundwater recharge. This is the case in the Sudanian areas of the river basin, where declining groundwater leads to a reduction of discharge. In the Sahel however, part of the runoff does not reach the main river and instead recharges the groundwater.[57] The hydrological regime concerning groundwater is still relatively unexplored, indicating the need for more research in that area.

Increasing temperatures, the projection with the highest probability will lead to increased evapotranspiration, reducing the amount of surface water.

Desertification: The observed shift of rainfall areas results in increasing deforestation and desertification. In a feedback loop, this in turn contributes to the persistence of the drought. As mentioned above, desertification can also happen due to changes in land use and land cover which is the case in the Niger River Basin.[58] The soil becomes loose and soil erosion increases. Loose soil has a poorer water holding capacity resulting in higher runoff.[59]

Future projections

Validity and consistency of projections

The IPCC reports remain reference documents for climate change science, although recent events[60] have re-emphasized the need to verify primary sources to check their consistency with the information in IPCC reports. For instance, the panel estimated that 75 to 250 million people in Africa would be exposed to increased water stress by 2020.[61] According to the Sunday Times, this projection is based on a study which only covers three countries in North Africa, i.e. Algeria, Morocco and Tunisia.[62] This clearly emphasizes the strong need to evaluate the validity of future climate change projections.

One way to do this is to check how many of the projections suggest similar developments. In order to assess the credibility of climate change scenarios in the Upper and Middle Niger and

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[53] UNEP 2005, p. 36-38
[54] IUCN 2004, p. 14; UNEP 2005, p. 36
[55] UNEP 2005, p. 36
[56] Republic of Niger 2006, p. 15
[57] Descroix et al. 2009, p. 99
[58] Descroix et al. 2009
[59] IUCN 2004, p. 15
[60] Reuters 2010
[61] IPCC 2007a, p. 50
[62] Sunday Times 2010

Forecasting future climate change is extremely difficult, in particular at the regional level. In a manual about integrating climate change adaptation into projects, USAID (2007) regards the "gathering of data about climate change for a specific location and interpreting that data to understand possible impacts on your project" as the most difficult part of adaptation. Today, nobody fully understands how the climate system works. General Circulation Models (GCMs) are already "among the most complicated models ever made". They are accurate in predicting an increasing temperature, but much less in projecting precipitation trends.

the Inner Delta, several spots in that area have been examined using the World Bank Climate Change Knowledge Portal, which compares the projections of 20 General Circulation Models (GCMs) used by the IPCC, based on the moderate A1B scenario.[63] They show the projected average situation in the period from 2030 to 2049 and compare it to the recorded data from the period from 1980 to 1999. The tool shows how many of these models agree on the direction of the projection (for instance: more precipitation vs. less precipitation).

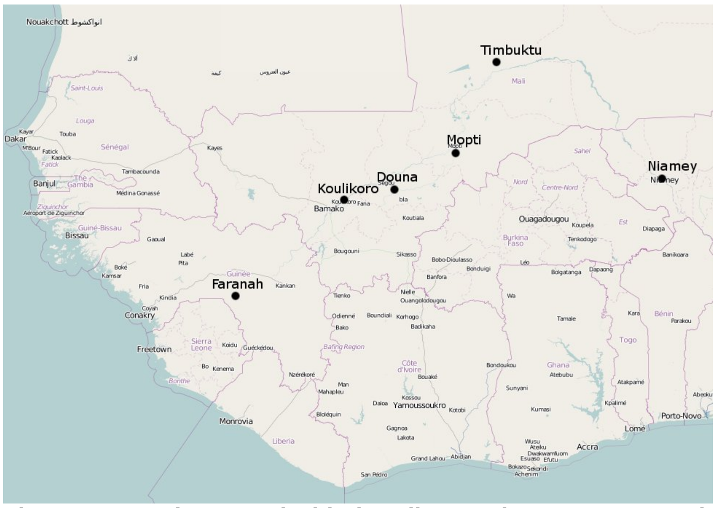

Figure 8. Locations used with the Climate Change Data Portal; map based on OpenStreetMap (http://www.openstreetmap.org/) contributors, CC-BY-SA (http://creativecommons.org/licenses/by-sa/2.0/)

An analysis using the locations of the gauge stations in Koulikoro, Douna, Mopti and Niamey plus the locations of Timbuktu and Faranah close to the source of the Niger River in Guinea (figure 8) shows a strong ambiguity of the projections. Concerning precipitation, only 12 or 13 of the 20 models project the same trend. Similarly, the models disagree on the future development of runoff (5 out of 12). These figures indicate a strong discrepancy of the different models and indicate that for the time being the projections are not consistent. However, all agree concerning temperature and predict an increase of 2°C in all locations except for Faranah (1°C). The tool does not give projections concerning the discharge of

[63] As a basis for projections, the IPCC uses about 40 Scenarios with different presumptions about the future development of the worldwide human society, concerning the degree of population growth, economic and social development, technological changes, use of resources, globalization and ecologic orientation. The scenarios are categorized into four groups, namely A1, A2, B1 and B2. The A1 scenario which is used by the Climate Change Data Portal assumes a strong population growth where the world population reaches a peak in the middle of the 21st century and declines afterwards and a quick adoption of new, efficient technologies. In addition, the scenario assumes increasing globalization and approximation of per capita income. A1 is further divided according to the kind of resources used (A1T: non fossile; A1B: balanced; A1FI: fossile intensive). The tool uses a A1B scenario. For more information on IPCC scenarios, please see IPCC 2000

rivers. A detailed table containing these findings is shown in annex 2, while the level of agreement of the models is shown in table 6.

	Mean annual precipitation	***Maximum 5-day precipitation***	***Consecutive dry days***
Faranah (Guinea)	13/20	3/8	7/8
Koulikoro (Mali)	12/20	7/8	5/8
Mopti (Mali)	13/20	3/8	4/8
Douna (Mali)	12/20	2/8	5/8
Timbuktu (Mali)	13/20	4/8	5/8
Niamey (Niger)	13/20	6/8	5/8

Table 6. Uncertainty of future climate change, expressed in number of IPCC models projecting the same (positive or negative) change; source: World Bank 2010

Accordingly, a 2002 document prepared by NBA and the United Nations Department of Economic and Social Affairs (UNDESA) states that “it is difficult to make forecasts regarding the Niger River Basin without risk of errors on short and medium terms rainfall.”[64]

[64] NBA 2002

Part two: Institutions, strategies and activities

This second part deals with the institutions which are relevant for water resources and adaptation and shows adaptation policies and approaches. At the end, a recommendation on future engagement in the light of climate change and variability is given.

Responsible institutions

Water Resources

At the national level, responsibilities on water resources management are shared by national ministries, their sub organizations and often other institutions. A detailed assessment of the institutional structure in each basin country goes beyond the scope of this study. In addition, responsibilities often remain unclear due to unstable governments. In Guinea, the *Direction Nationale de l'Hydraulique* (DNH) under the Ministry of Water and Energy is responsible for general policies and guidelines on water resources.[65] It should however be noted that Guinea was governed by a military junta for about two years until democratic elections took place in November 2010.[66]

In Mali, the Ministry of Energy and Water is responsible for planning and implementing national water resources policies. It includes the National Administration for Hydraulics.[67] A lack of coordination between the Malian institutions has been reported concerning environmental protection.[68] Niger has a national Ministry of Water Resources (*Ministère de l'Hydraulique*).[69] However, the institutional structures are unclear, in particular since the recent coup d'état by the national military forces in February 2010.[70]

Figure 9. The dam of Markala, where water is abstracted and used by the Office du Niger; source: Wikimedia Commons 2008c

The *Office du Niger* in Mali was established in 1930 by French colonists.[71] Today, it controls a large irrigated agriculture area. Irrigation water is taken from the Niger River at the Markala dam and distributed through gravity schemes.[72] The irrigated area covers about 70,000 hectares. Some 370,000 people depend on agriculture inside this area. There are plans to significantly extend the irrigated area. Foreign development assistance including German

[65] KfW 2007a, p. 38
[66] Federal Foreign Office 2010a
[67] WMO, GWP 2004, p. 17
[68] weADAPT 3.0 2009b
[69] KfW 2009c, p. 1
[70] Federal Foreign Office 2010b
[71] Office du Niger 2009
[72] Zwarts et al. 2005, p. 189-209

financial cooperation supports the *Office du Niger* (see below).[73]

In 1964, nine basin countries formed the River Niger Commission. In 1982, its name was changed to Niger Basin Authority (NBA). The NBA remained a weak institution and lost the support of development partners, in particular during the 1990s, partly due to a lack of financial commitment of the member states. In 2004, a shared vision for the sustainable development of the basin was declared by the nine member states.

In 2008, the heads of state and government of all member states decided to adopt the Niger Basin Water Charter, which is expected to increase cooperation among the countries and an integrated management of the basin's water resources. Furthermore, a 30 year investment plan and a 5 year priority investment plan were adopted. Investments include the construction of the *Taoussa* Dam in Mali and the *Kandaji* Dam in Niger, as well as the rehabilitation of the *Kainji* Dam and the *Jebba* Dam in Nigeria.[74]

Adaptation

It is difficult to find information on the institutional roles in the countries concerning climate change adaptation. One method is to check which institution acts as contact body for the UNFCCC, editing NAPAs and national communications. Within the four countries, only Niger's NAPA has been prepared under a central body, i.e. a council under the Prime Minister. In Burkina Faso, documents were prepared by the Environment Council under the Ministry of Environment. In Guinea, it was the Ministry of Agriculture, Livestock Breeding, Environment, Water and Forests. In Mali, the NAPA was edited by the National Meteorology Authority under the Ministry of Equipment and Transport (see annex 3).

Since 1974, the *Comité Permanent Inter-Etats de Lutte contre la Sécheresse au Sahel* (CILSS) provides research and training through *Application en Agrométéorologie et Hydrologie Opérationnelle* (AGRHYMET). It includes a project on strengthening the capacities of the CILSS member States to adapt to climate change in the Sahel, funded by the Government of Canada.[75]

With assistance of the Netherlands Climate Assistance Programme (NCAP), Mali evaluated its own vulnerability and adaptation capacity. The project was implemented in two phases in three years. The final objective was to formulate national climate change policies which are consistent with the national poverty reduction strategy and can become a part of national and local development plans. In the first phase, a refined climate scenario at the national level was designed. The phase consisted of studies to improve the national understanding of climate change. The impacts of climate change on corn and cotton and associated adaptation strategies were identified.

[73] KfW 2007b
[74] Niger Basin Water Charter, quoted in ECLAC 2009
[75] IUCN 2004, p. 25

The Water Evaluation And Planning (WEAP) system is a tool which is used for climate change adaptation studies focused on water. It creates scenarios of water demand, supply, runoff and discharge, irrigation requirements, groundwater and surface water storage, pollution etc. Input variables include changes in policy, hydrology, climate, land use, technology and socio-economic factors like population growth. WEAP was created in 1988 and is developed by the US center of the non-profit Stockholm Environment Institute (SEI), based at the Tufts University in Massachusetts. The software license is free of charge for organizations which are based in developing countries, while other users pay between USD 250 (students) and USD 3,000 (non-consulting license) or more (consulting license).

Moreover, the impact of climate change on two Malian rivers (the Baoulé and the Sankarani) was assessed. Phase two was focused on the link between climate change and poverty. An application was developed using the Water Evaluation and Planning (WEAP) tool (see box above) which can be used in order to evaluate the effectiveness of adaptation strategies.[76] Based on records from the reference period between 1970 and 2000, the assumption was made that the same climate development will continue from 2005 to 2025 with a decrease in precipitation by 0.5% and an increase in temperature of 0.2% per year. Increasing water requirements in the three localities of Diouna, Kiban and Massabla were added, considering population growth, livestock etc.

It is important to note that this methodology relies exclusively on developments of the past and their application to the future. No future projection, e.g. using a GCM was compared to the scenario designed. They concluded that water resources will not meet the future requirements and suggested specific adaptation measures, among them deep boreholes with low cost technology and water and soil conservation technologies.[77] Given the unclear situation concerning groundwater, the former recommendation is risky.

Policies and strategies

Burkina Faso, Guinea, Mali and Niger each adopted National Adaptation Programs of Action (NAPAs). The concept was introduced at a 2001 UNFCCC conference. Through NAPAs, LDCs can "identify priority activities that respond to their urgent and immediate needs to adapt to climate change".[78] The priority activities are those which would increase vulnerability and/or costs at a later stage if they are further delayed.[79]

The focus of the NAPAs is on identifying urgent activities, not on implementing them. They do not provide a long-term adaptation strategy and they do not include any implementation mechanisms. Instead, an important outcome of NAPAs is awareness raising and capacity development inside the concerned countries, resulting from the process of preparation. This is why national ownership and multi stakeholder involvement at the national level is regarded as crucial.[80] Table 7 gives some details of the NAPAs in the four selected countries which are shown in more detail in annex 3. It is unclear if any elements of the NAPAs became part of national policies and/or development cooperation.

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[76] NCAP 2009
[77] wikiADAPT 2009
[78] UNFCCC 2010
[79] UNFCCC 2010
[80] UNDP 2009b, p. 3

	Year of publishing	*Number of projects*	*Total cost (in million USD)*
Burkina Faso	2007	12	5.9
Guinea	2007	25	8.2
Mali	2007	19	49.8
Niger	2006	15	N/A

Table 7: overview of National Adaptation Programs of Action (NAPAs) source: UNFCCC 2010

Climate projections were made in the NAPAs of Burkina Faso, Mali and Niger using the MAGICC SCENGEN software.[81] MAGICC (Model for the Assessment of Greenhouse-gas Induced Climate Change) is a climate model which has been used in IPCC assessment reports for projecting future global mean temperature and sea level change. SCENGEN (Scenario Generator) is a tool used for downscaling the projections to the regional level. The regional results are based on several coupled atmosphere-ocean GCMs. MAGICC/SCENGEN is free of charge.[82]

In addition to the NAPAs, the four countries also published their first national communications to the UNFCCC from 2000 to 2002. Niger published its second national communication in 2009.

Possible adaptation measures

Given the uncertain future climate projections, it is recommended to rely on no-regret measures, i.e. measures which are justifiable even in the complete absence of climate change and variability. Measures which partially or exclusively target the impacts of climate change include a certain risk of uselessness, since these impacts are not clear. However, water in the Upper and Middle Niger River Basin is under pressure due to other developments. Climate change and variability could, if they happen, further exacerbate the situation. Therefore, action against trends like population growth, deforestation, and pollution of water resources contributes to improving resilience to climate change and variability and to decreasing vulnerability. There is a wide range of possible no-regret measures which might be implemented in the basin. The NAPAs and National Communications of the countries include lists of proposed adaptation measures. The following list gives some ideas on adequate measures.

Cooperation and research

In the light of uncertain climate change and variability in the future, it is strongly advised to intensify research on future developments and their impact on the basin. This can be done through downscaling of global models, which however implicates a fair range of uncertainty. In order to understand the hydrological and climatic regime in the area as good as possible, measurements should be intensified and thoroughly evaluated. Climate projections could then be relined using relevant data. Future climate projections might be elaborated at the level of sub basins. Once established, an adequate climate observing system together with climate projections allow for the establishment of an early warning system for extreme weather situations. Since the borders of basins and sub basins do not follow political borders, research related projects are likely to include an aspect of transboundary cooperation.

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[81] Referred to as *Magic Shungen* in the NAPA of Mali; source: Republique du Mali 2007, p. 26

[82] UCAR 2007; UNFCCC no date

Among other strategies, regional cooperation can be achieved by supporting NBA, the existing transboundary institution in the basin.

Further research is also useful when it comes to adaptation options. Local communities have had to adapt to climate change and variability long before science and development cooperation discovered the issue. Their strategies and activities contribute to widening the range of possible adaptation options.

Capacity building
Climate change and variability are already on the political agenda in the countries of the river basin. For instance, this happened through the national dialogue with UNFCCC, including the preparation of NAPAs and National Communications. However, knowledge on climate change and variability differ significantly from country to country. Therefore, the issue should be included in the political dialogue with the objective to adapt national policies to climate change and variability. For instance, this includes sustainable land use and environmental policies.

Land use planning / disaster preparedness
Some areas in the basin are threatened by erosion and severe damage caused by floods. The level of these floods might increase due to rising climate variability. Sustainable land use planning could prevent damage by regulating the construction of buildings in areas known as exposed to that risk.

Spontaneous adaptation

Adaptation to a changing climate is not a new development. As shown above, climate in the Niger Basin has changed at least since the second half of the last century, with strong variations in precipitation and discharge and an increase in temperature. Therefore, communities were forced to adapt to the changing situation with limited external support. In four small villages in the basin close to Niamey, Amoukou found numerous agricultural strategies with the objective to reduce climatic risks. Some of these approaches receive support from NGOs and development cooperation organizations. Concerning water resources, he mentions the following adaptation measures:

- Removal of sand from pools
- Manual removal of water hyacinth from the river
- Limitation of fishing practices
- Introduction of new fishing techniques
- Watering of animals at the river when pools run dry[83]

One important approach of adaptation is migration.[84] People leave areas in which climate becomes hostile. In Mali for instance, a large share of people move towards the southern regions and cities due to low yields and shrinking water resources.[85] Future adaptation measures have been identified through the NAPAs. It is not clear if any of these projects started so far. Hence, there is a large amount of possible future adaptation measures (see annex 3).

[83] Amoukou 2009
[84] IUCN 2004, p. 11; Zwarts et al. 2005, p. 152; UNEP 2006, p. 11
[85] ECA 2009, p. 86

Development cooperation activities

Many bilateral and multilateral donors are active in the region in numerous projects, among them GIZ, KfW, DANIDA, the Netherlands, USAID, UNDP, UNEP and the World Bank. A short excerpt with some selected projects is given below. Due to a lack of resources, it is not possible to do a full survey of donor activities.

German development cooperation

The Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) is active in adaptation to climate change in several African countries, among them Mali and Burkina Faso. The activities are concentrated on agriculture. The *Community Management of Crop Diversity to Enhance Resilience, Yield Stability and Income Generation in Changing West African Climates* (CODE-WA) project supports increased crop diversity among farmers in Mali, Burkina Faso, Niger and Ghana. Under the projects, they are expected to become more independent from climate variations due to a wider scale of crops, varieties and techniques. CODE-WA started in 2008 and is expected to end in 2011.[86] In the *Support of the Niger Basin Authority* project with a budget of EUR 7.5 million, GIZ contributes to the joint river management. Among other activities, the staff of the NBA headquarters in Niamey and the responsible national ministries receive training for the whole project duration time of ten years (2007-2016).[87]

The KfW Entwicklungsbank has supported the *Office du Niger* in Mali since 1988. Together with other donors, areas for irrigated agriculture have been rehabilitated and expanded. The *Integration of Marginal Land Users* project has the objective to improve irrigation conditions in the irrigated area which is controlled by the *Office du Niger* and extend it by about 900 hectares and to integrate land users which are located outside of the irrigated area through improved drainage. Under the project, the hydraulic functions of a drainage canal are rehabilitated and improved. The construction of a track next to the canal facilitates easier access for future maintenance. Through an extension of the irrigation system, agriculture becomes more independent from erratic rainfalls, which is a concrete adaptation measure. The total cost of the project is EUR 8.6 million, 8 of which are financed by KfW.[88]

The recently approved KfW *Protection of Niger River II* project improves the condition of the Niger River through the rehabilitation of its river bed in selected areas which are particularly threatened by erosion in Mali. Moreover, the project includes a study for sewage treatment and waste disposal in Mali and Guinea. The project partner is the NBA. The cost of the project is EUR 10 million.[89]

Selected other development partners

Together with several partners, the World Bank supports the NBA under the *Niger Basin Water Resources Development and Sustainable Ecosystems Management Project*. The main objective of the project is to increase regional coordination and to develop and sustain water resources management in the river basin. The project is composed of three components. The first one aims at institutional strengthening and capacity building of NBA,

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[86] GTZ 2009
[87] GTZ 2007
[88] KfW 2007b
[89] KfW 2009

including national structures and institutions. Component two aims at improving and developing infrastructure including the rehabilitation of the Kainji and Jebba dams. The third component concerns sustainable management of selected degraded ecosystems and small infrastructure.

The World Bank accounts for more than three quarters of the total project costs of USD 233.2 million. The remainder is financed by the African Development Bank (AfDB), the French Development Agency (AFD), the Canadian International Development Agency (CIDA) and the European Commission. The project started in 2007 and will presumably end in 2013.[90]

Conclusions and recommendations

Communities in the Upper and Middle Niger River Basin strongly depend on the river. However, its flow has been highly variable through the second half of the 20th century. Similarly, future hydrologic patterns are unclear. In addition to climate change and climate variability, direct human impacts through land use changes have a decisive impact on hydrology in the river basin. For the time being, the developments in rainfall, discharge and runoff cannot be unambiguously traced back to one of these causes.

The high level of uncertainty about future climate developments emphasizes the relevance of adapting to different scenarios. This includes a reduction of vulnerability to climate variability and preparedness to possible challenges and opportunities.[91] The contradictory projections of the future climatic development related to hydrology in the region impede clear recommendations, except for the suggestion to intensify research. Transboundary cooperation and management of resources have proved to be a useful approach in this regard.

As long as the impacts of climate change remain unclear, it is advised to rely on no regret measures instead of developing new measures that exclusively target climate change. Local experience with adaptation and NAPAs enrich the scope of concrete approaches, regardless of their doubtful basis.

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[90] World Bank 2007
[91] IUCN 2004, p. 11-24

References

Adaptation Learning Mechanism (ALM) (2009): Strengthening capacity to address climate change adaptation concerns in the preparation and implementation of development plans, programmes and projects. http://www.adaptationlearning.net/project/strengthening-capacity-address-climate-change-adaptation-concerns-preparation-and-implementa

Adaptation Learning Mechanism (ALM) (2010a): Guinea - National Adaptation Programme of Action (NAPA): http://www.adaptationlearning.net/guinea-napa

Amoukou, Ibrahim A. (2009): Un village nigérien face au changement climatique. Stratégies locales d'adaptation au changement climatique dans une zone rurale du basin du Niger. http://www2.gtz.de/dokumente/bib/gtz2009-0548fr-niger-changement-climatique.pdf

Awaiss, Aboubacar; Humphrey, Sarah (no date): Atlas du Bassin du Niger / Niger Basin Atlas http://www.wetlands.org/LinkClick.aspx?fileticket=EfeRMcQ5QsY%3d&tabid=56

Cappelaere, B., Descroix, L., Lebel, T., et al., (2009): The AMMA catch observing system in the cultivated Sahelian of South West Niger – strategy, implementation and site conditions. In: Journal of Hydrology Volume 375, Issues 1–2, p. 34–51

Central Intelligence Agency (CIA) (2010): The World Fact Book. https://www.cia.gov/library/publications/the-world-factbook/

Economics of Climate Adaptation (ECA) Working Group (2009): Shaping Climate-Resilient Development. A framework for decision-making. ClimateWorks Foundation; Global Environment Facility (GEF); European Commission; McKinsey & Company; The Rockefeller Foundation; Standard Chartered Bank and Swiss Re. http://www.mckinsey.com/App_Media/Images/Page_Images/Offices/SocialSector/PDF/ECA_Shaping_Climate%20Resilent_Development.pdf

Descroix, L.; Mahé, G; Lebel, T.; Favreau, G.; Galle, S.; Gautier, E.; Olivry, J.-C.; Albergel, J.; Amoga, O.; Cappelaere, B.; Dessouassi, R.; Diedhiou, A.; Le Breton, E.; Mamadou, I.; Sighomnou, D. (2009): Spatio-temporal variability of hydrological regimes around the boundaries between Sahelian and Sudanian areas of West Africa: A synthesis. In: Journal of Hydrology. Volume 375, Issues 1-2, p. 90-102

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) (2007): Factsheet: Support of the Niger Basin Authority.

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) (2009): Factsheet: Community management of crop diversity to enhance resilience, yield stability and income generation in changing West African climates (CODE-WA). http://www.gtz.de/de/dokumente/gtz2009-5-en-factsheet-icrisat.pdf

Economic Commission for Latin America and the Caribbean (ECLAC) (2009): International Rivers and Lakes. Newsletter No. 47. http://www.eclac.org/drni/noticias/circulares/1/35841/irl_47.pdf

Federal Foreign Office of Germany (2010a): Guinea. Reise- und Sicherheitshinweise. http://www.auswaertiges-amt.de/diplo/de/Laenderinformationen/Guinea/Sicherheitshinweise.html

Federal Foreign Office of Germany (2010b): Niger. Reise- und Sicherheitshinweise. http://www.auswaertiges-amt.de/diplo/de/Laenderinformationen/Niger/Sicherheitshinweise.html

Food and Agriculture Organization (FAO) (1997): Irrigation potential in Africa: A basin approach. The Niger Basin. http://www.fao.org/docrep/w4347e/w4347e00.htm#Contents

Food and Agriculture Organization (FAO) (2010a): Aquastat. Geo-referenced database on African dams. http://www.fao.org/nr/water/aquastat/damsafrica/index.stm

Food and Agriculture Organization (FAO) (2010b): Aquastat. Country fact sheets. http://www.fao.org/nr/water/aquastat/countries/index.stm

Gleick, Peter H. (2000): The World's Water, 2000-2001: The Biennial Report on Freshwater. Island Press, p. 33

Intergovernmental Panel on Climate Change (IPCC) (2000): IPCC Special Report on Emissions Scenarios. http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/emission/

Intergovernmental Panel on Climate Change (IPCC) (2001): IPCC Third Assessment Report (AR3). Impacts, Adaptation and Vulnerability. Annex B: Glossary of Terms. http://www.grida.no/climate/ipcc_tar/vol4/english/204.htm

Intergovernmental Panel on Climate Change (IPCC) (2007a): IPCC Fourth Assessment Report (AR4). Climate Change 2007: Synthesis Report. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm

Intergovernmental Panel on Climate Change (IPCC) (2007b): IPCC Fourth Assessment Report (AR4). Climate Change 2007: The Physical Science Basis. Annexes. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-annexes.pdf

KfW Entwicklungsbank (2007a): Guinea. Ländliche Wasserversorgung Fouta Djallon. Ex-Post Evaluierungsbericht.

KfW Entwicklungsbank (2007b): *Office du Niger* – Integration marginaler Landnutzer. Projektprüfungsbericht.

KfW Entwicklungsbank (2009a): Dem Klimawandel trotzen. http://www.kfw-entwicklungsbank.de/DE_Home/KfW_Entwicklungsbank/Aktuelles/Archiv_2008_bis_2009/Dem_Klimawandel_trotzen.jsp

KfW Entwicklungsbank (2009b): EZ-Programm Integriertes Wasserressourcenmanagement ABN. Programmvorschlag FZ-Modul Schutz des Nigerflusses I. Prüfungsbericht.

KfW Entwicklungsbank (2009c): Ländl. Wasserversorgung Maradi Phase II. Ex-Post Evaluierung.

Laë, R.; Williams, S.; Malam Massou, A.; Morand, P.; Mikolasek, O. (2002): Review of the Present State of the Environment, Fish Stocks and Fisheries of the River Niger (West Africa) ftp://ftp.fao.org/docrep/fao/007/ad525e

Lebel, Thierry and Ali, Abdou (2009): Recent trends in the Central and Western Sahel rainfall regime (1990-2007). In: Journal of Hydrology. Volume 375. Issues 1-2, p. 52-64

Mahé, Gil and Paturel, Jean-Emmanuel (2009): 1896–2006 Sahelian annual rainfall variability and runoff increase of Sahelian Rivers. In: Comptes Rendus Geosciences.Volume 341, Issue 7, p. 538-546

Netherlands Climate Assistance Program (NCAP) (2009): Mali. http://www.nlcap.net/countries/mali/

Niger Basin Authority (NBA); Global Environment Facility (GEF); United Nations Development Program (UNDP); United Nations Department for Economic and Social Affairs (UNDESA) (2002): Reversing Water and Land Resources Degradation Trends in the Niger River Basin. http://www.iwlearn.net/iw-projects/Fsp_112799468181/project_doc/niger-river-basin-project-brief-acrobat.pdf

Niger Basin Authority (2010): Personal Communication. Hydrologic Data.

Office du Niger (2009): Le Site de l'Office du niger. Historique. http://www.office-du-niger.org.ml/internet/index.php?option=com_content&view=category&layout=blog&id=3&Itemid=3

Organisation for Economic Co-operation and Development (OECD) (2006): “Adaptation to Climate Change. Key Terms.” http://www.oecd.org/dataoecd/36/53/36736773.pdf

Organisation for Economic Co-operation and Development (OECD) (2009): “Policy Guidance on Integrating Climate Change Adaptation into Development Co-Operation.” http://www.oecd.org/dataoecd/26/34/42747370.pdf

Olomoda, Ibraheem A. (2002): Impact of climatic change on river Niger. Niger Basin Authority. http://www.riversymposium.com/2006/index.php?element=06OLOMODAIbraheem

Republic of Niger. Prime Minister Cabinet. National Council of Environment for Sustainable Development (2010): National Adaptation Program of Action (NAPA). http://unfccc.int/resource/docs/napa/ner01e.pdf

République du Mali. Ministère de l’Equipment et des Transports. Direction Nationale de la Météorologie (2007): Programme d’Action National d’Adaptation aux Changements Climatiques. http://unfccc.int/resource/docs/napa/mli01f.pdf

Reuters (2010): U.N. to create science panel to review IPCC. http://www.reuters.com/article/idUSTRE61P1BV20100226

Schuol, Jürgen; Abbaspour, Karim C.; Srinivasan, Raghavan and Yang, Hong (2008): Estimation of freshwater availability in the West African sub-continent using the SWAT hydrologic model. In: Journal of Hydrology. Volume 352, Issues 1-2.

Sunday Times (2010): Africagate: top British scientist says UN panel is losing credibility. February 7, 2010. http://www.timesonline.co.uk/tol/news/environment/article7017907.ece

Sustainability and the Global Environment (SAGE), Center for (2010): River Discharge Database. Nelson Institute for Environmental Studies. University of Wisconsin-Madison. http://www.sage.wisc.edu/riverdata/

United Nations Development Program (UNDP) (2005): Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. Annex A: Glossary of Terms. http://www.undp.org/GEF/documents/publications/apf-annexes-a-b.pdf

United Nations Development Program (UNDP) (2009a): Country fact sheet: Mali and climate change. http://content.undp.org/go/newsroom/2009/december/fiche-pays-le-mali-et-les-changements-climatiques.en;jsessionid=axbWzt8vXD9

United Nations Development Program (UNDP) (2009b): Water Adaptation in NAPAs: Freshwater in Climate Adaptation Planning and Climate Adaptation in Freshwater Planning. http://unesdoc.unesco.org/images/0018/001818/181887E.pdf

United Nations Educational, Scientific and Cultural Organization (UNESCO) (2006): Water: a shared responsibility. The second United Nations World Water Development Report. http://unesdoc.unesco.org/images/0014/001454/145405E.pdf

United Nations Environment Program (UNEP) (2005): Facing the Facts: Assessing the Vulnerability of Africa's Water Resources to Environmental Change. http://www.unep.org/DEWA/products/publications/2006/Facing_Facts_prelims.pdf

United Nations Environment Program (UNEP) (2006): Climate Change and Variability in the Sahel Region: Impacts and Adaptation Strategies in the Agricultural Sector. http://www.unep.org/Themes/Freshwater/Documents/pdf/ClimateChangeSahelCombine.pdf

United Nations Framework Convention on Climate Change (UNFCCC) (2009): NAPA Project Database http://unfccc.int/cooperation_support/least_developed_countries_portal/napa_project_database/items/4583.php

United Nations Framework Convention on Climate Change (UNFCCC) (2010): National Adaptation Programmes of Action (NAPAs) http://unfccc.int/national_reports/napa/items/2719.php

United Nations Framework Convention on Climate Change (UNFCCC) (no date): Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change: MAGICC/SCENGEN http://unfccc.int/adaptation/nairobi_work_programme/knowledge_resources_and_publications/items/5430.php

United Nations Institute for Training and Research (UNITAR): National Adaptation Programme of Action. http://www.napa-pana.org/

United Nations Institute for Training and Research (UNITAR): ACCCA Data Base. Pilot project for building capacities to adapt to climate variability, extreme climatic events and climate change in urban and peri-urban Ouagadougou, Burkina Faso http://www.acccaproject.org/evolution/modules/knowledgebox/external2/view.php?id=290&kbid=5

United Nations Office of the High Representative for the Least Developed Countries, Landlocked Developing Countries and Small Island Developing States (UN-OHRLLS) (2010): Least Developed Countries - Country profiles. http://www.unohrlls.org/en/ldc/related/62/

United States Agency for International Development (USAID) (2007): Adapting to Climate Variability and Change. A Guidance Manual for Development Planning. http://www.usaid.gov/our_work/environment/climate/docs/reports/cc_vamanual.pdf

University Corporation for Atmospheric Research (UCAR) (2007): MAGICC/SCENGEN: About. http://www.cgd.ucar.edu/cas/wigley/magicc/about.html

weADAPT 3.0 (2009a): Mali http://www.weadapt.org/wiki/Mali

weADAPT 3.0 (2009b): Mali Institutional Issues http://www.weadapt.org/wiki/Mali_Institutional_Issues

weADAPT 3.0 (2009c): Burkina Faso http://www.weadapt.org/wiki/Burkina_Faso

weADAPT 3.0 (2009d): Mali http://www.weadapt.org/wiki/Mali

wikiADAPT (2009): Key Findings from Mali Case Study 1, 'The Study of Ultimate Users of Water Resources and Dialogue with Communities'. http://wikiadapt.org/index.php?title=Key_Findings_from_Mali_Case_Study_1%2C_%27The_Study_of_Ultimate_Users_of_Water_Resources_and_Dialogue_with_Communities%27 and http://wikiadapt.org/index.php?title=Key_Findings_from_Mali_Case_Study_2%2C_%27The_Identification_and_Selection_of_Appropriate_Water_Resource_Management_Technologies%27

Wikimedia Commons (2006): “File:Niger river map.PNG” Map of the Niger River. Author: User:Astrokey44 in Corel Painter IX from several sources http://commons.wikimedia.org/wiki/File:Niger_river_map.PNG

Wikimedia Commons (2008a): “File:Mali balancing.jpg” 6 o'clock in Mali. Author: Ferdinand Reus. http://commons.wikimedia.org/wiki/File:Mali_balancing.jpg

Wikimedia Commons (2008b): “File:Niger.Inland Delta.NASA2001291.jpg” Niger River in Mali, 2001. Author: Jacques Descloitres, MODIS Land Rapid Response Team, NASA/GSFC. Visualization Date 2001-10-18 http://commons.wikimedia.org/wiki/File:Niger.Inland_Delta.NASA2001291.jpg

Wikimedia Commons (2008c): “File:Pont-de-Markala.jpg” Markala's dam on the Niger. Author: Rgaudin http://commons.wikimedia.org/wiki/File:Pont-de-Markala.jpg

Wikimedia Foundation (2010): Wikipedia: Kandaji dam. http://en.wikipedia.org/wiki/Kandadji_dam

World Bank (2005): The Niger River Basin : A Vision for Sustainable Management. http://siteresources.worldbank.org/INTWAT/Resources/4602114-1206643460526/Niger_River_Basin_Vision_Sustainable_Management.pdf

World Bank (2007): Projects - Africa: Niger Basin Water Resources Development and Sustainable Ecosystems Management Project. http://web.worldbank.org/external/projects/main?Projectid=P093806&theSitePK=40941&piPK=64290415&pagePK=64283627&menuPK=64282134&Type=Overview

World Bank (2010): Climate Change Data Portal. http://sdwebx.worldbank.org/climateportal/

World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) (2008): Joint Monitoring Program. Country files. http://documents.wssinfo.org/?type=country_files

World Meteorological Organization (WMO) and Global Water Partnership (GWP) (2004): The Associated Programme on Flood Management. Integrated Flood Management. Case Study. Mali: Flood Management – Niger River Inland Delta. http://www.apfm.info/pdf/case_studies/cs_mali.pdf

World Resources Institute (WRI) (2010): Water Resources and Freshwater Ecosystems. Searchable database. http://earthtrends.wri.org/searchable_db/index.php?theme=2

Zwarts, Leo; van Beukering, Pieter; Kone, Bakary; Wymenga, Eddy (2005): The Niger, a lifeline. Effective Water Management in the Upper Niger Basin. http://www.wetlands.org/WatchRead/tabid/56/mod/1570/articleType/download/articleId/1921/Default.aspx

Note: all electronic sources were accessed in April 2010.

Annexes

Annex 1: Existing and planned dams in the Niger Basin

Name	***Country***	***Nearest city***	***River***	***Operational since***	***Capacity of the reservoir***	***Used for***
Existing dams						
Ségou	Mali	Markala	Niger	1947	0.175 km³	Irrigation
Sélingué	Mali	Bamako	Sankarani	1982	2.17 km³	Irrigation, flood control, hydropower, navigation
Sotuba	Mali	Bamako	Niger	1929	N/A	Irrigation, hydropower
Planned dams and dams under construction						
Fomi	Guinea		Niandan		6.4 km³	Hydropower, irrigation, flood control
Talo	Mali	Douna	Bani		0.2 km³	Irrigation
Djenné	Mali	Djenné	Bani		0.4 km³	Irrigation
Taoussa/ Tossaye	Mali	Gao	Niger		4.5 km³	Hydropower, irrigation
Kandadji	Niger		Niger	2013 (est.)	1.6 km³	Hydropower, irrigation, flood control

Table 8. Dams in the Niger River Basin; sources: FAO 2010; Zwarts et al. 2005

Annex 2: Climate change projections for selected locations

Faranah (Guinea)				
	Japanese High Resolution GCM	IPCC GCMs		
	Change (2091 - 2100 vs. 1981- 1990)	Change (2030 - 2049 vs. 1980-1999)	# Models Projecting Same Change	Country Average Values
Mean annual precipitation	5%	2%	13/20	1%
Runoff		-5%	5/12	-5%
Mean annual temperature (°C)	2	1		1
Maximum 5-day Precipitation	7%	-2%	3/8	1%
Consecutive Dry Days	11	2	7/8	3

Koulikoro (Mali)				
	Japanese High Resolution GCM	IPCC GCMs		
	Change (2091 - 2100 vs. 1981- 1990)	Change (2030 - 2049 vs. 1980-1999)	# Models Projecting Same Change	Country Average Values
Mean annual precipitation	15%	2%	12/20	3%
Runoff		-7%	5/12	-5%
Mean annual temperature (°C)	2	2		2
Maximum 5-day Precipitation	36%	15%	7/8	15%
Consecutive Dry Days	-1	0	5/8	-2

Mopti (Mali)				
	Japanese High Resolution GCM	IPCC GCMs		
	Change (2091 - 2100 vs. 1981- 1990)	Change (2030 - 2049 vs. 1980-1999)	# Models Projecting Same Change	Country Average Values
Mean annual precipitation	14%	3%	13/20	3%
Runoff		-4%	5/12	-5%
Mean annual temperature (°C)	2	2		2
Maximum 5-day Precipitation	15%	-2%	3/8	15%
Consecutive Dry Days	0	0	4/8	-2

Douna (Mali)				
	Japanese High Resolution GCM	IPCC GCMs		
	Change (2091 - 2100 vs. 1981- 1990)	Change (2030 - 2049 vs. 1980-1999)	# Models Projecting Same Change	Country Average Values
Mean annual precipitation	19%	3%	12/20	3%
Runoff		-7%	5/12	-5%

Mean annual temperature (°C)	2	2		2
Maximum 5-day Precipitation	23%	0%	2/8	15%
Consecutive Dry Days	3	-1	5/8	-2

Timbuktu (Mali)				
	Japanese High Resolution GCM	IPCC GCMs		
	Change (2091 - 2100 vs. 1981- 1990)	Change (2030 - 2049 vs. 1980-1999)	# Models Projecting Same Change	Country Average Values
Mean annual precipitation	17%	4%	13/20	3%
Runoff		-3%	6/12	-5%
Mean annual temperature (°C)	2	2		2
Maximum 5-day Precipitation	27%	-13%	4/8	15%
Consecutive Dry Days	9	-2	5/8	-2

Niger (Niamey)				
	Japanese High Resolution GCM	IPCC GCMs		
	Change (2091 - 2100 vs. 1981- 1990)	Change (2030 - 2049 vs. 1980-1999)	# Models Projecting Same Change	Country Average Values
Mean annual precipitation	11%	4%	13/20	7%
Runoff		2%	7/12	4%
Mean annual temperature (°C)	2	1		2
Maximum 5-day Precipitation	-4%	2%	6/8	15%
Consecutive Dry Days	-4	-1	5/8	-3

Table 9. Results of selected locations from the World Bank Climate Change Portal; source: World Bank 2010

Annex 3: NAPA Details

Burkina Faso NAPA		
NAPA prepared by*: Ministère de l'Environnement et du Cadre de Vie: Sécretariat Permanent du Conseil National pour l'Environnement et le Developpement Durable* (2007)		
Project Number	Project Title	Indicative Project Cost (USD)
1	Mitigating vulnerability to Climate Changes through the strengthening of a prevention and food crisis management system	400,000
2	**Securing cereal production through the promotion of supplemental irrigation in the following areas: North Region (Oudalan Province) and Centre-North region (Namentenga Province)**	**408,660**
3	**Restoration and management of Oursi pond**	**275,000**
4	Fodder production and development of fodder stocks for livestock in the Sahelian Region of Burkina Faso	330,000
5	Rehabilitation, sustainable management of natural vegetation, and valorisation of Non-timber Forest Products in the Eastern region of Burkina Faso	700,000
6	**Control of sand encroachment/mud silting in the river basins of Mouhoun, Nakanbé and Comoé**	**352,000**
7	**Implementation of irrigated crops in Gourma, Namentenga, Tapoa and Sanmatnga regions**	**443,300**
8	Protection of pastoral-suited regions in the Sahelian and Eastern regions	320,000
9	Securing agricultural production through the use of appropriate technological packages in the South-East and East regions	297,924
10	Promoting community-based fauna management in the Mouhoun region	810,000
11	**Implementation of safety zones and backup devices to control pollution of underground and surface water catchment infrastructures (lakes, wells, boreholes) in the cotton belts of Burkina (Mouhoun, South-West, Comoé and the Easetern part of Nakanbé)**	**330,000**
12	Promoting the use of energy saving equipment (improved stoves, M'Bora stew pan) and renewable energy-based technologies (pressure-cooker, water heater and solar dryers, etc.)	1,230,000
Total cost: 5,896,884		
URL: http://unfccc.int/resource/docs/napa/bfa01f.pdf		
Additional documents (all in French): • First National Communication (2002): http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=3461#beg • Annexes to First National Communication (2002): http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=5459#beg • National Strategy (2002): http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=3647#beg		

Guinea NAPA

NAPA prepared by: *Ministère de L'Agriculture, de l'Elevage, de l'Environnement, des Eaux et Forets: Conseil National de l'Environnement* (2007)		
Project Number	Project Title	Indicative Project Cost (USD)
1	Promotion of sylviculture 1. Support to the development of community and private plantations of cashew	600,000
2	Promotion of sylviculture 2. Assistance for the implementation of community-based forest management plans	600,000
3	Valorisation of positive local knowledge and practices	300,000
4	Promoting adaptation-oriented technologies. 1. Training of the coastal community on environmental friendly techniques to exploit oysters from mangrove ecosystems	250,000
5	Promoting adaptation-oriented technologies. 2. Promotion of sea salt production based on solar energy	300,000
6	Promoting adaptation-oriented technologies. 3. Dissemination of soil conservation practices	300,000
7	Promoting adaptation-oriented technologies. 4. Intensification of bulrush millet crops in the North region of Guinea	600,000
8	Promoting adaptation-oriented technologies. 5. Implementation of a system of early warning climate forecasts to protect agricultural production	350,000
9	Promoting adaptation-oriented technologies. 6. Promoting the use of solar energy for fish drying to reduce pressure on mangroves	200,000
10	Promoting adaptation-oriented technologies. 7. Training on and dissemination of techniques of making compacted bricks to mitigate the environmental impacts of cooking bricks	350,000
11	Promoting adaptation-oriented technologies. 8. Promotion of wire fencing and hedge planting in Moyenne Guinea	150,000
12	Promotion of fire management techniques and fencing	300,000
13	Protection of cultivated areas neighboring the coast	350,000
14	Promotion of and sensitization on Multilateral Agreements on Environment and national legal texts related to the protection and sustainable use of natural resources	300,000
15	Promoting Environmental Education for coastal communities	200,000
16	**Promoting the restoration and integrated management of small-scale hydraulic infrastructures. 1. Construction of multiple use small-scale dams**	**600,000**
17	**Promoting the restoration and integrated management of small-scale hydraulic infrastructures. 2. Construction of artificial lakes**	**180,000**
18	**Promoting the restoration and integrated management of small-scale hydraulic infrastructures. 3. Construction of improved wells**	**250,000**
19	**Promoting the restoration and integrated management of small-scale hydraulic infrastructures. 4. Surface water potabilisation by means of hydropur**	**320,000**
20	**Promoting the restoration and integrated management of small-scale hydraulic infrastructures 5. Dissemination of techniques of impluvia**	**280,000**
21	Protection of spawning areas in Fatale, Konkoure and Mellacore estuaries	250,000
22	**Rehabilitation of hydro-agricultural system of plains and lowlands 1. Implementation of irrigated rice cultivation in Moyenne and Haute Guinea**	**300,000**
23	Promoting income-generating activities 1. Intensification of small	325,000

	ruminant breeding	
24	Promoting income-generating activities 2. Development and promotion of vegetable growing	250,000
25	Promoting income-generating activities 3. Implementation of a ranch for cane rats to prevent unsustainable hunting of wildlife	300,000
Total cost: 8,205,000		
URL: http://unfccc.int/resource/docs/napa/gin01f.pdf		
Additional documents: • First National Communication (2002, in Frech): http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=3568#beg		

Mali NAPA		
NAPA prepared by: *Ministère de l'Equipement et des Transports: Direction Nationale de la Méteorologie* (2007)		
Project Number	Project Title	Indicative Project Cost (USD)
1	**Agricultural extension of improved food crop varieties adapted to climate change**	**300,000**
2	**Agricultural extension of animal and plant species with the highest adaptation potential to climate change**	**350,000**
3	Promotion of income-generating activities and development of mutual assistance	350,000
4	**Rehabilitation of aquaculture sites in Mali**	**25,760,000**
5	Promoting cereal stocks	500,000
6	**Promoting the use of meteorological information to improve agricultural production and contribute to food security**	**2,000,000**
7	Low land Improvement	2,000,000
8	**Implementation of drilling equipped with solar- or wind-driven systems**	**1,500,000**
9	Energy Valorisation from Typha australis	2,000,000
10	Contribution to barrier removal for the promotion of the use of solar energy in Mali	1,500,000
11	**Implementation of a runoff water harvesting system and restoration of water points (backwater, ponds and lakes)**	**280,000**
12	Sensitization and organization of the population for the preservation of natural resources (elaboration of local conventions on reforestation and agroforestry)	2,000,000
13	Management of brush fire in Mali	3,000,000
14	Intensification of soil conservation actions and composting	1,500,000
15	Intensification of fodder crop	500,000
16	Elaboration of a technological package of training for the population with simple adaptation practices to climate change	500,000
17	Promotion of fodder stock for livestock	220,000
18	**Promotion of Jatropha oil**	**5,000,000**
19	Implementation of an information system on climate change risk-related diseases	500,000
Total cost: 49,760,000		
URL: http://unfccc.int/resource/docs/napa/mli01f.pdf		
Additional documents: • First National Communication (2000, in French): http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=2733#beg		

Niger NAPA		
NAPA prepared by: *Cabinet du Premier Ministre: Conseil National de l'Environnement pour un Développement Durable* (2006)		
Project Number	Project Title	Indicative Project Cost
1	Introducing fodder crop species in pastoral areas	NA
2	Creating Livestock Food Banks	NA
3	**Restoring basins for crop irrigation**	**NA**
4	**Diversifying and Intensifying crop irrigation**	**NA**
5	Promoting peri-urban market gardening and livestock farming	NA
6	Promoting income-generating activities and developing mutual benefit societies	NA
7	**Exploitation of surface and ground water**	**NA**
8	**Producing and disseminating meteorological data**	**NA**
9	Creating Food Banks	NA
10	Contributing to fight against climate-related diseases	NA
11	Improving erosion control actions (CES/DRS) for agricultural, forestry and pastoral purposes	NA
12	Improving erosion control actions (CES/DRS) for agricultural, forestry and pastoral purposes	NA
13	Disseminating animal and crop species that are most adapted to climatic conditions	NA
14	**Watershed protection and rehabilitation of dump-off ponds**	**NA**
15	Building of material, technical and organizational capacities of rural producers	NA
16	Introducing fodder crop species in pastoral areas	NA
17	Creating Livestock Food Banks	NA
18	**Restoring basins for crop irrigation**	**NA**
19	**Diversifying and Intensifying crop irrigation**	**NA**
Total cost: NA		
URL: http://unfccc.int/resource/docs/napa/ner01e.pdf (English) http://unfccc.int/resource/docs/napa/ner01f.pdf (French)		
Additional documents: • First National Communication (2000, in French): http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=2736#beg • Second National Communication (2009): http://unfccc.int/resource/docs/natc/nernc2e.pdf (English) http://unfccc.int/resource/docs/natc/nernc2f.pdf (French)		

Table 10. Projects under the NAPAs in Burkina Faso, Guinea, Mali and Niger; source: UNFCCC 2010

Annex 4: Glossary of terms

This section provides definitions of the main frequently used terms concerning climate change adaptation.

Adaptation: is a process by which strategies to moderate, cope with, and take advantage of the consequences of climatic events are enhanced, developed, and implemented.[92]

Adaptive capacity: The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.[93]

Climate change refers to a change in the state of the climate that can be identifi ed (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.[94]

Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).[95]

Impacts are the detrimental and beneficial consequences of climate change on natural and human systems.[96]

Maladaptation: Any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead.[97]

Resilience: Amount of change a system can undergo without changing state.[98]

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.[99]

Note: for more information concerning definitions, please refer to IPCC 2007b and OECD 2006.

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[92] UNDP 2005, p. 248
[93] IPCC 2001
[94] IPCC 2007b
[95] IPCC 2007b
[96] IPCC 2001
[97] IPCC 2001
[98] IPCC 2001
[99] IPCC 2001