



Water sharing in the Upper Niger Basin

A&W-report 1739



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Photo Cover

Crossing the river ... and seeking new opportunities, Leo Zwarts

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1 Introduction

1.1 Food security and water management in Mali

Since the Great Drought in the 1970s and 1980s the promotion of food security has become one of the top priorities in the Sahel. To deal with the unpredictable climatic conditions, and to meet the demands of growing populations, countries as Senegal, Mali, Niger and Burkina Faso are stimulating the rural sector to improve inland food production. Enhancement of the inland food production is complicated, however, as soil fertility in the Sahel is low, water scarce and the agricultural sector underdeveloped. Large scale irrigation of low lying parts of river basins is an important option to raise food security: the production is independent from rainfall and lowers the dependency on foreign imported cereals. In Mali large scale irrigation has been realized in Office du Niger which today is the rice granary of West Africa (Bonneval *et al.* 2002, Zwarts *et al.* 2005).

Mali is facing a huge challenge. Promotion of food security is of top priority for which a further expansion of Office du Niger is one of the most promising options. This implies land development and additional water extraction from the Niger. At the same time water is needed for the booming energy demand. Water, however, is limitedly available and crucial to other sectors of the environment, not in the least the flood-driven ecosystem and economy of the downstream Inner Niger Delta. Almost 1,5 million fishermen and farmers make a living in the delta. Their livelihoods - fishing, rice growing and livestock grazing – depend on the annual floodings. Globally, the Inner Niger Delta is an ecological hotspot and the region is of crucial importance for Eurasian migratory bird populations. Tapping the Niger's flow is, therefore, not without consequences. In a nutshell, this shows that integrated water resources management is of utmost importance in the Upper Niger Basin, where food security, water management and ecosystem services are closely linked.

1.2 Green growth and water management

The sustainable development of (rural) economies and poverty eradication is recently promoted under the umbrella's of *green growth*, *green development* or *green economy*. A Green Economy is defined by UNEP (2011) as 'one that results in improved human wellbeing and social equity, while significantly reducing environmental risks and ecological scarcities.' In particular in growing economies this approach can lead to increased investments in sectors that enhance the earth's natural capital or reduce ecological scarcities and environmental risks (UNEP 2011). What new is to this development is the increased involvement of the private sector. Is the concept of *green development* also a promising option for African river basins?

A green development in African river basins is strongly connected to integrated water resources management (IWRM). In African river basins the limited water resources play a pivotal role in economic growth, both where the rural and urban communities are involved. This appears from the competition for water resources between the agricultural and energy sector, but it becomes even more prominent when ecosystem services are involved. Especially in Africa rural communities depend on ecosystem services for their livelihoods. These services, including biodiversity, are increasingly recognised as important sustainability criteria for development. The question arises whether green growth opens windows to developments or initiatives that balance water use between sectors in such a way that sustainable room is left for ecosystem services and natural capital.

To investigate this for African river basins, WWF initiated a project, commissioned by the Directorate for International Cooperation (DGIS) of the Dutch ministry of Foreign Affairs, to develop a framework for green development in relation to water management (WWF 2012). The project is aiming to identify the best approaches, based on an ecosystem approach, to integrate food security, land and water use, and other sectors. This quest can be seen from two perspectives: 1) from the context of developing river basins in which IWRM is the 'green motor' of the economic growth, and 2) from the viewpoint of new initiatives in a river basin which support or stimulate a green development. Although the project may identify smart solutions for integrated water management, the focus lies on the way to implementation. As far as appropriate, the concept draws on lessons learned in three African river basins: Lake Naivasha (Kenya), Lower Zambesi basin (Mozambique) and the Inner Niger Delta (Upper Niger Basin, Mali). The current report summarises the case of the Upper Niger Basin in Mali.

1.3 Scope and outline of this study

The geographical scope of this study encompasses the Upper Niger Basin in Mali, focussing on the downstream Inner Niger Delta up to Tombouctou (Fig. 2.1). This case study is focussing on the core bottlenecks and options with regard to IWRM and green development in the basin and steps which have been set – in terms of knowledge development, stakeholder engagement, implementation (emerging practices) - towards a more integrated approach. This report does not deal with related Sectors to water resources management as water sanity and purification.

Chapter 2 summarises the water resources in the Upper Niger Basin. It succinctly pictures the upstream-downstream chain of related factors: rainfall – river discharge – flooding, whereas In Chapter 3 the impact relation with the main infrastructure in the Upper Basin is worked out (water use). In Chapter 4 the flood-dependent ecosystem and economy of the Inner Niger Delta is presented. The future of the delta as a floodplain directly depends on the management of water resources in the Upper Niger Basin. The flood-dependent relationships with the ecosystem services and production of natural resources are highly relevant to green development.

Chapter 5 shortly pictures the administrative and institutional system for water management in the river basin. In addition, a synthesis is given of past and ongoing initiatives – projects, studies, processes – focussing on integrated water resources management in the Upper Niger Basin; the situation of IWRM is tested against a set of criteria which are important for change, and derived from the main report about green development (WWF 2012). The main lessons learned are summarised in Section 5.4. This report is concluded by putting forward promising options for 'greening' the future development in the Upper Niger Basin and, by making use of the lessons learned, possible strategies and activities are formulated (Chapter 6). Special attention is paid to the process of stakeholder engagement and ways for implementation of technical solutions which are already on the table.

2 Constraints to water use

In Mali, a land-locked country, rainfall is the sole water resource, although it varies from almost nothing in the north (Sahara desert) to superabundant in the south (Fig. 1). The annual variation in rainfall is huge and unpredictable. The surplus of rainfall in the south is being drained by the Niger river and its tributaries flowing into the Inner Niger Delta, one of the largest floodplains in the world. Besides a part of the Upper Senegal Basin in the east of the country, the Niger system and floodplains form the main water system in Mali. This Chapter describes the rainfall and river flow in the Upper Basin of the Niger, showing the natural constraints, including climate change, set to the water use described in the next Chapter.

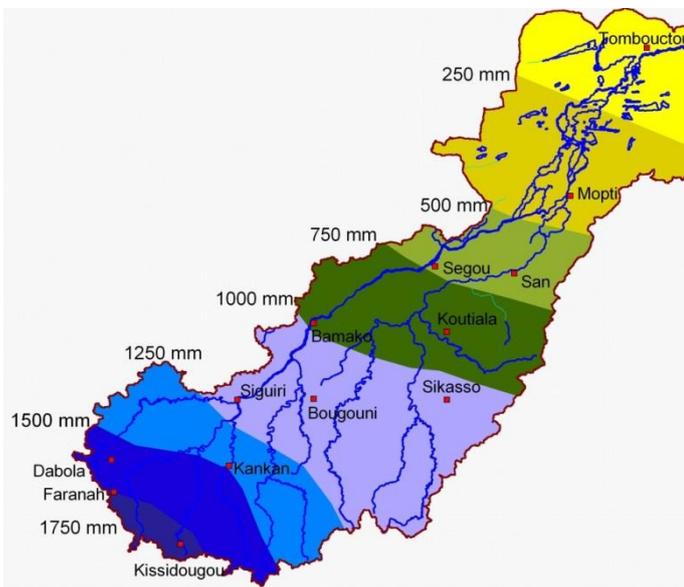


Fig. 2.1. The annual rainfall (mm/year) in the basin of the Upper Niger shown as eight different zones. The Inner Niger Delta is situated between Mopti and Tombouctou. From: Zwarts et al. (2005).

2.1 Rainfall

The inter-annual rainfall in West Africa is highly variable. During the 20th century, three periods of drought can be discerned: the first two - 1900-1915 and 1940-1949 respectively - were followed by periods of improved rainfall. Again 30 years later another drought occurred, but instead of an expected recovery in rainfall, there was a further decline until 1984. This last period is called the Great Drought in West Africa – *La Grande Sécheresse* (1972-1993). Since then, rainfall has gradually improved somewhat. Over the last centuries there have been similar climate epochs: from 800 to 1300 it was thought to have been relatively wet, to be followed by a drier period from 1300-1450, a wetter period until 1800 and a gradual decline since then.

Climate is an important driver of change. The daily rainfall in Saint Louis (Senegal) has been registered since 1848. Altogether in seven stations the measurements started in the 19th century. Although the annual rainfall is highly variable, the downward trend in these stations is evident, showing an average long-term decline of about 3% per year. The rainfall in Africa largely depends on the sea surface temperature of the oceans, but the rapid changes in land usage and loss of vegetation cover in the Sahel have enhanced the decline of the rainfall.

Since there are several competing mechanisms leading to more or to less rain in the Sahel, it is extremely difficult to predict whether there will be more or less rainfall in the Sahel. One of the

problems with the available Global Circulation Models is that they are not able to capture the Great Drought in the 1980s. Nevertheless, 16 of the 19 models being used in the recent IPCC Report do reproduce a drier Sahel at the end of the 20th century. Aerosol emissions from industrialization, causing global dimming, and thus cooling in the northern hemisphere, play a role in causing the Sahel drought. At least 30% of the observed negative rainfall trend over the 1930–2000 period was estimated to be externally forced, most likely anthropogenic.

In conclusion, still much is uncertain, but an ongoing decline of the rainfall, the sole water resource, in the Sahel seems to be likely. Since human influences are assumed to be substantial in the global climate change, this gives reasons to worry about the future.

2.2 River flow

The rivers in West Africa demonstrate huge between-season variations in discharge, being 80 times larger in the short intense rainy season than in the late dry season. Without this large seasonal variation in rainfall there would be no seasonal floodplains and thus no Inner Niger Delta. The flooding of the Inner Niger Delta is determined by the inflow from the Niger and Bani Rivers, which in turn relate to the rainfall experienced 600-900 km SW of the area (Fig. 2-1), in the Guinean Highland where it starts to rain April to reach a peak in July and August.

The Niger and tributaries rise in the Guinean Highlands, except the most northerly branch, the Tinkisso, which originates in the Fouta-Djalou. The main tributary to the Niger, the Bani, drains southernmost Mali and the northeastern corner of Ivory Coast. After the Bani flows into the Niger near Mopti, at the southern edge of the Inner Niger Delta, there is no further run-off from eastern Mali and Niger. Consequently, evaporation gradually diminishes the river flow.

The total catchment area of the Bani (129,000 km²) is nearly as large as the rest of the Upper Niger Basin (147,000 km²). Yet the discharge of the Bani is less than half of the Niger, because the Bani sub-basin receives less rainfall than the other sub-basins of the Upper Niger. The annual rainfall in the Bani catchment area usually varies between 1000 and 1200 mm. The Bani's flow in September fell back from 3000 m³/s to only 250 m³/s during the drought in the early 1980s, but subsequently gradually increased again. The long-term effect of a series of dry years on the flow of the Bani is evident. The Bani was a river with a fully natural flow until 2006 when the Talo dam became operational.

Since 1922, the average annual rainfall in the Upper Niger has varied between 1300 and 1600 mm. The trend resembles those shown for the Bani. But where the Bani lost 80% of its flow during the Great Drought, the decrease in the Niger was slightly less than 50%. The comparison between rainfall and discharge in the Upper Niger basin reveals a large variation in river flow and a much smaller variation in rainfall. This larger variation in river discharge is an important ecological asset of the Sahel. The explanation hinges on the cumulative effect of rainfall on river discharges: dry years lower the discharge, but it takes a number of wet years to attain subsequently a high discharge. In other words: river discharges not only relate to rainfall in the preceding wet season, but to a large extent also to earlier wet seasons. After a series of dry years, the discharge is insufficient to keep the groundwater table at a certain level; in turn a low groundwater table increases infiltration of surface water.

In conclusion, a continuing decline of the river flow of the Niger and Bani is to be expected given the anticipated climate change. The next Chapter shows that the flow will decrease even more due to the planned interventions in the Upper Niger Basin.

3 Water use

Many people in Mali, in particular the rural communities, depend for their living on the Niger and Bani flows. The large annual variation in river flow leads to a simultaneous variation in the production of food (natural resources). To make the economy of Mali less dependent on climate and river flow, hydro-agricultural irrigation schemes have been developed. At the same time, the need for electricity has increased, leading to the (planned) construction of hydroelectric dams. This Chapter describes the impact of these dams and irrigation schemes (Fig. 3-1) on the river flow and shortly indicates the (expected) economic functions.

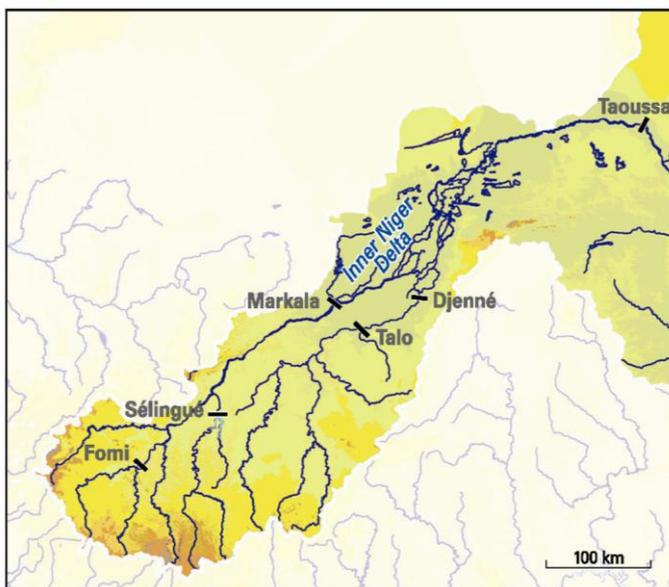


Fig. 3.1. The Upper Niger with the Niger River and its branches. Sélingué, Markala and Talo are existing dams. Fomi is still in study, Djenné is being build, and for the Taoussa dam preliminary building works have started.

3.1 Seven interventions in the Upper Niger

Sélingué

Since 1982, the flow of the Upper Niger has not been fully natural due to the construction of the Sélingué reservoir in the Sankarani. The Sélingué reservoir covers 450 km² when full (2.1 km³). The (natural) flow is reduced by, on average, 61% in August and by 36% in September due to the filling of the reservoir. In contrast, when water is released from the dam in the dry season, the outflow between February and April is about three times the amount of the natural flow. 1.8 km³ of the annual flow is withheld by Sélingué in August and September, of which 0.5 km³ is lost due to evaporation. In the dry season 0.2 km³ per month is released, as a consequence of which the (natural) river flow roughly doubles in these months. The water stored annually in the reservoir amounts to 10-20% of the peak flow in wet years, but to 20-30% in dry years.

The difference between the inflow into and outflow from the Sélingué reservoir is a direct measure of the impact of the Sélingué reservoir on the monthly river flow. In a year with a large inflow the reservoir is already filled for a large part in August, but in a dry year relatively more water is withheld in September. Furthermore, the annual variation in river flow has hardly any impact on the seasonal pattern of storing and releasing the water.

To irrigate the rice fields immediately downstream of the Sélingué dam (1400 ha) 1.1 m³/s is taken from the river; the total annual rice productions amounts to 17,000 tonnes. The hydropower plant results in a production of electricity varying between, on average, 10 GWh in January - February and 20 GWh in August - November. The annual total production varies since 1983

Small irrigation schemes in the Upper Niger

Office Haute Vallée Niger (OHVN) manages, beside the irrigation scheme of Maninkoura (850 ha) 40 km downstream of Sélingué, 28 other irrigation areas with a total surface of 12.000 ha and plans to make seven other rice polders (with a total surface 3700 ha) further downstream along the Sankarani. The planned weir near Kourouba in the Sankarani would enable to irrigate the rice fields of Maninkourou (5000 ha). The total annual water intake to irrigate the 17,776 ha of rice polders along the Upper Niger may be roughly estimated at 18 m³/s. This will increase to 20-25 m³/s if the Kourouba dam is functional. The irrigated area of Baguinéda near the Sotuba dam just downstream of Bamako has a surface of 2400 ha. The water consumption varies between 3 m³/s in the dry season and 9.5 m³/s in the wet season. The rice production at present amounted to 18,700 tonnes in the areas managed by "Office du Perimetre Irriguee de Baguineda" (OPIB) and 10,800 tonnes in Baguinéda.

Office du Niger

The irrigation zone managed by Office du Niger is possible thanks to the Markala dam, a weir across the river used to raise the water level 5.5 m above the lowest water level of the river. This enables irrigation under gravitation. The irrigation zone of Office du Niger is located in the *Delta mort*, an ancient branch of the Niger. The Markala dam has been operational since 1947, but it took many years before the irrigation scheme was developed.

The water intake, as registered by Office du Niger, amounts to 2.69 km³ per year, equivalent to 86.5 m³/s and does not differ for dry or wet years. Despite the gradual extension of the irrigated zone, the total water extraction remained at the same level between 1988 and 2011. Over the same period, the annual river discharge at Markala varied between 539 and 1229 m³/s. As a consequence, water use by Office du Niger is not more than 7% of a high river flow (1995), but this may increase to 16% when the flow is low (1989). The monthly water use by Office du Niger varies seasonally and is 60 m³/s in January, gradually increasing to 130 m³/s in October, decreasing to 90 m³/s in November and 50 m³/s in December. The available water supply varies between 100 m³/s in March and 3200 m³/s in September. Hence 60% of the flow is tapped in March against only a few percent in September.

The irrigated zone in the Office du Niger has gradually been extended. The zone with irrigated rice fields during the wet season has increased from 40,000 ha in the 1980s to 77,000 ha in 2007. Since in the same period the yield of rice has increased from 2 to 6 tonnes/ha, the total rice production in the wet season has shown an even larger boost from about 10,000 tonnes in the 1970s to more than 450,000 tonnes in 2008/09. Including Sukala (4200 ha with sugarcane), the irrigated area has increased to 84,140 ha in 2009 and a further extension is planned. The *Plan d'Action du Schéma Directeur de Développement de la Zone Office du Niger* (2009) provides a detailed planning. The irrigated zone will be extended by 33,595 ha in 2010-2012 and 71,888 ha in 2013-2020 (planned), by which in 2020 the total irrigated zone will have reached a surface area of 193,394 ha. In addition, a potential extension is mentioned of 105,483 ha in 2010-2020.

The expansion of the Office du Niger so far has been able without an increase of the total water consumption in September – February, but the intended extension is only possible at a higher

water intake. The water consumption in September and October amounts to 120-130 m³/s and has never been higher than 146 m³/s during a month. This limit is determined by the dimensions of the hydrological system. The water from the river just upstream of the weir is directed through a large main canal with a maximum capacity of 200 m³/s to *Point A (the capacity of this canal should be upgrade to 350 m³/s in the frame of the Millennium Challenge Corporation funded by the USA)*, from which it is divided between three smaller canals:

- Canal du Sahel (max.100 m³/s) discharging northwards into Fala de Molodo leading to the irrigated areas north of Niono.
- Canal Costes-Ongoïba (max. 13 m³/s) supplying the sugar plantation of Siribala.
- Canal du Macina (max. 45 m³/s) leading into Fala de Boky-Wéré, running in an easterly direction towards the polders of Macina.

The first priority of Office du Niger has been so far to enlarge the capacity of the Canal du Sahel (from 100 to 190 m³/s) and of the canal du Costes-Ongoïba (from 13 to 45 m³) and not to increase the flow along the canal du Macina (45 m³/s). This means that the total maximal water extraction would increase from 130 m³/s in September-October to 280 m³/s. The intended scheme has changed by a concession given in 2008 to *Malibya*, to develop 100,000 ha east of Office du Niger. The Chinese CGC constructed the last 3 years a 40 km long canal to halfway the Canal du Macina, with a capacity of 127 m³/s. To feed this new canal, also the western part of the Canal du Macina and the main canal have to be enlarged. All in all, the total water consumption by Office du Niger would arrive at about 400 m³/s, and even more if all other concessions are taken into account (Mali Plan de Zonage des Amenagements et Projections; October 2011).

Bigger channels may enable Office du Niger to take more water and thus to extend the irrigation zone. However, this will only be possible in the period July-February, but not in March-July. In the present situation the river discharge sets a limit to the water consumption in March-July. During these months the water intake has increased the last 15 years by about 30%. A further increase is hardly possible, since the river discharge cannot be used completely for irrigation to avoid serious ecological and economic problems downstream of the Markala dam. The minimal required water flow passing the weir is set at 40 m³/s. During recent years, this lower limit is passed already between mid-March and mid-May. In other words, water is the limiting factor.

In conclusion, Office du Niger has become the granary of Mali. It consumes at present 7% of the river water in a year with a high flow, but 16% in a year with a low flow. The seasonal variation is even larger, with 60% taken in March and a few per cent in October. Office du Niger has the ambition to grow but faces two constraints: the capacity of the canal between the Niger and the irrigation areas sets a limit to the water intake in July-November, whereas the low river discharge during the dry period sets a limit to the present water use in March-May. The implications for the water management and possible solutions are discussed below.

Fomi

The Fomi dam is planned to be constructed in the Niandan tributary in Guinea-Conakry. The reservoir is meant for hydropower in combination with irrigation and flood control. There are still several scenarios (Coyne & Bellier *et al.* 2009). If the Fomi reservoir will be kept at 390 m above sea level, the lake will have about the same surface area as Lac Sélingué (varying seasonally between 247 and 507 km²), but it will be much deeper (12 m, on average at high water). That is why it will contain, if full, three times as much water as the Sélingué reservoir (6.16 km³). Another difference between Sélingué and Fomi is that the annual inflow into the

Fomi reservoir (7.07 km^3) would be nearly twice as low as the average inflow of the Sankarani (12 km^3) into the Sélingué reservoir.

The Fomi reservoir will be managed in about the same way as Sélingué, as far as possible given the limitation of the relatively low inflow compared to the large volume. To fill the reservoir between July and October 0.29 , 0.69 , 0.80 and 1.94 km^3 will be stored, respectively. The stored water is released between December and June, as a consequence of which the future flow of the Niandan River will become in March and April ten times larger, on average, as the natural flow. The expected potential annual electricity production is estimated at 243 GWh, on average being variable however, due to the variation in annual flow. In a dry year the production will be not higher than 136 GWh.

In conclusion, the electricity produced at Fomi will be 20% larger as Sélingué, although showing a larger annual variation due to the limited inflow. The Fomi reservoir will have a large impact on the flow of the Niandan: from July to October. 37% of the inflow into the reservoir is withheld, whereas as the outflow in March-April will become ten times larger as in the natural situation.

Talo

The Talo dam, built in 2006 in the Bani River, is meant to facilitate irrigation under gravitation in the plains between Tounga and San. The planning was to develop 20,320 ha, of which 16,030 irrigated rice fields; the rest is planned to be converted into *bourgou* (water meadows) and fish ponds. The reservoir would remain small (maximum surface 50 km^2 , maximum volume 0.18 km^3) but, as can be seen on Google Earth, its surface may be as large as 80 km^2 , and even larger because it actually reaches the main road between San and Bla. The present effect of Talo on the river flow is obvious from the seasonal variation in the water level downstream upstream at Douna and downstream at Beleni-Kegny. Since 2005, the peak flood level in Beleni-Kegny has been reduced by about 50 cm.

The expectation is that due to the Talo dam, the flow of the Bani at Mopti between July and October will be reduced by 0.39 km^3 , being a likely underestimation.

Djenné

The Djenné dam, to be constructed south of the town of Djenné, is intended to counteract the water losses in the lower Bani caused by the Talo dam. Moreover, low dikes will be made along the Bani and along the Niger near Kouakarou. It is the intention to develop rice polders west of the dam and to rehabilitate the rice polders near Djenné and Sofara, and between Fatoma and Kouna. Part of the new perimeters will be rarely flooded, however, e.g. the zone along the Bani River near the barrage itself.

Due to the dam a reservoir of 150 km^2 and 0.357 km^3 will come into existence, 245 km^2 will be flooded and assumed to be covered by a vegetation of *bourgou*. Two alternatives have been worked out: either rice will be grown on 435 km^2 with a controlled submersion, or 100 km^2 will have a full-water-control and 335 km^2 controlled submersion. The investments are high with 1.0 and 1.8 million CFA/ha, respectively for both variants. In a year with an average flow, the water level in Sofara will be reduced by 30-55 cm in September, but in a dry year by 64-90 cm. The impact is less further downstream. In Mopti, where the Bani flows into the Niger, the water level is yet reduced by 5-15 cm in a year with an average flow and by 17-27 cm in a dry year.

In conclusion, a part of the southern Delta will be artificially flooded, but this will be at the expense of floodplains downstream of the dam.

Taoussa dam

The Taoussa dam is projected at 130 km upstream of Gao and 280 km downstream of Tombouctou. To maximize the production of electricity, the lake will be filled during the flooding period (August-January) and emptied during the deflooding period in the rest of the year. The minimum working level will be some 40 cm above the lowest gate level, by which the seasonal variation in water level will be about 4 meter, being more than the natural variation in extreme dry years but less than the variation in wet years.

As a consequence of the dam, a lake of 1572 km² will come into existence, being, on average, about 300 km long, 5 km wide and 3 m deep. The flooding system in the Inner Niger Delta will not be affected, but the impact will be very large in the Niger River closer to the dam: the water level will be raised about 30 cm in Koryoumé, 70-80 cm in Gourma and 110-120 cm in Bamba. These figures refer to the high water level, but what will change in the flooding dynamics at a lower water level? This all depends on the water management. If the gates would remain closed in the dry period, the expectation is that the northern Delta will only be partly be deflooded and that even the water level in Mopti will remain relatively high during the dry period. Although, this is not more than a theoretical possibility, the Taoussa dam has a potentially huge impact on the functioning of the Inner Niger Delta.

On a short and middle long term the objectives of the dam comprise the enlargement of the level of self-subsistence in the region through the restoration of the local economy (agriculture, fisheries, pastoralism) and the restoration of groundwater levels and environmental conditions comparable to the pre-drought situation.

In conclusion: the Taoussa dam will have a large impact on the seasonal river dynamics 100-200 km upstream. In the envisaged management the lake will be emptied during the deflooding period, by which the seasonal variation of the water level will be simulated, although at a higher level. The impact downstream are very large but beyond the scope of this study.

3.2 Benefits of the interventions

The construction of dams and weirs in the Niger river are meant to develop the agricultural and hydropower potential of the river basin. This Section first summarises the benefits from the (expected) electricity generation and then the expected higher food production through irrigation. Wood and charcoal are still important as source of energy for many people in Mali, but the demand for electricity is growing fast. Hydropower produces cheap energy (9 Euro cents/kWh), being 2-3 times cheaper than power generation from fossil fuel. Moreover, it contributes to the reduction of greenhouse gas emissions.

Electricity generation started since 1966 at Sotuba, a low weir just downstream of Bamako, which produces 40 GWh. The Selingué reservoir generates 200 GWh since 1982 (although it was less in the first two years of its existence). The large Manantali reservoir in the Upper Senegal River (W Mali) was constructed between 1982 and 1988, but began to produce electricity not before 2001. Its annual production amounts to 740 GWh (being not more than 42% of the theoretical maximal production), of which 55% or 410 GWh is delivered to Mali, 30% to Senegal and 15% to Mauritania.

The total generation of hydropower available for Mali has increased from 40 GWh per year in 1966 to 240 GWh in 1982 and 650 GWh per year presently. This would further increase to

1020 GWh, including the planned Fomi dam (374 GWh), and 1250 GWh if the Taoussa dam (still in study; 230 GWh) would be constructed.

The effective power consumption in Mali increases by 7% per year since 1980 (data of ENP). Up to now, the energy demand could be covered more or less with the existing hydropower. Some cities in the Sikasso region, in the southern part of Mali, have been interconnected to electricity produced by dams in Ivory Coast. Nowadays this interconnection program is underway and will cover more cities such as Koutiala, Bla, Segou, etc. Fomi would cover the growth for some other years if all energy would be transported to Mali. In fact, the majority of generated electricity by Fomi will be used in Guinée-Conakry. The electricity generated by Taoussa would be equivalent to the growth in one year in the 2010s. There are plans for 19 Malian hydropower stations in the Upper Niger and in the Bani. Would they be realised, they will in total produce 5100 GWh annually. This will be enough to cover the growing demand for another couple of years, but not more than that (Fig. 3-2).

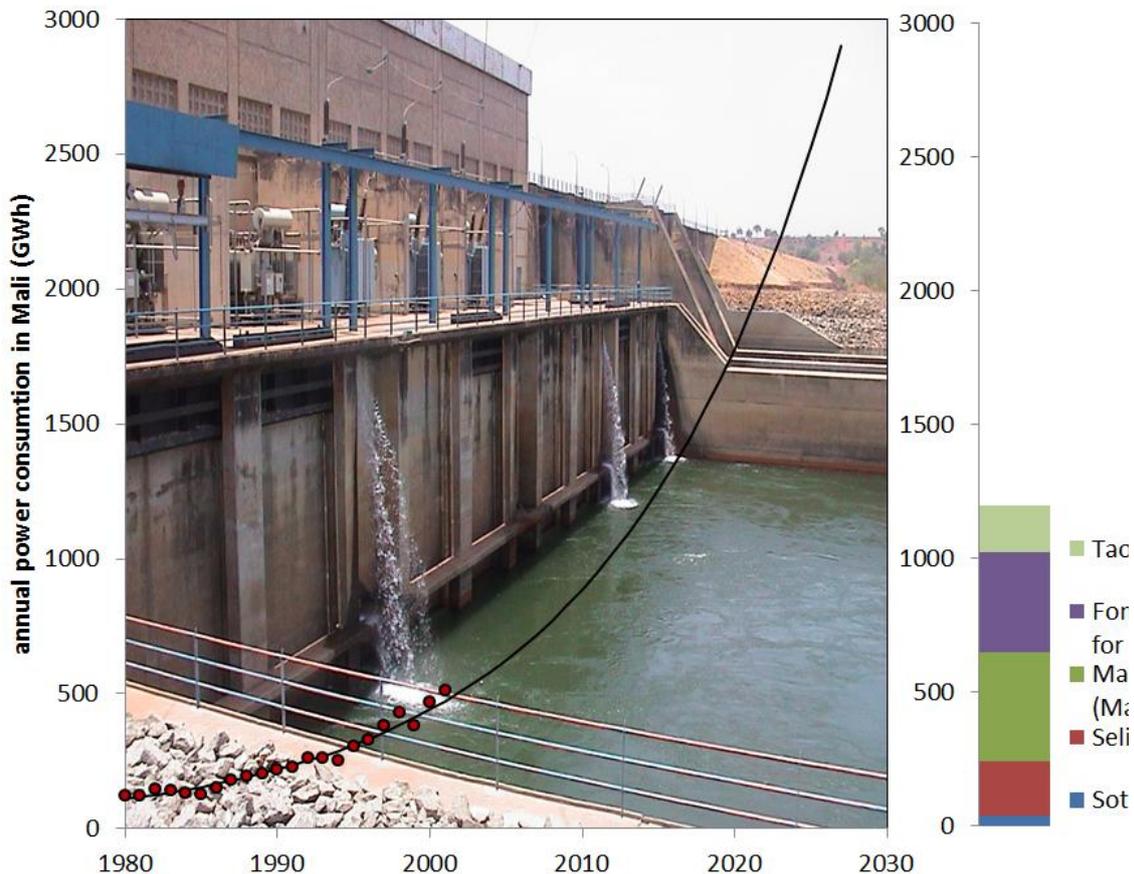


Fig. 3.2. Annual power consumption in Mali for the period 1980-2001 and expected consumption up to 2030. In the bar on the left the annual electricity production of the existing (Sotuba, Sélingué) and planned (Fomi, Taoussa still in study) is shown.

Next to the production of electricity the agriculture sector, producing food for the urban and rural population, may benefit in several ways from dams:

1. With irrigation under gravitation it is cheap for farmers to transfer water from the river to water their land (no expensive fuel costs).

2. Irrigation makes farmers independent of rainfall and flooding. In this way, a more or less secured food production is achieved in a climate being highly variable.
3. The yield may be enhanced considerably. In traditional rice farming systems - rain fed or flood-dependent - one family with on average 3,5 active members exploits about 5-6 ha, yielding 1-2 tonnes/ha per year Rice farmers in the irrigation zone of Office du Niger rent about 2 ha on which they produce 5-6 tonnes/ha per year.
4. The annual production may be further enhanced by double-cropping, having one harvest after the wet season and the other in the dry season.

The Markala dam allows Office du Niger to take 2.7 km³ per year from the Niger. The water use as fraction of the river discharge varies between some per cent in the wet season to over 60% in the dry season. The water use in the dry months is about equivalent to the water released from the Sélingué reservoir. Hence, the seasonal variation in the flow of the Niger is so large, that the current large-scale irrigation in the dry season is only possible because of a second dam (Selingué) further upstream.

The planned extension of Office du Niger is constrained by the available amount of water in the dry season The Fomi dam is considered as an opportunity to solve the latter problem. Sahelian rivers are characterised by a huge seasonal variation in their discharge. Dams regulate the river flow by storing water at peak flood levels and subsequently release it in the dry season. Seasonal floodplains disappear by removing the flood pulse (Fig. 3-3). The next Chapter describes how far this is, or will be, the case.

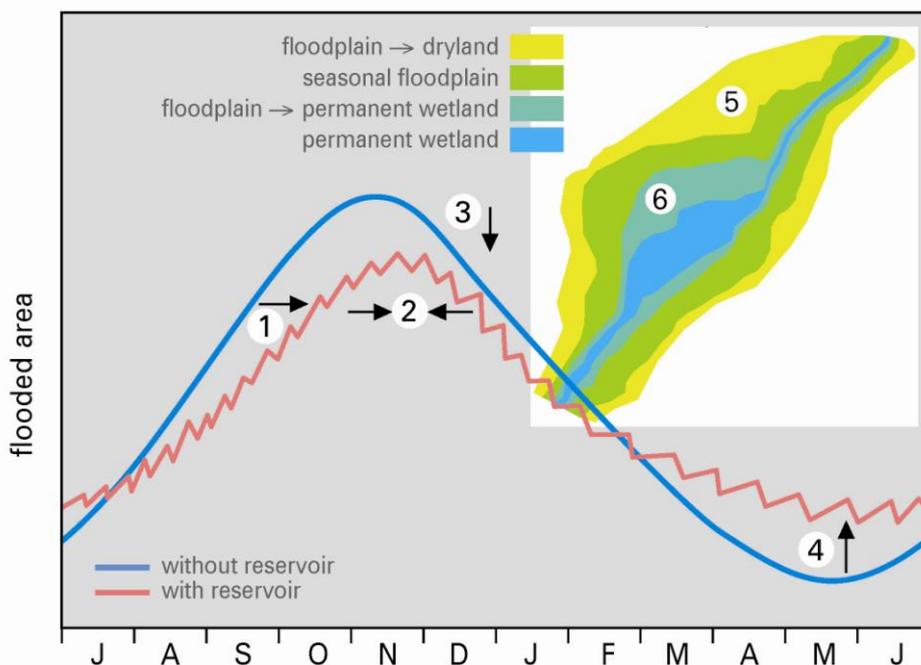


Fig. 3.3. Dams in river basins in (semi)arid climates as in the Sahel have in general six main effects: 1) the timing of the flood will be retarded, 2) the flood peak will be smaller, 3) the flood peak will be lowered, 4) the river discharge during the dry period will be increased, 5) floodplains will be reduced in favour of drylands, 6) permanent wetlands infested by invasive plant, mainly *Typha*, will increase (from Zwarts et al. 2009).



Rural communities in the Inner Niger Delta depend on flooding for their local economy, notably rice growing, fishing and cattle grazing. Bourgou is used a fodder for cattle – photo Leo Zwarts.

4 Losing the Inner Niger Delta?

The ecosystem and economy of the Inner Niger Delta depends on the annual flood. The higher the flood, the larger the floodplains and the higher the production of natural resources on which the rural communities rely. These relationships could be quantified since long series of data are available of flood levels, fish production, rice production and cattle numbers. In this Section we use these data to picture the flood-dependent ecosystem and economy of the delta, and show this system is and may be interrupted by upstream interventions. The data series have been analysed by Zwarts et al. 2007 and 2009; see also there for extensive references

4.1 Flooding

The Inner Niger Delta is one of the largest floodplains in Africa. The Delta not only stands out because of its size, but also due to its hydrological dynamics. Starting in July, the water rises about 4 m in 100 days. In years of high river discharge, peak level may be 6 m higher than a few months previously. The large between-year differences in flooding make the system even more dynamic. In a year with a high peak flood level in the Inner Delta, the flood lasts four months longer than in a year with a low flood: the wave comes in a wet year one month earlier and continues for an additional three months. When the water level starts to rise in July in the southwestern part of the Delta, the plains in the northeast are still dry. By the time the northern plains become flooded two months later, the water level is already declining in the south.

The topographical maps of the Institut Géographique National (IGN) reveal that the inundation zone of the Inner Niger Delta measures 36,470 km², including 5340 km² of levees, dunes and other islands within that area. They also show that water coverage declines from 31,130 km² in wet periods to 3840 km² in the dry period. The entire floodplain area is included in the 41,195 km² designated as a Ramsar Wetland Site of International Importance in January 2004. Topographical maps show the maximal flooded zone, but the area actually inundated varies considerably between years. Zwarts & Grigoras (2005) used satellite images to construct a digital flooding model, covering the range of water levels between -2 and +511 cm, as measured on the gauge at Akka in the central lakes.

There is a very good fit between the water level, such as measured in Akka (situated in the middle of the Inner Niger Delta) during rising water and the flood extent (km²). In 1984, the water level at Akka did not exceed 336 cm and the flooded area was limited to a mere 7800 km². In contrast, in 1957 and 1964, the water level at Akka reached the very high level of about 600 cm, leading to a flooded area of 22,000 km². It should be noted that this is still substantially smaller than the total floodplain of 31,000 km² as shown on the IGN maps. This apparent discrepancy is caused by the shallow northward slope of the floodplain that delays flooding in the north with two-three months; by that time the southern floodplain has already been drained of water. Because the remote sensing analysis is based on actual water coverage, the area flooded at any one time is always less than the total area flooded in the course of a year.

The flood level and flood extent are determined by the inflow of the Bani (flow at Douna) and Niger River (flow at Ke-Macina). The peak flow in September showed a huge variation since the measurements started at Douna in 1922: between 254 m³/s in 1984 and 3470 m³/s in 1929. The variation is less extreme for the Niger at Koulikoro, known since 1906: the September flow was at a minimum in 1984 (1649 m³/s) and reached its maximum in 1928 (7586 m³/s). The maximum water level in Akka, usually reached in November, can be predicted reliably from the

average river flow in July, August, September and October combined for both rivers. The existing and planned reservoirs have a cumulative impact on the river flow and, consequently, on the flooding of the Inner Niger Delta. Since the amount of water consumed hardly differ for dry and wet years, the relative impact of these infrastructures on the river flow becomes more pronounced in years with a poor discharge.

The average flow in August-October for Bani and Niger between 1982 and 2004 has varied between 1482 and 4618 m³/s, equivalent to a total seasonal flow of 16 and 49 km³ respectively. Without Sélingué the average flow in August-October would have been 184 m³/s higher and without irrigation by Office du Niger 108 m³/s. Due to the reduction of the flow because of Sélingué and Office du Niger the flood extent has already declined by, on average, 5.5% and 2.9%. The Fomi dam will cause a further reduction by 5.8%, the Talo and Djenné dams by 2.5% and the extension of the Office du Niger by 4.9%.

Over the past century, rainfall in the Sahel and the flooding of Inner Niger Delta alternate between extended periods of drought and abundance. The annual rainfall and the flooding fluctuate in accordance, but apparently the floods are irreversibly smaller than in the past, independent of the rainfall in the same year. This may be partly attributed to water loss due to the construction of the Sélingué reservoir in 1982 and the water taken from the river for irrigation. A further reduction of the Inner Niger Delta is to be expected given the ongoing extraction of river water upstream of the Inner Niger Delta (and expected climate change).

4.2 Floodplains

The Inner Niger Delta is vegetated with plant and tree species that are adapted to steep fluctuations in water level, seasonal flooding and long dry periods. Wild rice *Oryza barthii*, for example, produces 2-metre-long stems and occupies the zone where the water column reaches up to 2 metres. Another grass species, *Echinochloa stagnina*, locally known as *bourgou*, has stems up to 3-6 metres and grows where the water depth is 4 m on average. During flooding, wild rice, *bourgou*, and also *Vossia cuspidata* (known as *didere* in the Delta), form huge floating meadows. *Bourgou* has a high nutritional value and is therefore also planted by local people to be used as fodder for cattle during the dry period. People are cultivating an increasing proportion of the floodplains to grow rice. Cultivated rice *Oryza glaberrima* requires the same water depth zone as do wild rice and flood forests, and so extension of cultivated rice fields occurs at the expense of natural habitats. For similar reasons, forests, except for tiny fragments, have now been removed.

The highest floodplains are covered by a tall grass species, Black Vetivergrass *Vetiveria nigritana*, and locally by *Acacia seyal* forests (Red Acacia or Shittim Tree). The lowest floodplains often become green as soon as a dense vegetation of grasses and Guinea Rush *Cyperus articulatus* emerges after the flood has passed. These green floodplains, however, are short-lived and quickly transform into dry dusty steppe with hardly any vegetation, a combined effect of the withering sun and intensive grazing by cattle, sheep and goats. Twenty percent of the 20 million goats and sheep and 40% of the five million cows in Mali are concentrated in the Inner Delta and its surroundings during the dry period. During the droughts there was a shift in the distribution of *bourgou*, *didere* and rice following the changes in maximum flood level. For instance, the low-lying Lake Walado has always been a lake where floating vegetation was restricted to the border zone. The lake was colonised by *bourgou* in 1985 and 1986, after the flood level had been low for a number of years. In the same period that *bourgou* settled in Lake Walado, elsewhere much larger *bourgou* fields were replaced by *didere*.

Given a water depth of 4-5 m, the surface area of optimal *bourgou* habitat can be calculated for different flood levels. In 1984, when peak water level reached only 336 cm, none of the floodplains in the Inner Niger Delta had a water column in excess of 4 m. *Bourgou* was outcompeted by plant species as *didere* in suboptimal habitats with less than 4 m of water. Relatively small changes in flood level of the Inner Niger Delta thus have a large impact on plant species restricted to a narrow range of water depths. At a reduction of peak flooding from 420 to 400 cm, caused by the construction of both existing two dams, the surface area of the floodplain was reduced by 12% (from 12 600 to 11 200 km²), but the extent of optimal *bourgou* habitat decreased with 45% (from 970 to 540 km²). Steeper declines are to be expected when more dams are built and flood level is further reduced. The emphasis on *bourgou* is particularly relevant given its significance as fodder for cattle, as a nursery for fish and also as habitat where waterbirds concentrate in high densities.

In contrast to *bourgou*, cultivated rice grows in shallower water 1.0-2.5 m deep. The area where water depth varies between 1 and 2 m measures only 800 km² during a low flood (360 cm at Akka), but increases to 4300 km² during a high flood (580 cm). Water depth is not the only criterion for farmers to cultivate an area for rice growing. Rice cultivation is restricted to substrates that are rather clayey, which explains why rice is almost absent from the sandy northern half of the Inner Delta. The clay content of the soil being rather high in the southern section of the Delta, it is here that most rice fields are concentrated. The area of the Inner Niger Delta cultivated for rice has increased from 160 km² in 1920 to about 1600 km² in 1980-2000.

Not only flooding is pivotal to the ecological significance of the Inner Niger Delta, but so is human exploitation. Over the decades, the Inner Delta has been converted into a semi-natural habitat by the local inhabitants. For instance, the tenfold extension of the area of cultivated rice between 1920 and 2000 caused a decline in the area of wild rice. In 1952, most rice fields were found on sites flooded and deflooded when the water level was 310-410 cm on the gauge of Akka (average 382 cm). Since the average flood level in the early 1950s amounted to 580 cm, this implies that the rice fields were then covered by 170 to 270 cm of water at most (on average 198 cm). In the mid-1980s, peak water level declined to 360 cm, and rice cultivation was forced down to lower sites flooded when the water level at Akka was between 230 and 360 cm (on average 303 cm, a drop of 79 cm from the 1950s). Despite this move, flooding of the new rice fields was poor or even non-existent, amounting to 0-130 cm of water. Consequently, rice production in the Inner Niger Delta crashed from 100,000 ton during normal and good floods to only 10,000-20,000 ton in the mid-1980s. As floods improved in the late 1990s and early 2000s, the low-lying rice fields were abandoned in favour of fields flooded at a water level of 250-360 cm in Akka (on average 321 cm). The accompanying average water depth during flooding of 149 cm is much better for rice cultivation than the 57 cm in the mid-1980s, but has not yet attained the level of 180 cm in the 1950s.

In the 1980s farmers adjusted their land use to the prevailing low flood levels by creating rice fields in the lower floodplains. *Didere* and wild rice had to be removed, and most of the remaining flood forests were cut. Of the forests still present in the 1980s, by 2005 seven had disappeared and eight had transformed into dry forest. Only 18 forests survived, mostly in degraded form. Two new forests came into existence. Altogether, forests now cover not more than 20 km², a small fraction of the several hundreds of km² before the 1980s and a tiny fraction of that existing in pre-colonial times.

Flood forests that had changed into dry forest were exclusively situated on the highest sites, beyond the reach of most floods. Lost flood forests were restricted to sites that became flooded when the water level at Akka was above 140 and below 360 cm (median 320 cm). The few

remaining flood forests were confined to sites flooded when the water level at Akka was above 150 and below 250 cm (median 190 cm). This fits in nicely with our knowledge of newly-created rice fields of the 1980s; flood forests survived only when situated in the lowest part of the floodplain (120-220 cm on the gauge of Akka), *i.e.* out of reach of new rice cultivations at 240-300 cm on the gauge of Akka. Similarly, new flood forests are found only in the very low floodplains (120 to 220 cm). These forests are in danger of conversion into rice fields only when flood levels decline again.

In conclusion, the Inner Niger Delta may be considered relatively unspoiled, at least from a hydrological point of view, despite the reduced inflow due to irrigation and water withheld in reservoirs in the Upper Niger. Not only flooding is pivotal to the functioning of the Inner Niger Delta, but so is human exploitation. Over the decades, the Inner Delta has been converted into a semi-natural habitat by the local inhabitants (planting bourgou, converting forest and floating grass meadows into fields with floating rice, etc.).

4.3 People

Many people make their living in the Inner Niger Delta. The four national censuses (1976, 1987, 1998 and 2009) show that the Ddelta was inhabited by 0,98 million people in 1976 and by 1,49 million people in 2009, an increase of 52%. In the same period the entire population in Mali grew from 6.39 million to 14.52 million people, an increase of 127%. Thus, in the course of these 33 years, the growth of the population in the Inner Niger Delta was less than in the country as a whole. In 1976, still 15.4% of the Malian population inhabited the ten *cercles* covering the Delta, but this had declined in the next national censuses to, respectively, 13.4%, 11.3% and 10.3% of the total population in Mali. The rate of population increase was remarkably low in the Delta between 1976 and 1987 (0.6%/year) and between 1987 and 1998 (0.8%/year), but extremely high in 2009 (3.3%/year). A similar difference is present in the national figures, but the contrast between the three periods is much less pronounced.

In 1976, the Delta was inhabited by 1,1 million people, of which 230,000 live in cities like Djenné, Mopti and Tombouctou. The remaining 870,000 were thinly distributed over the area. As detailed in previous censuses (1976, 1987), the rural population has remained stable, which is again remarkable in the light of the overall annual population growth of 2.3% in 1976-1998 in Mali. Many people have left the Inner Niger Delta, especially in the northern half where the population has actually decreased by 0.6% per year between 1976 and 1998. Most moved to cities in the region and elsewhere in Mali, or went abroad. The depopulation was a direct result of the prevailing drought and low floods, which make survival difficult.

It is obvious that higher flood levels since 1992 has changed the living conditions for the people in the Delta and that many people remained in the area or even returned to their villages. For instance, the population in the *cercle* Tombouctou, being stable between 1976 and 1998, increased by 7% per year between 1998 and 2009. The largest population increase between 1976 and 2009 occurred in Macina, which may partly be attributed to the ongoing extension of the irrigated rice schemes within this *cercle*.

The rural population in the Delta in 1987 amounted to 0.83 million people of which 0.225 million fishermen. Eleven years later these numbers had increased to 0.88 and 0.28 million, respectively. Thus, about 30% of the rural population in the Delta depends for their living on fishing. In 1957, there were 78,000 rice farmers and, including women and children, 170,000 people depended on rice cultivation for a living. In 1987, the population of farmers had doubled

(Marie 2002). Thus about 40% of the rural population in the Inner Niger Delta are farmers. According to RGA (2004-2005), cattle breeding is for 6.6% of the families in Mopti their main and for 42% a secondary activity. In Timbuktu, these figures are 42 and 23% respectively.

In the past, the rural population in the Inner Niger Delta could be divided into fishermen (30%), farmers (40%), cattle breeders (30%). However, in more recent years people have started to abandon their specialisations, due to increasing competition for the available natural resources.

4.4 Rice cultivation

Mali produced in 2007-2008 3.69 million tonnes cereals on 3.28 million ha of arable land. Millet is mostly produced in Ségou, sorgho and mais in Sikasso and rice in Ségou and Mopti. The yield of millet is low in the northern regions of Mali and about twice as high as in the humid, southern regions. This drought-related trend is lacking, however, in the other cereals. This has all to do with way of cultivation, of which the most important is whether there is irrigation or not. The surface area being cultivated by farmers growing rice in the DIN has increased from 180 km² in 1920, 645 km² in 1935, 790 km² in 1952, less than 1648 km² in 1952 (IGN maps), 1590 km² in 1987 and at least 1040 km² in 2003.

In the last decades, about 1600 km² in the southern half of the Inner Delta (5.1% of the total floodplains) are cultivated by farmers growing rice on the floodplains. Another 680 km² are managed as rice fields by *Opération Riz Mopti* and *Opération Riz Ségou*. Both areas lack active irrigation but employ dikes and sluices to delay flooding, and to manage the water level during deflooding ("*submersion semi-contrôlée*"). However, if the flood is not high enough, the areas remain dry. This means that rice production, as elsewhere on the floodplains, depends exclusively on local rain and the river floods; pumping occurs locally, albeit on a small scale. The yield in these areas with *submersion contrôlée* is not higher than on the floodplains (*submersion libre*) and the depression (*bas fonds*).

Farming is not easy in the Inner Delta, and rice farming especially so. *Oryza glaberrima*, known as *riz flottant* is well-adapted to grow as the water rises during the flood. Ideally, the seed should germinate before the flood arrives. Farmers have to sow before the first rains, in the hope that the rain will precede the flood, allowing rice to sprout before the flood arrives and before the water starts to rise with several cm a day. Because rice plants can grow up to 3-4 cm per day, they do not drown. The stems may attain lengths of 5 metres, but usually only 2 metres of growth suffice. After a 3-month flood period, the rice is harvested when the floods recede. Much can go wrong in such an unpredictable cycle, and annual rice production therefore varies between 50,000 and 170,000 tons.

The irrigated rice fields in the Inner Niger Delta have a more stable harvest of 40,000-60,000 tons per year. Floodplain rice yield is low (1.0-1.5 ton/ha) when compared with that of irrigated rice fields (5,0-5,5 ton/ha), but the latter incur high costs related to investments and irrigation schemes. Farmers on the floodplains have few if any overheads. The total rice production in the region of Mopti and Tombouctou has increased from 50,000-100,000 tonnes in the 1980s to more than 300,000 in most recent years. This increase is partly due to the better flooding and more rainfall, but for a much larger part due to a shift to cultivation with a higher yield and a further extension of the area being cultivated for rice. According to the annual *Enquête Agricole de Conjoncture*, the cultivated rice area in Mopti and Tombouctou amounted to 50,000-80,000 ha in the 1980s, about 100.000 ha in the 1990s and 150,000-200,000 in the early 2000s.

The Inner Niger Delta delivers a substantial part of the national rice production. The production has increased since the 1980s, due to (1) the higher flood level and more rain since 1993, (2) extension of the cultivated rice fields (area with submersion libre but mainly irrigated land).

4.5 Livestock

At low flood levels, most livestock concentrates on the low-lying parts of the floodplains where cattle reach a density of 100 per km² and goats and sheep of 30 per km² or more. As zebu-cows weigh 250 kg and goats and sheep about 20 kg, the total annual grazing pressure is equivalent to 26 tonnes/km². Although the grazing is limited to less than half a year, it remains high compared with an average annual grazing pressure of 2-4 tonnes/km² on grassland in the western Sahel (Penning de Vries & Djitéye 1982). A high stocking rate is feasible because floodplains are highly productive. Young grasses cover the emerging floodplains and floating, aquatic grass species like *didere* and *bourgou* gradually become available after flood recession. During the following dry months the vegetation withers and decreases in quality. To improve survival conditions for their stock prior to the next rainy season, pastoralists burn remaining vegetation to stimulate regrowth. Moreover, *bourgou* – planted on a large scale by the herders – is used as fodder in the dry period. *Bourgou* is also cut in the dry season to stimulate sprouting. Heavy grazing on *bourgou* sprouts, however, leads to its eradication, as happened during the Great Drought in the 1980s.

Annual counts of cows, sheep and goats performed since 1980 reveal a huge loss of cattle between 1984 and 1986, after which there was a very low and still incomplete recovery. According to the annual counts in Mopti and Timbuktu that there lived 2-3 million cows and 5-6 million sheep and goats in both regions in the early 1980. This declined to, respectively 1.2 million and 4.5 million in the late 1980s and increased again to 2 million and 7 million in the late 1990s and 3 million and 7.5 million in 2005. Not all these animals graze in the Inner Niger Delta. A count in the Delta in 2004 arrived at 1.8 million cows and 3 million sheep + goats.

The livestock has recovered from the mortality in the Grande Sécheresse, but not raised above this level. Since the survival of the cattle is so clearly related to the flooding, the carrying capacity of the system has been reached apparently.

4.6 Fishery

Annually, fishermen in the Inner Niger Delta catch 60,000-120,000 tonnes of fish according to the FAO statistics. As the annual trade is registered, catches sold on the market are known to have varied between 10,000 and 50,000 tonnes between 1977 and 2005. The variation is closely associated with the previous year's flood level. Theoretically, because the number of fishermen increased from 70,000 in 1967 to 225,000 in 1987 and to 268,000 in 2003, the trade should have increased at the same rate. However, correcting for flood level, there was no increase in trade at all. When 270,000 fishermen are unable to bring more fish to the market than 70,000 fishermen, this strongly suggests that fish capture is constrained by an absolute ceiling in biological production. The same conclusion arises from seasonal catch data. On average, the daily catch per fisherman decreases from 35 kg/day in early February to 7 kg/day at the end of June. This decline is consistent with depletion of the available fish stocks; at the end of the fishing season, nearly all fish have been removed from the floodplains.

Fish more than one year old have become increasingly scarce in the Inner Delta. The only way for a fish species to survive here is to reproduce as early in life as possible. Indeed, fish species in the Inner Niger Delta have adapted to the extreme predation pressure by reducing their age of reproduction. Reproduction for most species is limited to the high water period. Therefore, the annual fish stock entirely depends on the spawn and fry produced by the few fish still alive at the end of their first year and by the very few fish over one year old.

The introduction of nylon nets in the 1960s enabled the near-depletion of fish stocks in the Inner Niger Delta, thus changing the exploitation system significantly. Concomitant with the steady decline of the size of captured fish, the mesh size of nylon nets decreased: before 1975, most nets had a mesh width of 50 mm, but this declined to 41-50 mm between 1976 and 1983, and to 33-41 mm between 1984 and 1989. This downward trend has continued: in 2007 we measured many nets with a mesh size of only 10 mm.

The fish population depends entirely on the young produced by the fish that managed to survive the previous year's intensive fishing campaign. As a consequence, fish species restricted in their distribution to flooded areas have decreased, whereas species able to reproduce at one year old became more abundant. The history of fish exploitation in the Inner Niger Delta is a classic example of overexploitation, but it is also a typical "tragedy of the Commons", where an individual takes a (small) benefit at the expense of the community as a whole.

Annual catches have become more variable in volume as most fish are now less than one year old and the total fish population is determined by flood level. Meanwhile, the future prospects for fishermen have become precarious – they may use more nets, but catch fewer and smaller fish.

4.7 The Inner Niger Delta, a flood-dependent economy

To what degree does the DIN have a flood-dependent economy? This question is highly relevant given the expected decline of the flood extent due to new barrages and irrigation schemes causing lower inflows of the Bani and Niger into the DIN. It is evident that the fish production is determined by the flood extent. The annual fish trade may be described as linear function of the maximal flood extent. If the flood extent is 1 km² less the trade will decrease by 4.45 tonnes. For livestock it is more difficult to show that the carrying capacity of the system has been already reached. However, the mass starvation during the *Grande Sécheresse* is a sad proof that the grazing intensity is limited by the flooding. Moreover, it is telling that the present number of cattle is about as large as 30 years ago.

A relatively small decline of the flood level will have a large impact on *bourgou*, a highly productive plant being essential for the survival of very large numbers of cows. *Bourgou* grows in deep water and deep water (and thus *bourgou*) disappears at a lower flood level. To illustrate this with an example: the extension of Office du Niger will lower the flood level in dry years with 15 cm and the flood extent by 715 km² being 7.7% of the total inundated area. At this reduction of the flood level, the surface with deep water (320 cm to 530 cm deep) will decline from 338 to 193 km², being a reduction of 145 km² or 43%. Hence we may predict that the cattle breeders will be hit disproportionately severe at each reduction of the flood level.

The relationship between rice production and flood level is more complicated. It is true that the annual rice production in the northern delta in the *bas fonds* is closely related to the flood level.

The same is true for the rice production on the floodplains in the southern delta with a *submersion libre* and *submersion contrôlée*. If at an extension of Office du Niger the flood level will be reduced by 15 cm, this will reduce the surface area of shallow of water at a high flood but not at a low flood. In theory, the impact may thus be small, but people have to grow their rice further down in the inundation zone. Rice farmers will then remove the most shallow *bourgou* fields. A reduction of flood level will therefore increase the competition between farmers growing rice and farmers raising cattle.

The reservoirs and irrigation schemes upstream of the Delta, have another negative impact beside the lowering of the flood level discussed before. The flood will arrive later in the Delta since relatively much water is extracted early, as a consequence of which the flood will arrive later and thus the gap between rainfall and arrival of the flood will get larger. This means a larger risk for crop failure. Rice farmers have an alternative, however, making them independent of the insecurity of the flood level. They may actively irrigate their land, albeit that is expensive and has other disadvantage.

The Delta is a highly productive ecosystem offering a wealth of food (rice, fish as well as meat), but due to the annual variation in the flooding the living conditions are variable. The realised and envisaged construction of dams and irrigation schemes will have only negative impacts on these living conditions.

4.8 The Inner Niger Delta, a flood-dependent ecosystem

The floodplains of the Inner Niger Delta are, once the floods have receded, home to millions of cattle which during the flooding period grazed on the surrounding grassland. Sahelian floodplains provide forage for up to ten times as many cattle compared to surrounding drylands. During the peak of the dry season, a crucial time for survival, cattle densities in the floodplains are up to 20-30% higher than in adjacent drylands. The Sahelian floodplains are equally important for wildlife, but that is not true anymore for the Inner Niger Delta as far as it concerns large mammals. Kobs, a typical floodplain antelope, were once common in the Inner Niger Delta, but they have been eradicated. Also giraffe and crocodile no longer occur in the area, and of all large African mammal species, only some dozen hippos remain.

The Inner Niger Delta still attracts millions of waterbirds, not only from Europe but also from Asia as far as eastern Siberia. Of the 500 species breeding in Europe, altogether 2 billion breeding pairs, a quarter cross the Sahara. Many of these birds are concentrated in the floodplain areas, among which the Inner Niger Delta stands out. Large numbers of waterbirds have been counted in the Inner Niger Delta, among which 900,000 Garganey, 300,000 Pintails, 25,000 Glossy Ibis, 9000 Gull-billed Terns and 3500 Caspian Terns. For these species, this constitutes a substantial part of the entire population. The significance of this area for European migrants can hardly be overestimated.

For waterbirds the large annual differences in flood extent are a matter of life and death. A high flood guarantees a multitude of pools and lakes with shallow water throughout the northern winter, at least up to the time of departure to the breeding grounds. Conversely, during a poor flood most water bodies dry up long before March. Waterbirds are then forced to concentrate along the edge of the river and in the few permanent lakes connected to the river. Many birds then die from starvation or are easy prey to the local people. In wet years the birds are more thinly dispersed across the entire delta, and the local people do not even attempt to catch them. The drier the Inner Niger Delta the fewer migrants survive the northern winter.

Flood level has a direct bearing on the survival of migratory birds spending the northern winter in the Inner Niger Delta, being poor in years with low floods and vice versa. Purple Heron and Caspian tern and many more species are affected by flood level in the Inner Niger Delta.

In conclusion, the condition in the Inner Niger Delta determine the population size of dozens of bird species, among which rare and endangered species, which breed 3000 to 12000 km from the Inner Niger Delta. Further permanent reductions of the floodplains will lead to irreversible losses in populations of Palearctic and African bird species that for part of their life cycle depend on floodplains in the Inner Niger Delta. The Fomi and Djenné dam and the extension of Office du Niger will have a huge impact on many bird species breeding in Europe and Asia.



The Baoulé, one of the tributaries of the Bani near Bougini with a small weir (E. Wymenga, January 2012)

5 Water resources management in Mali

Water is a lifeline resource in Mali and its management is a top priority, at present, as it was in the past. In Section 5.1. we briefly sketch the administrative system and organizations concerned with water resources management in the Upper Niger Basin in Mali. We ignore important sectors as water sanity and purification as these are beyond the scope of this report. The need for integrated water resources management (IWRM) has been taken up in the Upper Niger Basin via a series of past and ongoing initiatives. In Section 5.2 we summarise these initiatives. The situation in Mali is briefly tested in Section 5.3. against a set of criteria which set the framework for possible change in the direction of IWRM and green development. In a concluding Section (5.4) we focus on the lessons learned derived from past and ongoing initiatives, consulting stakeholders in Mali and the testing.

5.1 Administrative and institutional system

In the traditional land and water use system in Mali the (spatial) allocation of water resources - mainly for fishing - was, and partly is, managed by the Maitre d'Eau (Box 1). The equal manager for land use resources – mainly grazing pastures for cattle – is the Dioro, still an important traditional institute in the Inner Niger Delta. On a local and regional scale these were natural resources managers, dealing with integrated water management or integrated natural resources management *avant le lettre* (e.g. Moorehead 1997).

After the independence of Mali in 1960 a period of centralisation was followed up by a policy of decentralisation. Today, many subjects are dealt with on a regional and local level within the frameworks set on national level; in general terms this also applies to land use and water management and related sectors. Water governance is relevant on different administrative levels, depending on the issue and scale¹. In this Section the institutional system is succinctly described, focussing on organisations, institutions and processes dealing with water management. We do not elaborate on institutes which are involved in water management as part of their operational field. An exception is made for the authority of Office du Niger managing the Office du Niger irrigation systems which plays a key role in the promotion of food security as well as the water management of the Upper Niger Basin.

Along the Niger River management bodies for water management exist at different scales, each with its own mission, objectives and operating procedures. The ultimate goal of these institutions is the (integrated) management of water resources at different levels of the Niger River basin. In Appendix 1 the different organizations and institutions are mentioned together with important documents relevant to (integrated) water management. On all levels the need for IWRM is expressed in policy documents and has growing attention in this matter.

International context

The water management of the Niger Upper Basin has a strong international component. Moreover, the production of electricity has an international basis via the joint production of energy at Manantali and (planned) Fomi. For the Senegal Basin the *Organisation pour la Mise en Valeur du fleuve Sénégal (OMVS)* is the leading international water authority. The international water cooperation for water management of the Niger is led by the Niger Basin

¹ Mali is divided into eight regions and one capital district (Bamako); the regions are subdivided into 49 cercles, 288 arrondissements and 703 communes.

Authority (*Autorité Basin du fleuve Niger*, ABN). Next to the promotion of cooperation among the 9 member countries, the objective of ABN is to ensure an integrated development of the Niger Basin in the areas of energy, hydraulics, agriculture, animal rearing, fisheries and fish farming, forest exploitation and sylviculture, transports and communication and industry.

In order to facilitate the implementation the actions of the ABN in its member countries, offices (focal points) were established including Mali. The focal point of Mali is directly affiliated with the Malian Department of Hydraulics (DNH, as representative of the Ministry of Water and Energy) as is one of its staff member. He participate in all meetings of ABN on behalf of Mali, as the Permanent Delegate, and is responsible for harmonization and coordination of the national policy on management of water resources in the Malian portion of the Niger River with those of other basin countries on behalf of the ABN.

To arrange the general obligations of states, and in particular to maintain the quantity and quality of water resources, ABN has set up the Water charter, a juridical and institutional framework on the governance of the Niger's water resources. The charter regulates, that before a state can implement specific measures on water management having significant adverse effects for other states, a member state must, through the NBA, inform other member states and provide them with any available information.

Internationally, the West African Water Partnership – derived from the Global Water Partnership (GWP) – is an international network that offers practical advice for sustainably managing water resources. In addition to development agencies and country members it offers a platform to NGOs and research organizations. The West African Water Partnership was instrumental in the development of IWRM Action Plan of Mali through research and as source for funding and technical assistance. The National Water Partnership in Mali could play an important future role in the implementation of the Water Charter; this will depend on the member countries which signed the Charter, but also the roles that will be vested.

National context

Mali has a well developed network of governmental ministries and related organizations dealing with water management. The National Water Policy of Mali is part of the Strategy for Growth and Poverty Reduction Strategy (GPRS). It aims to contribute to socio-economic development by providing appropriate solutions to problems related to water, in accordance with sustainable management of water resources. In terms of legislation, the relevant framework is provided by Law No. 92-006 of January 2002 Water Code, dealing with all aspects of water management.

The current management of water resources involves, due to the transversal nature of water resources, a wide range of technical governmental institutions (ministries), private and civil society. Water management proper resides under responsibility of the Ministry of Water and Energy. This ministry has decentralized and devolved managing of water resources to regional and local levels. The National Directorate of Water Resources (DNH), under the umbrella of the Ministry of Water and Energy, is responsible for developing the elements of the national policy of hydraulics, coordination and technical supervision of services regional, subregional and related services in charge of the implementation of the policy.

In the governance of the water sector the important role should be noted of specialized agencies (EDM-SA, Office du Niger, Office Riz Segou, Mopti Rice Office, Office of the irrigated Baguineda, Office of Rural Development and Selingue Agency Niger River Basin) and research institutions (National School of Engineering, Institute of Rural Economy, IRD, AGRHYMET, etc.).

Box 1. Traditional management - Maitre d'Eau

The Maitre d'Eau of the Bozo was traditionally the water master in the Inner Niger Delta. The Bozo spring on the water, and their historical 'Master of the river' or 'Master of water' came from the mists of times. The master of water is at the centre of the group of fishermen, and has three essential rights: 1) he/she renewed annually the sacrificial pact with the spirits of the river, 2) he/she decided on the establishment of the largest annual fisheries, including fisheries group of low water, and 3) regulates the practice of fishing, as well as any local and deferred grazing permits or prohibited gear. The water master owns specific fisheries (on which he has an exclusive right or privilege or precedence). However, other lineages also have "properties" which are obtained by gift, through inheritance or marriage covenant. Fishermen from outside the local community are allowed to make dams in small canals to catch fish, but they have to pay a 'toll' representing one third of the catch. The toll is important since it guarantees the traditional fishing rights of the local communities.

Today the "water masters" are no longer involved in the administrative decisions in the management of water resources and even less in conflict management of fisheries that revealed their powers. Its roles and powers were transferred in their majority to mayors.

The Inter-ministerial Committee for Coordination of the water sector and sanitation has been created for purposes of consultation and coordination in the areas of water and sanitation. This Committee is chaired by the Minister of Water and Energy and has two working committees: a) the board "Water Management" chaired by the Director General of the DNH and b) the board "Environment and Health" chaired by the Director of the National Public Health. Coordinating and consultation bodies within the water sector are: the National Water Council, regional and local water committees, the basin and sub-basin committees and the Regulatory Commission for Water and Electricity.

The Malian Water Partnership (Partenaires National de l'Eau, PNE) is an important institution, affiliated with the West African Water Partnership, for stimulating and social and political mobilization for the implementation of Integrated Water Resources Management (IWRM). This organisation played an important role in the realisation of the National Action plan for IWRM.

Water Code and Action plan IWRM

The development of the IWRM Action Plan (2004-2007) fits within the current changes in the Malian water sector during the last decade, starting from the *Act No. 02-006 of 31 January 2002 Water Code*. The *Water Code Act* offers the framework for water management in Mali and redefines the roles and functions of the State and all other players in the water sector. Through the Water Code, the Government of Mali has taken IWRM as a way to manage the water resources in a sustainable way. The Government has instructed in July 2002 the ministries in charge to develop a National policy based on IWRM involving all stakeholders: populations, communities, users and professionals. The Ministry of Water and Energy is primarily responsible for the implementation of the IWRM Action Plan.

Regional and local context

In Mali the management of water resources is the responsibility of the Minister of Water and Energy. However, the management of water interferes with the skills and interests of several other ministries (Agriculture, Livestock and Fisheries, Environment and Sanitation, Santee, Mining, etc.). These many interests and sectorial policies have led to the adoption of several laws and strategies in the water sector with often competing interests and orientations. Consequently, there is an urgent need to harmonize the various existing policies and strategies

in the water sector and the revitalization of existing interdepartmental committees in this area for better governance.

The Ministry of Water and Energy is the parent of management of water resources in Mali. Among its national directorate, the National Directorate of Water (DNH) deals with IWRM. The DNH is represented at the regional level by the regional directorate of hydraulics (DRH) and often the latter at the “cercles” levels by local services of hydraulics. The regional and local services support the decentralization policy in technical support for integrated management of water resources of urban and rural districts. The major weaknesses in the regional and local levels are the lack of financial resources, lack of qualified human resources and lack of coordination in the implementation process of existing and future multiple projects. Also, there is no clear framework on responsibilities and jurisdiction. An example is the conflict of jurisdiction between the National Directorate of Water (who created the sub-basin committees) and the Agency of the Niger River Basin (ABFN), a national Agency of the Ministry of Environment and Sanitation which also created similar committees.

At the level of rural and urban districts, the situation of the management of water resources has been made more clear by the Decree No. 02 - RM 315/P- of 04/06/2002 describing in detail the powers transferred from the State to local authorities in terms of water resources management. The major drawback of this transfer is and remains the lack of human and financial resources to implement. At the village level, as with other levels mentioned above there is confusion in the communities in the implementation of laws and strategies for the integrated management of water resources of the river as there are many stakeholders. The existence of State laws beside traditional regulations makes the situation even more complex.

Finally, several stakeholders are trying to implement IWRM, according to different State laws or traditional and existing strategies in this area. Important constraints that exist are: a) no co-operation between the stakeholders in the water sector, b) the multiplicity of different sectorial policies and strategic programs related to water resources, and c) lack of operational activities of the various governing bodies of the water sector (inter-ministerial committee, committee sub-basins, water committees and other consultative frameworks).

Conclusions

The following conclusions can be drawn from the existence of this array of institutions:

1. The Authority of the Niger River Basin is coordinating the management of water resources in the Basin and as manager of multiple sub-regional projects, despite several institutional reforms, specific laws and several projects and programs; this coordination could be strengthened in particular where IWRM is concerned;
2. The Global Water Partnership and the West African Water Partnership actively support its member states, including Mali; they offered important technical and financial support for the development of the National IWRM Action.
3. There are in Mali technical services and civil society organizations, formal or informal, for the integrated management of water resources, on national level as well as on the level of administrative regions, districts, sub-prefectures, municipalities and villages, The low success of various projects and programs – in lacking actual implementation - is partly due to the lack of coordination between sectors, lack of human capacity and financial institutions.
4. As part of the national policy to decentralize the power, the management of water resources has been transferred to municipalities, but at the same time human and financial resources are under developed. As a result, some traditional laws and

institutions continue to manage water resources at the local level, although organs such as the CLE were developed as part of GIRENS project.

5.2 Past and ongoing initiatives

Parallel to the development elsewhere the concept proper of IWRM became known in the 1990s. As explained in the previous Section, the traditional system of communal sharing of natural resources in the Inner Niger Delta can be seen as a early forerunner in this respect. A more coordinated management of water resources on a basin level dates from the 1980s with the creation of the Niger Basin Authority. From the late 1990s onwards IWRM was promoted and supported via several initiatives and studies (Appendix 2 mentions only the larger projects). In this Section we mention some important initiatives and projects (only water resource management, not sanity and purification) without being complete.

Ghenis (1999-2002)

One of the first larger projects in this sense was the Ghenis-project focusing on the (development of a strategy for the) hydro-ecological management of the Upper Niger (1999-2002). Important results included capacity building of the technical staff of DNH, improved knowledge of the hydro-ecological system as well as an increasing awareness among stakeholder about the risks of the environment; The approval of the strategic plan by resource users of the river and the creation of basin committees are very important to increase this awareness and to come to concrete actions.

Water for food and ecosystems (2003-2005)

The main goal of this program was to quantify the relationship between the available water resources, water use and the flooding and production of natural resources in the Inner Niger Delta. The data made it possible to make a flooding model and quantify the impact of infrastructures on flooding, and subsequently on the production of the natural resources. This knowledge and information was widely distributed among stakeholders, strengthening their capacity and insight in upstream – downstream relations. It provided insight at the level of DNH on the opportunities of a more effective water management in the Upper Niger Basin, and provided a clear cost – benefit analyses of the different infrastructures in the Niger river (Zwarts et al. 2005).

GIRENS (2005-2010)

The Dutch-funded Girens program focuses on integrated water resources management in the Upper Niger basin, involving two main players, the DNH (including Directions Régionale de l'Hydraulique de Mopti, Segou, Koulikoro) and the Laboratoire National de Eaux. The main goal was to establish monitoring tools and alert systems on water resources and the environment in the Niger river, and to contribute to institutional strengthening of public services concerned and stakeholders of the basin. Also, the program envisaged to develop and implement a Plan of Action for Integrated Water Resources of Upper Niger (PAGIRE / NS) to restore and protect water resources of the basin. Important results include the creation of Local Water Committees, capacity building and a significant contribution to the awareness on degradation of water resources through the local water committees. Also, two laboratories were established and first steps were set in the action plan IWRM (PAGIRE). Following the termination of GIRENS the Local Water Committees were supported by the Danish DANIDA.

Action Plan of IWRM (2004-2007)

The Action Plan of IWRM is also a response to the recommendations of various international and regional conferences which Mali is a party. The World Bank through the National Rural Infrastructure Program has funded the implementation of six thematic studies related to the Action Plan of IWRM. These studies have contributed valuable in-depth analysis of the current situation of the water sector, to formulate concrete proposals on policies and strategies relevant to IWRM, in defining the elements of the plan action and identifying the necessary resources for capacity development. Also, Mali is one of five elected African countries (Kenya, Malawi, Mali, Senegal and Zambia) that have benefited from the initiative of the Canadian government to support the process of developing action plans for IWRM through the Partnership global Water Partnership (GWP). Other partners such as The Netherlands, Germany and France also provide valuable support in the process especially with regard to pilot implementation of IWRM, decentralization and transfer of skills in the field of water sector. It should be noted that several ongoing projects already fit within the framework of the implementation of the Action Plan IWRM in Mali (see list of projects and programs).

Integrated Water Resources Management – Decidaid & Opidin (2007-2009)

This Dutch-funded project builds upon the information and data collection from earlier project carried out in the Upper Niger Basin on IWRM, and aimed to develop and demonstrate the value of an operational integrated approach for water resources management 1) at political level (Entire Niger basin upstream Taoussa), and 2) at local level (in the Inner Niger Delta). Next to the actual development of tools, technical assistance and institutional capacity building made part of the project. The project resulted in a decision support model on basin level, called DECIDAID (GIRE-DECIDAID), which is a statistical tool which integrates hydrology, economy and environment, and which is able to optimize surface water infrastructures planning and management in the Niger basin. It also allows for simulation of scenarios of surface water structures planning and their management in comparison to actual situation.

Apart from DECIDAID a flood prediction tools was developed (OPIDIN), which is a simplified tool to predict the flood in the Inner Niger Delta on the basis of water levels in Mopti and Akka. This tool is developed for stakeholders in the Delta (farmers, fishers, herders, etc.), missing information on the future behaviour of the flood. OPIDIN is now in a pilot phase. It proved to be a very useful planning tool, well accepted by local stakeholders and authorities. The further development of OPIDIN is done in concordance with a Steering Committee for OPIDIN, in which all relevant stakeholders have a seat.

PNE Mali

PNE Mali is being engaged in several projects. Amongst others, one of these concerns the support and capacity building of the Local Water Committees and the creation of a framework of IWRM in Mali. Also PNE works on the capacity building of the members of the Local Water Committees, focusing on IWRM.

Running and future projects

Growing attention for integration of food security, land and water use together with climate change makes that several initiatives (from local to basin scale) are running or planned in Mali. Wetlands International is engaged in the Wetwin project (2009-2010, www.wetwin.net) which focused on the sustainable management of the Inner Niger Delta in relation to Climate change; Fromaison is a project on the sustainable management of natural resources (www.afromaison.net). This started in 2011 and aims to develop tools for spatial planning (use of natural resources) and tools for restoration and adaptation, specifically on the meso-level.

The project will build upon the results of Wetwin, and support the further development of OPIDIN, accompanied with an intensive process of stakeholder engagement.

With the Danish-Swedish support a Climate Change Study will be initiated in due time. According to the terms of reference, this in-depth study aims to clarify the consequences of climate changes and increased anthropogenic pressure on the quality and quantity of the water resources and on the water usages. It also aims to identify mitigation and adaptation measures. The expected result is a report on present scientific knowledge of the topic including an appreciation on the impact on different usages. The findings of the study will be used for identifying next steps in order to increase climate change adaptation and updating the national IWRM action plan.

In general it should be noted, that the majority of projects - past, running or future initiatives – concern, sometimes partly overlapping, desk studies on scenarios, options, models and strategies for IWRM or integrated management of natural resources. Actual monitoring or collection of new data is very limited, while some projects have deliberately shown how important this can be to set new steps in IWRM. Also, in most of the projects and programs implementation is not part of the project.

5.3 State of IWRM in the Upper Niger Basin (Mali)

Within the framework of investigating the opportunities for green development and IWRM in the Upper Niger Basin, the current state of IWRM in Mali was considered in two ways. First of all, in Mali, Wetlands International involved its network of partners and stakeholder engaged in this matter, to derive lessons learned from the current process. These have been summarized in Section 5.4. Secondly, IWRM and green development is tested against criteria as determined in the main report on green economic development for this project (see Chapter 1, WWF 2012a). These criteria set the framework for a process of change (WWF 2012a, Fig. 5.1). For each of the criteria there is a short introduction (derived from the main report on green development) followed by a synthesis of the situation for the situation of the Upper Niger Basin.

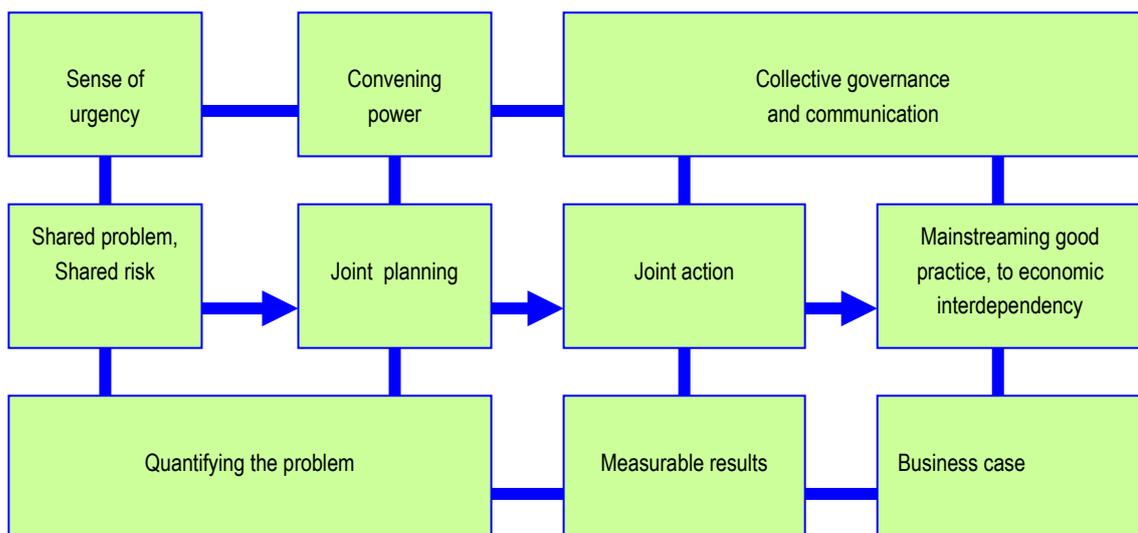


Fig. 5.1. Criteria for an emerging framework for collective action for IWRM and green development, from WWF (2012a).

Shared problem, risk & vision

An essential prerequisite for the implementation of new measures and management options in general is acceptance of problem ownership by relevant stakeholders and confidence in proposed options. If these criteria are not met beforehand, options will remain on paper despite their promising perspective.

Fitting within the decentralisation processes in Mali, new developments are intensively communicated with stakeholders. For example, recently in each cercle regional committees have been installed, involving stakeholders from all relevant sectors, which assess and need to approve new plans and projects on rural development including water management. On a more strategic level visioning is being practised, especially in the projects mentioned in Section 5.2. For the Inner Niger Delta this has led to a 'vision commune' about the development of the area, resulting in the *Programme de Développement Durable du Delta Intérieur du Niger 2011-2020, PPD-DIN*. In this process a wide range of stakeholders participated, but the question is whether the problem ownership was recognised enough. IWRM is a cornerstone of this programme but at the same time green developments are not translated, are only partly, in the decision making process. Also in other sectors shared visioning is practised (for example on economic growth in 2011 led by the UNDP, on food security in 2009 led by the FAO). A concern is the gearing of these visions between sectors and the representation of (interests) of local stakeholders.

Sense of urgency

In Mali the Great droughts of the 1970s and 1980s are rooted in the collective memory. The variable alternation of wet and dry series of years are ruling the rural economy. Especially the local stakeholders – land and water users - are imbued with the necessity of enough water for the flood-driven economy and ecology of the Inner Niger Delta. The current water management with upstream interventions may have a far-reaching impact on the Inner Niger Delta (Chapter 4). It is the question whether this is sufficiently acknowledged by decision makers.

In recent years have been relatively wet years in Mali (rainfall) but the low flood in 2011-2012 in the Inner Niger Delta evoked a sense of urgency. Within this framework - limited water resources, climate change versus food security, a booming energy production and a population growth - the urgency for IWRM and integrating water use and food security is broadly communicated in Mali, much endorsed by the Dutch, Swedish and French Embassy. Also NGO's are actively involved in these awareness processes and stakeholder engagement (for example Wetlands International, PNE Mali).

Quantifiable problem

To avoid elaborate discussions and misconceptions the problems and challenges to be addressed should be based on measurable and quantifiable facts. Such an analysis should be undertaken by a credible and impartial organization, such as a renowned university or research institute. Quantification of the problem and a credible baseline study facilitate monitoring of emerging solutions and their positive effects on mitigating the problem or reducing damage to stakeholders (WWF 2012a).

The hydrology, ecology and economy of the Inner Niger Delta have been studied since decades. Especially the availability of long term data on rainfall, river discharge, flooding and the production of fish and cereals has been instrumental in several analysis's on the hydro-ecology of the delta and the flood-food relationships (see the extensive references in Chapter 7). A major step in this matter was set in 2005 with the Dutch Partner for Water project on Water for food and ecosystems, which resulted in the publication of *Niger, a lifeline* (Zwarts et

a/ 2005). This knowledge base, including a flooding model, makes it possible to quantify the downstream impact on river discharge and food production of upstream interventions. This has been an important layer to build a decision support model (DECIDAID) on IWRM. Chapter 2-4 summarizes the most important conclusions. DECIDAID is not yet operational.

Convening power

One of the criteria mentioned by WWF (2012a) important for change is convening power: 'Multi-stakeholder processes of change are often initiated by a one party having sufficient convening power to convince other parties to participate in early meetings on the problem. This legitimacy of one party must be acknowledged by all relevant stakeholders, and not exclude any relevant stakeholder who shares the problem, wanting to make a contribution to its solution. Convening power can be attributed to an independent party or stakeholder considered able to mediate between parties. An external party must be considered highly credible, for example through its international reputation, by all stakeholders. Often, this party becomes the catalyst of the early process of joint action. However, this role should not exceed the pilot phase of an action and a careful transfer of responsibilities must be planned early.'

In the case of the Inner Niger Delta Wetlands International Mali plays an active role in stressing the importance of the ecosystem of the delta and the dependency of continued flooding, supported and recognised by the government of Mali and donors. From 1998 onwards WI invested a lot of effort in involving local communities as stakeholders. The development of a flood prediction tool in 2009 (OPIDIN) led to the creation of a Steering Committee with a broad range of stakeholders. This process is still growing and made the upstream – downstream relationship manifest. An improvement might be that water users in the delta unite their voice independently to stress the importance of a sound water management for the delta.

Joint action and planning

Following a process of sharing problems, vision and potential risks among stakeholders, collective action requires joint analysis, identification of plausible solutions and commitment to joint action by all stakeholders. It must be recognised, that stakeholders contribute according to their ability and their actions may differ. Frequent monitoring and communication is therefore needed to share information on progress with all stakeholders (see WWF 2012).

Stakeholder engagement in Mali is a base line for running and ongoing initiatives, and within these programmes a lot of effort has been put in capacity building and supporting stakeholder processes. A good example is the creation of local water committees within the GIRENS project and the endorsement of PNE Mali. IWRM and green development initiatives can build on this. Problem ownership may be felt quite differently amongst stakeholders and especially the lack of coordination between sectors is problematic. This may be an important reason that many projects and plans lack implementation.

Good governance, communication and transparency

In general a successful process of change, especially when it comes to the phase of identifying potential solutions, decision making and finally implementation, depends on a climate of good governance, communication and transparency. Crucial in this process is acceptance of problem ownership by relevant stakeholders.

In the Upper Niger Basin the focus on good governance, communication and transparency is an ongoing process and all three are continuously points of interest. The importance of IWRM and more green developments, especially in the context of food security and water sharing, is recently brought to the notice of local, regional and national managers and rulers via various

stakeholder meetings. This process, in which NGO's and national institutes are involved, is much endorsed by the Dutch and Swedish Embassies. As mentioned before (Section 5.1) there is a lack of integrated coordination between sectors; this is a clear opportunity to improve water governance in this context.

Measurable results within reach

The acceptance of promising options for change is positively influenced if results can be shown from pilot projects or it can be underpinned that effective results are within reach. The actual implementation of IWRM is a serious concern in the Upper Niger Basin (see Section 5.4. Lessons learned), and effective pilots may encourage and endorse the process of implementation. On the level of the Upper Niger Basin as a whole a IWRM-pilot in practise is hardly feasible, which was one of the motivations to build a decision support model (DECIDAID), which shows the outcomes in flood performance and food production under different water management scenarios (see previous Section). In the Inner Niger Delta several successful pilots have been carried out on 'green developments' or measures which support the ecosystem functioning. These include forest regeneration (see Beintema *et al.* 2005) and the tool OPIDIN. This tool is now being tested in the currently running Afromaison project (www.afromaison.net). So far these pilots have not been translated in a scaling up.

Business case and scaling up

In general successful pilots on new initiatives should have a follow up in terms of a business case, or more appropriate for IWRM, a translation in economic values. Pilots and demonstration projects are often financed with donor support, but the financing of scaling up successful pilots is another matter. This applies especially to IWRM initiatives and green developments, which initially often have a negative cost-benefit balance, which may hamper implementation of promising options. Partly this may also be stimulated by the way these projects are financed (project support instead of program or process support).

On the level of the Upper Niger Basin a trade-off or cost benefit analysis of upstream interventions was done in the Partners for Water project which resulted in Niger, a lifeline (Zwarts *et al.* 2005). This project showed, that investing in existing infrastructures and a more efficient water use would be more effective, in terms of economic gains, than building new infrastructures. On a smaller scale a flood prediction model is being developed for the Inner Niger Delta. This model may be used as an early warning system for flood performance, and is already tested in the delta. Stakeholders have already asked for scaling up this tool, which is one of the key activities in the actually running Afromaison project (www.afromaison.net).

Mainstreaming good practise

It goes without saying that good practise must be exploited in the sense that promising option and measures should be actively and broadly communicated. This is an important prerequisite to scaling up successful pilots. Most of the past and ongoing initiatives in Mali are broadly communicated. As an example, the results of the Niger, a lifeline project were also presented in the local language by Wetlands International. However, in the multitude of new projects and initiatives successful good results are in danger of being overlooked. The focus of organizations easily shifts to pressing new projects (with new funding opportunities) instead on the exploitation of achieved results. With the multitude of NGO's and projects opportunities in Mali this is a serious point of interest.

5.4 Lessons learned

The previous Sections show that in Mali a well developed institutional system of water resources management exist, on all governance levels, embracing IWRM as a leading or promising approach in future water management. IWRM is also rooted in the National policies and juridical framework. Despite this advantageous situation and the progress that has been made in the field of IWRM, useful lessons can be drawn from the past and ongoing initiatives. In this Section we summarise the most important lessons learned in the context of IWRM in Mali. These are derived as a synthesis from a number of executed IWRM projects and studies in Mali (Appendix 2), interviews with relevant stakeholders in Mali and mission reports or publicised information. These lessons deal with water governance as well as with the operational part of IWRM.

1. The pivotal role of water resources management in the (development of) the rural and urban economies is mirrored in a strongly developed institutional governmental system and affiliated organizations. Diverse interests and policies per sector have led to the adoption of several laws and strategies in the water sector with often competing interests and orientations. Consequently, there is an urgent need for harmonization and coordination of IWRM across sectors, possibly via the revitalization of existing interdepartmental committees in this area;
2. Simultaneously, the coordination of IWRM across scales needs improvement as there is no proper mechanism for coordinated management in this sense. This applies to the translation of local and regional downstream interests into national policies as well as to national interests into international agreements on water sharing. In general the information on water and land resources among stakeholders is not sufficient to allow for a coordinated management. Nevertheless, a lot of progress has been made recently in this matter (for instance the creation of local water committees).
3. Water is limiting the development. However, the notion of water scarcity in relation to the available land for rural development is not widely known or accepted amongst decision makers and donors;
4. Water conservation and improvement of the water efficiency must be the guiding principles for all water users (across scales and sectors), including irrigation.
5. IWRM is widely accepted as the leading (future) approach for water management in Mali. Also, technical studies have provided promising solutions. However, the actual implementation of IWRM is lacking and only practiced on a very local scale. The national IWRM action plan might be an opportunity to endorse the actual implementation of IWRM.

6 Options for IWRM and green development

The demand for water by several sectors in Mali shows an increase, inevitably leading to a growing competition for water resources (Chapter 2-3). IWRM may serve as a promising strategy to seek a balance in the sustainable development of competing sectors, and is indeed acknowledged as such in Malian policies and development programmes (for example in the Programme de Développement Durable du Delta Intérieur du Niger 2011-2020, PPD-DIN). Nevertheless, the actual implementation of IWRM is complicated by a lack of coordination across sectors and across scales (Chapter 5). A sound management of available water resources is pressing and essential to the future of the economy and ecology of the Inner Niger Delta (Chapter 4). This sense of urgency is certainly felt in Mali, reinforced by the recent low flood of 2011. In this Chapter promising options are forwarded for IWRM in the context of green growth.

6.1 Stakeholder engagement

The development of options for IWRM in a 'green' context must be stakeholder-oriented, focussing on the dissemination of information on (local, regional, national) water consumption and water availability, the consequences in dry and wet years and the expected developments in the future. Relevant stakeholders in rural as well as urban communities should be involved. Next to information about the envisaged problems in short and long term, possible options for future water management have to be explored in this stakeholder process (shared vision, option scanning). If promising options are available, feasible and jointly seen as future strategies for adaptation, then implementation is within reach.

In the recent past, capacity building and information dissemination on national, regional and local level has been given a lot of attention (Section 5.2). This concerns technical assistance and transfer of knowledge to DNH and affiliated institutes, stakeholder participation in IWRM processes in the delta (for example Steering Committee OPIDIN) and the setting up, and continued support of, Local Water Committees. A next step will be to work towards more coordination on national level, in particular between sectors, and translate these into implementation measures. In this respect it should be investigated whether the desired harmonization and coordination in this matter fits within the current institutional system or new structures are needed to meet this goal. This also accounts for the coordination between upstream and downstream interests.

6.2 Water for food and ecosystems

The most important sectors depending on water use in Mali are energy, agriculture (food production, notably irrigation) and environment (production of natural resources, ecology); other sectors are insignificant in this respect. For the Inner Niger Delta river discharge is the one and only driver of the flood-dependent economy and ecosystem, and any alternatives are lacking. For agriculture the same is true: rain-fed agriculture and irrigated cultivation rely on rainfall and artificial inundation of the cultivations. The latter however offers possibilities for improvement (efficiency of water use, see Section 6.3). With respect to the energy-sector, there may be alternatives regarding electricity production via hydropower. A more efficient water use as well as an alternative strategy for energy production fit within a green development and also both may be interesting leads for public private partnerships.

Alternatives to energy production?

Currently nearly all electricity in Mali is generated via hydropower. As shown in Fig. 3.2 the current and planned production will not be able to meet the steeply growing demand. This discrepancy will be manifest in the coming decade. Moreover, the unpredictability of rainfall in the Sahel combined with climate forecasts does not provide a sound basis for a stable electricity production.

In this context, it is crucial to seek alternatives for electricity generation. This is the best alternative to avoid the building of still more dams in the Niger tributaries and also maintain a more or less natural flow regime in the Niger, which is essential to the Inner Niger Delta. An obvious alternative in Mali, with on average 300 sunny days a year, would be solar power. Since a number of years, solar power attracts attention by the Malian government and donors as alternative source of energy, but it is not (yet) practiced on a significant scale. However, since the turn of the century several pilots have been tested, and projects have been carried out, amongst others in the framework of the Malian National Program for Renewable Energy for the Advancement of Women (PENRAF), a project started by the Malian government. In 2008 a first solar power plant in Mali was opened in the village of Kimparana, which provides daily energy for 500 households and small businesses (supported by Foundation Rural Energy Services (FRES)). A new step was set in 2011 by the installation of a 216 kw grid-connected solar power plant Ouéléssébougou, 70 km from Bamako in the Koulikoro region. These examples show that solar power is an interesting alternative in Mali.

Generation of solar power could be realized via two strategies: the realization of large solar power plants, as suggested for the Sahara-Sahel region, and/or the production of small solar power units which can generate energy on village or household level. Huge solar power plants (>50 MW) have been realized already in China, Spain and the US. In terms of electricity production, these kind of large scale plants are comparable to hydropower plants in Sahelian river systems. To realize a production which is significant on a national scale, a huge investment is necessary; this could be tested in a cost-benefit analysis against a hydropower plant on short and long term.

Reserve water for food and ecosystems?

Since alternative options for water use for food production and the flood-driven ecosystems are lacking, water consumption could be strictly allocated to these sectors (not counting potable water and other small consumers). Such a policy in water resources management would guarantee in the long run the availability of water for these sectors. Apart from the generation of electricity (see above), this would imply that crops which do not directly relate to the inland food consumption do not have access to the scarcely available water resources; this would imply that no biofuels and/or cotton crops are produced in irrigated areas.

6.3 Efficient water use

A basic principle for a green and sustainable water management is the maximization of the efficiency of water use in all infrastructures. The water use per kg rice could be lowered which means that much more production is feasible with the same amount of water. This leaves room much for development. Office du Niger made already a lot of progress. In the 1980s, they used annually 40,000-50,000 litre of water to produce one kg of rice, but this has declined to less than 10,000 l per kg rice since the mid-1990s. This increase is due to (1) a higher yield per ha while the water use remained at a similar level, (2) an improved irrigation system, (3) a restructuring of the irrigation zone. A still higher efficiency is still possible, however.

Office du Niger consumes 86.5 m³/s during the last 20 years, being equivalent to 2.69 km³ or, given an exploited surface of 85.000 ha, 26.900 m³/ha. This is much more than the amount of water actually needed on the irrigation fields (varying between 7100 m³/ha for rice growing in the wet season to 18.200 m³/ha for sugar cane). This large difference may be explained by water loss during the transport due to evaporation, infiltration, etc. Much may be gained if the irrigation efficiency might be improved, certainly in the dry months, but also by a selection of crops needing less water, e.g. vegetables instead of sugar cane. In this respect it is interesting to note, that increasingly in Mali rice varieties are tested which need little water.

6.4 Water sharing for the Inner Niger Delta

The vital significance of the ecosystem of the Inner Niger Delta for rural populations and the natural capital, on an regional, national and international level, is recognised by regional and national authorities. Recently this has lead to the development of a Strategic Sustainable Development Plan for the Inner Niger Delta (*Programme de Développement Durable du Delta Intérieur du Niger 2011-2020, PPD-DIN*) under responsibility of the Ministère de l'Environnement et de l'Assainissement. This plan aims at the implementation of a shared vision on the priority measures concerning poverty reduction and sustainable development of the Inner Niger Delta (MEA 2011). The plan contains concrete strategies and priority measures on the development of the different sectors in the Delta, institutional development and the management of the natural resources and ecosystem, including the integrated management of water resources. These are in line with the options mentioned below.

The future of the Inner Niger Delta as an annually flooded plain depends on the river discharge at the entrance of the Delta, and thus primarily on the interventions upstream (Section 6.2-6.3). Next to strategies and technical solutions which focus on water efficiency, the core of IWRM is water sharing between sectors. As the river discharge of the Niger and Bani is largely managed by upstream infrastructures, water sharing is principally a matter of water governance.

Operational management of Fomi

Water sharing starts at the source headwaters in Guinea, where the Fomi dam will be constructed in the Niandan tributary. There are still several management scenarios possible for the Fomi dam (Coyne & Bellier *et al.* 2009). To the future of the Inner Niger Delta it is essential that the natural flow regime is maintained as much as possible and at the same time the retention of water in the storage lake is optimized taking into account downstream interests (Office du Niger, Inner Niger Delta); limiting the water retention at Fomi in the wet season is the most discriminating measure for the Inner Niger Delta. Optimization of water sharing asks for a thorough international cooperation at basin level (ABN).

Water sharing upstream

From upstream to downstream water is or will be extracted from the Niger river at several locations culminating in a diminished river flow (Chapter 2). The impact of these upstream interventions on the Inner Niger Delta is asserted most in periods with relatively dry years with low rainfall and consequently a low river flow (Chapter 3). The most significant interventions are the large dams and the water intake for Office du Niger. In the context of IWRM a balanced water intake of Office du Niger is proposed, in such a way that in the long term a resilient and vital flood-dependent economy and ecosystem in the Inner Niger Delta is maintained. Water sharing could be balanced in a trade off analysis, using sustainability criteria (maintaining ecosystem services) as well as information on downstream and upstream production of natural

resources. It goes without saying that water sharing between sectors on an national level requires a thorough coordination, as was established in Chapter 5 and Section 6.1.

Water sharing presses for stringent requires on water governance especially in the situation where rainfall and consequently river flow are unpredictable and highly variable. To materialise and quantify IWRM on a basin level and balance interests of the different sectors it is recommended to make use of a decision support model. For the Upper Niger Basin such a model is available (DECIDAID), as a result of earlier initiatives for the promotion of IWRM (Section 5.2). The next step would be the actual implementation of the model. This is also one of the priorities recognised in the PPD-DIN.

6.5 Sustainable use of natural resources

The options treated in the previous sectors deal with the maintenance of a sufficient river flow for the ecosystem services and natural capital in the Inner Niger Delta, both of which are backbones of a green development. Within the Inner Niger Delta the focus lies on a sustainable management of the environment, including the natural resources – vital for the rural population of 1,5 million people – and biodiversity. In the Strategic Sustainable Development Plan for the Inner Niger Delta (PPD-DIN, MEA 2011) the priority measures in this sense are worked out. In coherence with the PPD-DIN (and we refer to this plan for a detailed overview of concrete measures), we briefly mention the following options:

- The rural communities in the Delta have no or limited access to information about the future developments or expectations. This applies for the short, within season term as for the longer term. As a result of IWRM-initiatives in the recent past a flood-prediction tool is constructed (OPIDIN), which is now piloted. This tool could play an important role in information sharing, understanding the impact of upstream interventions and may help the formulation of adaptation options in the framework of future scenarios (Afromaison); it is recommended to implement the use of OPDIN (upscaling).
- The natural assets of the Delta – of paramount importance on a global scale – are under high pressure. Although the Delta is not protected as national park, the area is designated as Ramsar site, and Mali ratified several international conventions on the protection of ecosystems and biodiversity. Conservation of the biodiversity in the Inner Niger Delta is urgent, as pressure in form of (over)exploitation grows. For instance, the ongoing depletion of fish stock may ultimately lead to the loss of fish production as a natural resource on a significant scale. Two elements are particularly important:
- Safeguarding of key habitats in the delta, in the terms of guarantee of sufficient water (flood duration, flood depth) and protection from overexploitation. This accounts in particular for bourgou fields and flood forests;
- Bird exploitation in the Delta in years with low floods is so high that it may threaten international population of water birds; the disappearance of certain populations is a realistic threat. The pressure on these assets will rise when water levels drop. Within this framework bird exploitation should be terminated as soon as possible, search promising economic alternatives together with law enforcement and maintenance.

6.6 Nature-inclusive design of new cultivations

Development of new irrigated areas is foreseen in the Office du Niger and other planned cultivations near storage lakes. In the present-day practise ecological criteria or ecosystem

services do not play a role in the design of cultivation. However, much can be gained by a nature-inclusive approach.

Up to now, such irrigation schemes are designed simply on the basis of hydraulic, technical and agronomic principles. In a sustainable design of irrigation schemes also ecological functions need to be involved. Not all ecological values and functions of natural floodplains can be 'transformed' to irrigated cultures, however there are clear opportunities to include ecological components in the design of irrigation schemes. This could involve an ecological infrastructure, set aside areas which are protected for breeding and resting (roosts for herons), fish productions areas etc.

6.7 Opportunities for actions

Based on the previous Chapters and the options for green development in this Chapter, a list of possible activities is mentioned in this Section. It goes without saying, that these activities have to be harmonized with the *Programme de Développement Durable du Delta Intérieur du Niger 2011-2020, PPD-DIN*), and the process which has been set into motion for the implementation of the national IWRM action plan. The presented action have not been prioritised.

- *Effective Water Governance*
Water governance issues are spread over many organisations in Mali related to the many interests and sectorial policies. This complicates the coordination of water management across sectors and scales, and also the implementation of IWRM (Section 5.1). An analysis of the water governance structure might reveal possibilities for optimization the effectiveness of water governance.
- *Scaling up Alternative Energy sources*
The experience with successful (more cost-effective, scaling up) alternative energy sources like solar power is rapidly growing, also in Mali. Given the growing demand of energy up-scaling of solar power in Mali is a potential growth market, also suitable for public-privat-partnership – constructions. This could actively be stimulated.
- *Working on efficient water use*
There are several options which could lead to actions for a more efficient water use. First of all this concerns the detailed management of water within irrigation schemes to minimize water loses. Other options concern alternative crops which consume less water. Research institutes like the Wageningen University and the International Rice Research Institute have a lot of experience with this matter and are actively involved in exploring new alternatives.
- *Make DECIDAID operational*
In the framework of a Partner for Water project, an decision support system was build which links up water management strategies with food production and ecosystem services. If this system is made operational (together with capacity building), it can help knowledge-based decisions on water management options in the Upper Niger Basin, relevant to the operational management schemes of large infrastructures but also to optimize water management choices in existing structures

- Scaling up OPIDIN
Connected to DECIDAID a flood prediction tool was built for local and regional stakeholders in the Inner Niger Delta (Zwarts *et al.* 2010). This tool suits pro-active management of natural resources in the delta. Currently the tool is optimised in a pilot areas in the delta in the framework of the EU-funded Afromaison-project. Scaling up OPIDIN serve all stakeholders in the delta, and improves pro-active and adaptive management to low and high floods.
- Nature-inclusive design of ON-extensions
In terms of green development, the extensions of ON for an increasing food production can be optimised through a nature-inclusive design. This means that important ecosystem services, amongst which are biodiversity, are included in the spatial design in such a way that these values can sustainably developed. The ecological values of rice cultivation do not meet natural flooded areas (Wymenga & Zwarts 2010), but in such a way can be much improved.
- Make DECIDAID operational
In the framework of a Partner for Water project, an decision support system was build which links up water management strategies with food production and ecosystem services. If this system is made operational (together with capacity building), it can help knowledge-based decisions on water management options in the Upper Niger Basin, relevant to the operational management schemes of large infrastructures but also to optimize water management choices in existing structures

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Appendix 1 Organizations and institutions involved in water management

This Appendix gives a list the organisations and institutions engaged in water management on international, national and regional/local level. If available the background and objectives are mentioned, together with important documents / policies relevant to integrated water resources management.

| International Organizations, Institutions | Important documents / policies |
|---|--|
| <p>Niger Basin Authority (NBA) It came to life on 21 November 1980 in Faranah (Guinea) with 9 member States: Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Guinea, Mali, Mali, Niger, Nigeria and Chad. The purpose of the Authority is to promote cooperation among the member countries and to ensure an integrated development of the Niger Basin in the areas of energy, hydraulics, agriculture, animal rearing, fisheries and fish farming, forest exploitation and sylviculture, transports and communication and industry. The member States revised the Convention relating to the creation of NBA in October 1987, assigning it the following objectives: a) to harmonize and coordinate the national policies relating to the development of water resources in the basin, b) to participate in development planning through the development and implementation of an integrated development plan for the basin, c) to ensure the control and regulation of any form of navigation on the river, its tributaries and sub-tributaries, in conformity with the Niamey Act and d) to participate in the formulation of requests for assistance and in the mobilization of funds for the studies and works required for the development of the resources in the basin. A <u>Shared Vision</u> was developed in 2002 with the purpose to create an "environment favourable" to cooperation through a Sustainable Development Action Plan (SDAP).</p> | <ul style="list-style-type: none"> - Shared vision - "a political declaration which defines the long term objectives and the commitment of the member States to an action program" - The Sustainable Development Action Plan for the River Niger (SDAP), a strategic framework of reference which defines and orients the integrated and shared development process of the River Niger - The Investment Program (IP) is the logical follow up of the SDAP of NBA, adopted by the extraordinary session of the NBA Council of Ministries on July 26, 2007 in Niamey, Niger - NigerWet, A Ramsar Network for the Niger Basin - The Water Charter of River Niger - Atlas of the Niger Basin |
| <p>Global Water Partnership (GWP) An international network that offers practical advice for sustainably managing water resources. It promotes and supports activities that operate at the national and regional levels of development. In addition to development agencies and country members the GWP includes NGOs and research organizations The Global Water Partnership's vision is for a water secure world. Its mission is to support the sustainable development and management of water resources at all levels. The GWP network works in 13 regions: Southern Africa, Eastern Africa, Central Africa, West Africa, the Mediterranean, Central and Eastern Europe, Caribbean, Central America, South America, Central Asia and the Caucasus, South Asia, Southeast Asia, and China. The GWP Secretariat is located in Stockholm, Sweden.</p> | <p>WWW.GWP.ORG</p> |
| <p>West Africa Water Partnership The following countries have Country Water Partnerships in West Africa: Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Ghana, Guinea, Guinea Bissau, Mali, Niger, Nigeria, Senegal and Togo. WAWP also works with Partner organizations in: Gambia, Liberia, Mauritania and Sierra Leone</p> | <p>WWW.GWP.ORG/WestAfrica</p> |
| <p>Bureau Provisoire du Comite National du Programme Hydrologique International (PHI-Mali) It is created with the Ministers in charge of Scientific Research, Water, Sanitation and a consultative body called the National Committee for International</p> | <p>Draft Decree establishing the National Committee for International Hydrological Programme (IHP) National workshop on Urban IWRM</p> |

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| <p>Hydrological Programme (CN- IHP).</p> <p>Mission:</p> <ul style="list-style-type: none"> - Coordinate the activities of IHP nationally and internationally; - Encourage, in connection with the themes of IHP, research, studies, bibliographic work, etc., Publish and promote them to the public; - Organize seminars, symposia and other events in the field of hydrology; - Promote the coordination of efforts of institutions and individuals who conduct studies and research in the field of hydrology. <p>IHP National Committee is composed as follows: a) Representative of the National Directorate of Water, (President), b) Representative of the National Directorate of Higher Education; c) Representative of the National Directorate of Agricultural Engineering, d) Representative of the National Directorate of Sanitation Control of Pollution and Nuisances, e) Representative of the National Water Partnership; f) Representative of National Commission for UNESCO and g) Specialists of Hydrological Sciences Faculties, Schools and Research Institutes.</p> | <p>House of partnership between Angers and Bamako - May 2009</p> |
|--|--|

| National Organisations, institutions | Important documents |
|---|---|
| <p>Direction Nationale de l'Hydraulique (DNH) Mission : Development of national policy on water supply, coordination and technical supervision of regional, sub regional services and related services that contribute to the implementation of said policy Tasks : a) to inventory and evaluate the potential at the national level, water, b) study, control, supervise the construction works of hydraulic structures and ensure their good working, c) conduct the assessment of development projects in the water sector and d) participate in the promotion of sub regional cooperation in the field of management of water resources.</p> | <p>National Action Plan for IWRM</p> <p>Logical Framework PAGIRE / MALI (CIDA))</p> <p>National Action Plan for Integrated Management of Water Resources 2004-2007.</p> <p>National Action Plans and PAGIRE NAPA</p> <p>Act to Water Code</p> |
| <p>National Water Laboratory : Mission : monitoring, analysis and control of water quality on the whole territory of Mali Provides public information on water quality for drinking and provides advisory support to communities to improve water quality</p> | <p>Decree No. 08/360 / PRM of 26/06/2008 Organization and operating procedures of the National Laboratory of Water</p> |
| <p>National Water Partnership (NWP) The National Water Partnership in Mali was created April 18, 2003 in Bamako with the support of GWP / West Africa. Mission: Contribute to promote IWRM in Mali in the sub-region and the world. It works to strengthen collaboration between the members and structures for the development of cooperation with national and international organizations. Objectives</p> <ul style="list-style-type: none"> - Provides advocacy for respect for conventions and for IWRM and the mobilization of political will - Promotes the emergence of associations or unions and other organized structures at the basin of water to ensure the contribution to behaviour change and strategic approach in the sense of sound management of natural resources nationally, regionally and global - Is to promote inter-sectorial collaboration for a better implementation of the IWRM strategy - Developing strategic alliances, and conducts operational actions in the direction of good governance - Contributes to the development of management tools and | <p>Capitalization Process Development and Implementation of PAGIRE</p> <p>Brochure: GWP/Mali: Implementation of IWRM in Mali</p> |

| | |
|---|---|
| <p>instruments to support the decision</p> <ul style="list-style-type: none"> - Supports local, national and regional or across a watershed, activities respecting the principles of sustainable management of water - Contributes to match needs and available resources - Stimulates exchange mechanisms for information and experiences <p>It is affiliated to GWP/West Africa and GWP</p> <p>The bodies of the National Water Partnership in Mali are: The General Assembly, the Steering Committee and the Permanent Secretariat.</p> | |
| <p>Scientific and Technical Committee of NWP</p> <p>The Scientific and Technical Committee is a permanent body of nine members selected by the Permanent Secretariat among academics, experts or other specialists recognized for their experience and expertise in disciplines related to the integrated management of water resources. The Scientific and Technical Committee is responsible for ensuring program quality</p> | <p>Brochure: GWP/Mali: Implementation of IWRM in Mali</p> |

| Regional and local level | Important documents |
|---|---|
| <p>Antennes du PNE dans toutes les régions administratives</p> <p>They have the same mission and objectives as the GWP at national level. They don't have any legal status as a result they are not allow to use the logo of GWP.</p> | |
| <p>26 Local Water Committees (CLE) across 26 circles, set up by the project GIRENS / DNH between 2006 and 2010</p> <p>A Local Water Committee (CLE) brings together representatives of all stakeholders of the company involved in water management. It is par excellence a body of integrated water resources at the local level, thereby implementing the principles of stakeholder participation in water management and subsidiarity.</p> <p>Three major groups of actors are members of the CLE: a) The State, with local administrative officials and decentralized technical services, b) Local elected officials, representatives of local authorities and c) Users of water: large private and public users, associations, groups, cooperatives, women's groups, youth, traditional and religious representatives, NGOs, nature protection groups, etc.</p> | <p>Final technical report</p> <p>Program: Integrated water resources of the Upper Niger</p> |

Appendix 2 Past and ongoing projects and studies on IWRM – a selection of important initiatives

Hydro-Ecological Management of the Upper Niger (GHENIS)

Timeframe: 1999-2002

Executor: Direction Nationale de l'Hydraulique

Assistance technique: ARCADIS Euroconsult, SERNES

Governmental organizations involved : All National Directions of Rural Development and Environment

Main goals:

- Analyse the problems and potential solutions, Improve knowledge and increase hydro-ecological skills of technical staff.
- Establish Centres of Information and Documentation to manage and archive the data and disseminate data and research results.
- Improve and update the current monitoring system, and establish a warning system.
- Develop a strategy and action plans to implement a policy for managing hydro-ecological development for the Upper Niger.

Main results

- A multidisciplinary and multinational worked as one team. Dialogue between experts and the willingness to cooperate was exemplary.
- The technical capacity of technical staff has increased significantly with training outdoors in the country and on the job and especially gain experience through the implementation of all project activities by teams of national experts
- Knowledge of the river environment has also increased, mainly through the study of eco-complex. Both teams are now better equipped to be able to analyze and demonstrate the environmental degradation.
- The two Centres of Information and Documentation are now well equipped, have a qualified staff and are able to accomplish all the tasks entrusted to them. They have the necessary tools for the sustainable management of the watershed of the Upper Niger.
- The warning system has already proved its worth during the floods in Bamako in 2001. With the data from the station Banankoro, hydrologists were able to inform the authorities in real time on the propagation of the flood.
- Resource users of the river began to be aware of the risks of their actions for the environment. The approval of the strategic plan by resource users of the river and the creation of basin committees are very important to increase this awareness and to come to concrete actions.

Lessons learned

- The preparation phase of a project is critical to the implementation phase of a project Omissions in this phase are immediately reflected on the project and the sustainability of achievements. The preparation of a logframe before the start of a project is an invaluable help to establish a realistic budget and achievable goals.
- The national counterpart is not limited to the project. Before the start of the project, budget requirements after the project must be determined and must be included in the commitments of the national counterpart.
- A development project is not simply a commercial contract, but a rather complex process that needs support and support in all phases of implementation. Project partners included the donor and the government should be flexible enough during project implementation to support the teams in their efforts to achieve the project goals.
- A national execution means that the national teams are fully responsible for financial payments. Responsibility for technical assistance is limited to technical support and services.

Recommendations

- That the donors and governments actively accompany (A) the execution of the strategic plan prepared by the project and (B) the functioning of the basin committees;
- That the national teams are given the chance to achieve all the objectives set for the third phase;
- That the water laboratories in the two countries are assisted in building the analytical capacity of the river pollutants;
- Let assists governments to develop more regional services of the hydraulic and environment.

Program for IWRM of the Upper Niger (GIRENS)

Timeframe: April 2005-June 2010

Executor: Direction Nationale de l'Hydraulique and Laboratoire National de Eaux

Assistance Technique : Royal Haskoning

Governmental organizations involved: Directions Régionale de l'Hydraulique de Mopti, Segou, Koulikoro

Main goals:

- The establishment in the Upper Niger basin upstream of Mopti, in Mali and Guinea, monitoring tools and alert on the water resources and the environment associated,
- A contribution to institutional strengthening of public services concerned and all stakeholders of the basin,
- The development and early implementation of a Plan of Action for Integrated Water Resources of Upper Niger (PAGIRE / NS) to restore and protect water resources of the basin

Main results

Result 1 : Strengthening instruments of knowledge and monitoring of water resources and the environment.

Program GIRENS focused its efforts on the following technical instruments: a) the water system, including a flood warning system, b) the piezometric network, c) Network for monitoring water quality, including a warning system for pollution of surface waters, including instruments and measures that are fundamental for laboratory analyses, d) Databases for storage and processing of information collected, e) The Geographic Information System (GIS) for the use of map data in relation to other databases and the use of satellite images to monitor environmental characteristics, f) hydrologic modeling to simulate scenarios of spreading flood, dam break and wave propagation of pollution in the river.

Result 2 : Institutional capacity building.

a) support to technical services of the two states, b) specific training given to various stakeholders, c) the creation of local Water committees, and d) specific action in terms of information, education and communication.

Result 3 : Knowledge of water resources and the environment

a) Hydrological data collected at the rehabilitated stations will allow the monitoring of the variation in level and flow of the river, b) the GHENIS model has been updated using Mike GHENIS 11-2005, whereas historical data were added in the database. This allows to reproduce the annual and seasonal variation in the flow of the Niger and the Bani. It is also possible to simulate flow scenarios, especially scenarios with flood consequences, c) participation in the strengthening of the piezometric network in the basin, the data collected by the program are incorporated into the national database Sigma, d) the creation of two laboratories in Mopti and Kankan, including equipment and training given to technicians. This allows to start monitoring the water quality of rivers. In parallel with this monitoring, laboratories provide services for the monitoring of drinking water, e) the production of maps with a single covering of the basin-wide and related to GIRENS program, and f) extension of the socioeconomic database for the Bani Basin (characterization of the actors, socio-economic activities carried out, environmental impacts) and also in relation to the development of Local Water Committees (CLE) and the development of their Action Plan for managing water (PAGE).

Result 4 : Actions physiques de protection des ressources en eau dans le bassin.

a) the construction of structures to defend the river walls to stop local erosion in Banankoro, et b) a reforestation campaign and construction of seedbeds.

Result 5 : Action Plan of IWRM/Upper Niger (PAGIRE/NS)

An action plan for the protection and restoration of water resources in the Upper Niger Basin was developed and its partial implementation of the plan began during Phase 2

Lessons learned

1. The creation of local water committees (CLE), which contributed significantly to the awareness of the degradation of water resources, their causes and the possibilities that exist to fight against. The CLE also provide a formalization, institutionalization of the real participation of all stakeholders in local management of water.
2. The action plan "PAGIRE / NS" is a guiding document and the quality has been recognized during evaluations of the document for the continuation of restoration and protection of water resources of the basin.
3. The two laboratories are expected to be centres of reference for issues of environmental quality of the water, and also control of drinking water in the basin.
4. The lack of dissemination of results, lack of visibility of the program, especially in regard to its technical results.

5. All the difficulties regarding acquiring materials and equipment and the administrative delays had no positive impact on the output.

Perspectives

- Support for CLE: methodological, technical and financial support, for facilitating access to credit for the implementation of management plans.
- Strengthen the current human resources of laboratory by permanent technical assistance to at least one year.
- Examine the feasibility of a laboratory strengthening to enable them to analyse the heavy metals (atomic absorption spectrometry), in 2012, and pesticides, 2015 after a diagnosis of laboratory operations
- Continue the reforestation of the river banks.
- Identify and promote socio-economic activities and alternative income generation to reduce the adverse impacts of certain activities in the basin

Water for food and Ecosystems- Efficient management of water resources of the Upper Niger

Timeframe: 2003-2005

Executor : Partners for Water/Netherlands, RIZA (lead), Altenburg & Wymenga, Wetlands International

Technical Assistance: Danube Delta National Institute, Rumania; DelftHydraulics, Netherlands; Direction Nationale de l'Hydraulique, Mali; Institute for Environmental Studies, Free University, Netherlands

Governmental organizations involved : CPS-MDR, DGE, DRAMR, DNH, EDM, IER, ON, OPM, ORM, ORS, EDM

Main goal: Develop a decision support system for effective management river management in the Upper Niger, in which ecological and socio-economic impacts and benefits of dams and irrigation system can be analysed in relation to different water management scenarios

Main results:

1. The study's hydrological assessment increased our understanding of the Upper Niger River's hydrology, highlighting natural variations as well as the impact of human-made structures
2. The annual rainfall in the catchment area of the Upper Niger amounts to an average of 1,500 mm and varies between 1,100 and 1,900 mm. The river discharge of the Niger which is determined by rainfall, its annual variation between 600 and 2,300 m³/s is much more pronounced than that of rainfall.
3. The recent decrease in flow of the Niger River cannot be solely attributed to reduced rainfall and depleted groundwater aquifers but also to dam and irrigation schemes in the Upper Niger region.
4. Selingue : In years of high river discharge, the water stored to fill the reservoir amounts to only 10-20% of the peak flow of the Niger. However, in years of low discharge, this fraction increases to as much as 20-30%.
5. Office du Niger: water use by the Office du Niger irrigation zone declines to 4% of total flow in years with high flow, but increases to 15% of total flow in years with low flow. In years with limited rainfall, the natural discharge of the Niger river is insufficient to feed the water requirements of Office du Niger. In May, for example, the natural river flow is only 40 m³/s, while the water consumption of the Office du Niger irrigation zone is at least twice this amount (using the water released by Selingue at that time of the year)..
6. Future expansion of the irrigation fields by the Office du Niger is only feasible if further improvements in water use are achieved.
7. A minimum flow (50m³) is required to prevent unsustainable fish stock depletion in the central Inner Delta and pressure on remaining biodiversity.
8. As river flow is reduced, one of the largest riverine floodplains in the world, the Inner Niger Delta, is affected. The flooding of this area completely depends on the river because local rainfall is limited.
9. A water balance model revealed that the water level in the Inner Delta from August to October is on average 5-10 cm lower due to irrigation of the Office du Niger zone, and another 15 cm lower due to the Sélingué reservoir. The Fomi dam will reduce the peak flood level by another 45 cm.
10. Depending on the overall climate, the management of respectively Sélingué reservoir, water intake of Office du Niger and Fomi dam lead to an average decline of the maximum inundated area of 300 km² and 600 km². The water diversion upstream has a major impact on the floodplain ecosystem, essentially because of reduced flooding.
11. Human impact in the Inner Niger Delta: fishing pressure is excessively high, while the floodplains are grazed by two million cattle and four million sheep and goats. As a result, some of the key habitats such as flooded forests and bourgou fields are at the edge of extinction.
12. Habitats: The floating bourgou fields are indispensable as a nursery habitat for juvenile fish, providing both protection and food. The bourgou fields act as a key habitat for a number of piscivorous bird species, and as soon

- as the flood retreats it provides food for the omnipresent livestock. The Fomi dam is expected to reduce the extent of floating bourgou fields (a key habitat) by 62% relative to the present situation.
13. Biodiversity. The Inner Niger Delta is one of the largest Ramsar sites in the world and is considered to be a biodiversity hotspot.
 14. The Inner Niger Delta accommodates two of the biggest known breeding colonies of herons and cormorants in Africa. In addition, this delta supports up to 3-4 million staging waterbirds, both residents and migrants, from all over Europe and Asia.
 15. The (maximum) flood level in the Inner Delta determines the recruitment of the Afro-tropical water birds and plays a qualifying role in the mortality rates of populations of African resident waterbird species as well as Palearctic migrant species. Consequently, The hydrological and related ecological conditions in the Inner Delta therefore have a qualifying impact on the population size of breeding and staging waterbird species.
 16. The Fomi dam will reduce the ecological value of the Inner Delta by at least 36%, but due to cascading effects the impact on survival of waterbirds and other wildlife is much greater at low floods.
 17. Fisheries: Nowadays, nearly all fish are captured long before the next flood arrives. Fish trade in the Inner Delta would be respectively 6%, 13 and 37 % higher in the absence of the Office du Niger irrigation zone, without the Sélingué reservoir and Fomi Dam
 18. Rice is cultivated in areas inundated by one to two meters of flood water. Based on the strong correlation between rice production and peak flood level, it has been estimated respectively that farmers on average produce 4,300 tonnes less (4.9%), as a result of Sélingué. Without the irrigation of the Office du Niger zone, rice production in the Inner Delta would be 8,900 tonnes greater (10.4%). The Fomi dam would have an even bigger impact: a decrease of 40%, or 34,500 tonnes.
 19. Economics. By building the Fomi dam, society at large will lose €35 million per year (i.e. €8.5 + €26.4 million). The Sélingué dam generates additional annual net-benefits of almost €5 million. The Office du Niger irrigation zone is the most economically feasible project of the three, generating aggregated net-benefits of almost €22 million per year (i.e. €26.4 - €4.8 million).
 20. Poverty and equity. An important dimension of the study is the spatial distribution of benefits in the different scenarios (Selingue, Selingue+Markala and Selingue+Markala+ Fomi). Besides changes in the absolute level of welfare, dams are likely to cause transfers of benefits from one region to another.

Lessons learnt:

All in all, this study shows that improving the performance of the existing infrastructure as well as the economic activities in the Inner Niger Delta itself, is a significantly more efficient way to increase economic growth, reduce poverty and protect the environment in the region than the building of a new dam and hydropower plant.

Publications and reports

- Beukering, P.J.H. van, Kone, B. , Goosen, H. b & Zwarts, L.: The impact of water management on poverty and the environment in the Upper Niger Basin (Mali). PREM, Free University Amsterdam.
- Zwarts, L., van Beukering, P., Kone, B., & Wymenga, E. (2005). The Niger, a Lifeline. Effective water management in the Upper Niger Basin. Altenburg & Wymenga Ecologisch Onderzoek BV. ISBN 9080715069.
- Zwarts, L., van Beukering, P., Kone, B., & Wymenga, E. (2005). Le Niger, une artère vitale. Gestion efficace de l'eau dans le Bassin du Haut Niger. Altenburg & Wymenga Ecologisch Onderzoek BV. ISBN 90807150670.
- Zwarts, L. & B. Kone. 2006. Dams in Mali: enhancing knowledge and awareness on their up- and down-sides. Technical report PREM-programme IVM.
- Zwarts, L & B. Kone. 2006. Towards an efficient water management in the Upper Niger. Rapport Wetlands International.
- Zwarts, L., P. van Beukering, B. Kone, E. Wymenga, D. Taylor. 2006. The economic and ecological effect of water management choices in the Upper Niger River – Development of decision support methods. International Journal of Water Resources Development 22: 135-156.

Integrated Water Resources Management in the Niger basin upstream Taoussa

Timeframe: 2007-2009

Executors: Partners for Water/Netherlands, Royal Haskoning (lead), Altenburg & Wymenga, Wetlands International, direction Nationale de l'Hydraulique, DLG/Netherlands, RIZA

Governmental organizations involved: Direction Nationale de l'Hydraulique, Office du Niger, Office Riz Segou, Office Riz Mopti, Directions Régionales de l'Agriculture, Peche, Elevage de Mopti, Tombouctou et Sikasso

Main goals:

Demonstrate the value of an operational integrated approach for water resources management:

- at political level (Entire Niger basin upstream Taoussa)
- at local level (in the Inner Niger Delta).

Main results

Result1: GIRE-DecidAid

- Tool to optimize surface water infrastructures planning and management in the Niger basin;
- Statistical tool which integrates hydrology, economy and environment
- Allows simulation of scenarios of surface water structures planning and their management in comparison to actual situation

Result2: OPIDIN (Flood Predicting Tool for the IND)

- Tool which provides stakeholders of the Delta (farmers, fishers, herders, etc.) missing information on the future behaviour of the flood.

Lessons learnt GIRE-DecidAid

- Wide integration of hydrology-economy-environment
- large flexibility : all parameters can be defined and adjusted
- Simplicity : easy to learn and use
- No specific software, 1 Excel file.
- Cost free to use
- large graphical presentation capacity

Lessons learnt OPIDIN

- Good level of reliability which is improving over time
- Simple and inexpensive
- Easily generalized to the entire area of the delta, with the participation of regional and local technical services
- Very useful for planning many activities: agriculture (particularly recession), fishing, livestock, logging and navigation

Perspectives

- Use the tools in real situation
- Continue the development of GIRE-DecidAid (Figures additional synthesis, integration of other irrigated productions such as wheat, corn, integration logging, navigation)
- Integrate into the tool the issue of quality water
- Detail the statistical approach in the Guinean portion of the Niger River in order to improve the reliability of the tool
- Extend downstream in the Niger Basin

Publications and reports

Wymenga, E & L. Zwarts 2009. What are the possible, ecological effects upstream of the planned Taoussa dam (Mali)? A&W report 1250-2.

Zwarts, L. 2009. Predicting the annual peak flood level in the Inner Niger Delta. A&W report 1250-1.

Dano-Swedish Programme for Support to PROSEA 2010-2014: Under Component: Integrated Water Resources

Timeframe: 2010-2014

Executor: Direction Nationale de l'Hydraulique- Cellule PAGIRE

Governmental organizations involved: All Rural Development Ministries

Main goals:

Component 1: Development of Local Water Committees (CLE)

- Support and develop existing CLE
 - Promote and expand the CLE
 - Strengthen the capacity of key players around the CLE to enable them to support existing and new CLE.
-
- Provide concrete results to pilot actions and promote their dissemination.

Component 2: Strengthening national and regional information system on water

- Strengthen monitoring of quantity and quality of water resources, needs and uses.
- Strengthen the system of storage and data management.
- Strengthen the assessment of water resources and dissemination of information.

Component 3: Strengthening the implementation of Action Plan of IWRM (PAGIRE)

- Support the creation of Unit PAGIRE Unit management
- Strengthen the evaluation process PAGIRE phase 1 and phase 2 formulation of PAGIRE
- Conduct studies on the qualitative and quantitative consequences of climate change on water resources in Mali
- Support advisory structures to create more social cohesion around the management of water resources
- Strengthen the institutional and individual capacities in preventing and managing conflicts related to water

- Develop and implement a plan and appropriate training programs for those involved in the implementation of PAGIRE

Main results

RESULTS Component 1: Development of Local Water Committees (CLE)

Results associated with the immediate objective no. 1.1

CLE already created remain functional and implement management plans

Results associated with the immediate objective no. 1.2

New CLE and Committees Sub-Basin were created

Results associated with the immediate objective no. 1.3

The water services at regional and subregional levels and regional water partnerships have been strengthened so that they can perform their duties vis-à-vis the CLE

Results related to the immediate objective no. 1.4

Research/Action projects identified in the PASEPAREI are implemented and the results of these activities have been disseminated and used

RESULTS Component 2: Strengthening national and regional information system on water

Results related to immediate objective no. 2.1

- Conditions for operationalizing sustainable monitoring systems established or rehabilitated as part of the immediate objective no.2.1 are evaluated and a plan for their implementation is developed.
- The monitoring of surface water is improved and effective databases are developed from this monitoring.
- The monitoring of groundwater is improved and effective databases are produced from this monitoring
- The monitoring of water quality is improved and the ability analysis of samples is increased
- A system for monitoring use and water demand is established

Results related to immediate objective no. 2.2

The system of storage and data management is strengthened

Results related to immediate objective no. 2.3

The evaluation system of water resources and distribution of information is reinforced

RESULTS Component 3: Strengthening the implementation of Action Plan of IWRM (PAGIRE)

Results related to immediate objective no. 3.1, support for the creation of the PAGIRE Management Unit

- Members of the PAGIRE Management Unit received the necessary training to enable them to fully assume their new duties
- PAGIRE Management Unit is equipped

Results related to immediate objective no. 3.2, the evaluation process PAGIRE Phase 1 and Phase 2 PAGIRE formulation is enhanced

- A baseline for the different indicators is established to allow better monitoring / evaluation of the Action Plan; The evaluation of the implementation of the Action Plan is made and the experiences are capitalized; The program for Phase 2 of PAGIRE is formulated
- Results related to immediate objective no. 3.3, Impact of climate change on the quantity and quality of water resources and the different uses of water in Mali and in the elaboration PAGIRE
- Analysis of impact on the quantity and quality of water resources in relation to climate change and the impact on the uses of water resources is made; the findings of the 'Impact of climate change on the quantity and quality of water resources and the different uses of water in Mali' are integrated into the current program PAGIRE

Results and activities related to the immediate objective no.3.4, Support the advisory structures to create more social cohesion around the management of water resources

Analysis of consultation structures in Mali; The National Council for Water has taken its role as a key structure in the formal consultation on the management of water resources; members and secretariats of the basin committees are formed in the IWRM, adaptation to climate change and conflict management; The Commission for Water Management of the Sélingué Reservoir is supported

Results related to immediate objective no. 3.5, strengthen the capacity for conflict management

A document is prepared for training in conflict management related to water, a prevention framework and conflict management (consultation framework) is implemented

Results related to immediate objective no. 3.6. Develop a plan and implement an appropriate training program for those involved in the implementation of PAGIRE

- A training plan targeted actors and a document of coherent programs of training for actors in the water are available

- After the approval phase PAGIRE, the national assistance and advisory support institutions will have strengthened their ability to make available to planners, policy makers and other stakeholders / users, tools, instruments and other methodological materials needed to build a vision and strategic plans, thematic development of water resources and to assist them in implementing the national policy on water.

Title : Enhancing the role of wetlands in integrated water resources management for twinned river basins in EU, Africa and South-America in support of EU Water Initiatives (WETwin)

Case Study: Inner Niger Delta

Timeframe: 2009-2010

Executors: Environmental Protection and Water Management Research Institute (VITUKI/Hungary), AnteaGroup (Belgium), Potsdam Institute for Climate Impact Research (PIK/Germany), Wasserkluster Lunz (WKL Institute for Water Education (UNESCO-IHE/Netherlands), Wetlands International (WI/Mali), National Water and Sewerage Corporation (NWSC/Uganda), International Water Management Institute (IWMI/South Africa), Escuela Superior Politécnica del Litoral (ESPOL/Ecuador)

Governmental organizations involved: Direction Nationale de l'Hydraulique, Laboratoire Nationale des Eaux, Université de Bamako, Institut Nationale de Recherche en Sante Publique

Main goals

1. Identify community based technical and institutional solutions for the management of wetlands and river basins with the aim of utilizing the drinking water supply and sanitation potentials of wetlands for the benefit of people living in the basin. This concerns solutions for improving the relevant capacities of wetlands.
2. Account for ecosystem functions and values of wetlands. The proposed management solutions should also take care of preserving (and also for improving as much as possible) the ecological values of wetlands.
3. Identify strategies for adapting the management of wetlands to the changing environmental conditions.
4. Identify solutions and strategies for integrating wetlands into river basin management and planning, by taking relevant national and international policies/guidelines into consideration, and also by accounting for the envisaged community service functions of wetlands.
5. Ensure that stakeholders and decision makers will benefit from the project, also after the end of the project.
6. Increase the exchange of expertise on wetland management and on IWRM; increase the transferability of results and achieve better international networking; enhancing North-South, South-North and South-South (Inter-African, African – South American) cooperation
7. Increase the capacity of relevant organizations to manage wetlands and river basins in an integrated way.

Main results

Work Package 1 (WP1): Project management

Result: Final Project Science Report of all case studies including the IND

WP2: Stakeholder participation

Result: Report on stakeholder analysis and strategy for stakeholder development in the IND

WP3: Natural and socio-economic status

Result: Qualitative description of the natural and socio-economic status of the IND

WP4: Management practices and institutional settings

Result: Report on management and institutional requirements for the implementation of existing technical guidelines of the IND

WP5: Vulnerability assessment and scenario design

Result: Advanced vulnerability assessment of the IND to climate changes

WP7: Development of evaluation and decision support tools

Result: Report on management options of the IND wetlands at local and global scales

WP8: Management solutions of the IND wetlands

Result: Report on the identification of the best-compromise management solutions of the IND wetlands at the local and global scale

WP9: Guideline development

Result: Generic guideline document on making use of wetlands capacities in improving drinking water and sanitation conditions on the river basin in a sustainable ecologically sound way for all case studies including the IND

WP 10: Communication and dissemination

Results: Up-to-date project website, Multi-lingual project Brochure (English, French and Spanish), scientific publications.

Planned scientific publications:

Cools, J, S Liersch, A Funk, M Diallo, B Kone: Trade-offs between ecosystem services, livelihood and human health for the Inner Niger Delta, Mali: a tool to support wetland management.

Cools J. *et al.* Wetlands and IWRM: lessons from WETwin

Liersch, S, J. Cools, B. Kone, H. Kocha, M. Diallo, V. Aich, S. Fourneta, F.F. Hattermann: Vulnerability of rice production in the Inner Niger Delta to water resources management under climate variability and change.

Title: Africa at meso-scale: Adaptive and integrated tools and strategies on natural resources management (AFROMAISON). Case Study: Inner Niger Delta

Timeframe: 2010-2012

Executors: ANTEAGROUP/ Belgium (lead), World Agroforestry Centre (ICRAF)/Kenya, Institute for Natural Resources (INR)/South Africa, Observatory of the Sahara and the Sahel (OSS)/Tunisia, UNESCO-IHE/Netherlands, Potsdam Institute for Climate Change Impact (PIK)/Germany, Wetlands International (WI)/Mali, International Water Management Institute (IWMI)/Ethiopia, Global Resource Information Database (UNEP) / University of Geneva/UNIGE/GRID /Switzerland, International Institute for Water and Environment Engineering (2IE)/Burkina, CIRAD/France, The University of KwaZulu-Natal (UKZN)/South Africa, Altenburg & Wymenga ecological consultants (A&W), Netherlands, Mountains of the Moon University (NMU)/Uganda

Partners: Direction Nationale de la Pêche, Direction Nationale de l'Hydraulique, Commission of Mopti Region.

Main goals

- To identify opportunities, challenges and operational requirements for the adoption of tools, strategies and methodologies at the meso-scale
- To provide a holistic and multi-disciplinary framework for long-term integrated natural resources management, in line with sustainable development principles. The framework aims to integrate landscape functioning, livelihood, socio-economic development, indigenous knowledge and local practices and institutional strengthening
- To improve the capacity of sub-national authorities on INRM to assure
- economic and social well-being of communities
- To improve the exchange and transfer of information and procedures for communication on natural resources management
- To contribute to bring concepts for INRM into operational practice, including vulnerability, ecosystem goods and services, adaptation to global change (including climate change).
- To evaluate and inter-compare promising tools and strategies on applicability, suitability (fit-for-purpose), sustainability for livelihood and ecosystem, cost-effectiveness (incl. impact) and cultural acceptance.

Main results:

WP2: Multi-disciplinary rapid assessment & constraints for effective INRM

- Report on context, opportunities and constraints for operational INRM
- Report on the potential of novel concepts for operational INRM

WP 3: Strategies for restoration & adaptation

- Report on framework to identify tools and strategies, constraints and opportunities with regard to adaptation restoration
- Report on best practices and promising tools and strategies for adaptation and restoration
- Report on Impact & Sustainability of tools and strategies on landscape functioning and livelihoods
- Implementation guideline document for tools and strategies for adaptation and restoration detailing contexts, methods and case study specific considerations

WP 4: Economic tools & incentives

- Report on framework to identify tools and strategies, constraints and opportunities with regard to economic tools and incentives
- Report on the best practices and promising tools and strategies for economic tools and incentives
- Report on Impact & Sustainability of tools and strategies on landscape functioning and livelihoods
- Implementation guideline document for economic tools and incentives detailing contexts, methods and case study specific considerations

WP 5: Tools for spatial planning

- Report on existing processes and tools for spatial planning of INRM

- Report on the application and adaptation of selected tools for spatial planning
- Maps of landscape functioning (ecosystem services and goods and livelihood)
- Implementation guideline document for tools and strategies on spatial planning detailing contexts, methods and case study specific considerations

WP 6: Global change, vulnerability and scenario design

- Initial vulnerability assessment and scenario storylines at meso-scale for each case study
- Report on quantitative vulnerability assessments including scenario impacts
- Vulnerability map for natural resources at meso-scale and Africa-wide
- Implementation guideline document for tools and strategies on vulnerability assessment detailing contexts, methods and case study specific considerations
- Operational strategies for adaptation and vulnerability reduction to global change

WP 7: Operational framework & toolbox for adaptive INRM

- Report on approaches for integrating local practices and knowledge on NRM with expert knowledge
- Compilation of toolbox and final operational framework

WP 8: Dissemination, capacity building & end-user involvement

- Report on end-users outreach strategy
- AFROMAISON Spatial Data Infrastructure

Title: Improved Drought Early Warning and FORecasting to strengthen preparedness and adaptation to droughts in Africa. Case study: Niger River Basin (Upper Niger and Inner Niger Delta)

Timeframe: 2010-2012

Executors: Deltares/Netherlands, UNESCO-IHE Institute for Water Education (IHE)/Netherlands, European Centre for Medium-range Weather Forecasts(ECMWF)/ Europe, Joint Research Centre(JRC)/Europe, Potsdam Institute for Climate Impact Research (PIK)/Germany, German Research Centre for Geosciences (GFZ)/Germany, Universidad Politecnica de Madrid (UPM)/Spain, Mediterranean Agronomic Institute of Zaragoza (IAMZ)/Spain, Faculty of Engineering, University of Porto (FEUP)/ Portugal, Nile Forecast Center (NFC)/Egypt, Wetlands International Afrique/Mali Office, Dinder Center for Environmental Research (DCER)/Sudan, IGAD Climate Prediction and Applications Centre (ICPAC)/Kenya, Faculty of Engineering, University Eduardo Mondlane (UEM)/Mozambique, Council for Scientific and Industrial Research (CSIR)/South Africa, WR Nyabeze & Associates (WRNA)/South Africa, Institut Agronomique et Vétérinaire Hassan II (IAV)/Morocco, WaterNet Trust (WATERNET)/Botswana, Hydraulic Research Institute - Nile Basin Capacity Building Network for River Engineering (NBCBN)/Egypt

Partners: Direction Nationale de la Meteorologie, Agence de l'Environnement pour le Developpement Durable (AEDD)

Main goals:

- To assess the existing capacities in Africa in terms of drought monitoring, forecasting and warning, and identify constraints and opportunities for improvement.
- Enhance drought monitoring methods through improved drought indicators that integrate drought hazard and vulnerability in a risk based approach, and to understand the relationship between drought hazard and vulnerability in the current climate and how this will change as a result of climate change.
- To increase the performance of methods used for forecasting droughts in Africa by implementing state-of-the-art in (seasonal) meteorological, hydrological and agricultural forecasting, and by adopting and adapting methods used in Europe, Australia and the US.
- To improve early warning of droughts through identification of appropriate thresholds for initiation of mitigation activities, and establishing mitigation and adaptation strategies to increase resilience to drought at seasonal and longer time scales.
- To transfer the knowledge developed with the implementation of drought early warning to practitioners and build capacity in Africa to ensure that the knowledge developed continues to be exploited beyond the project.

Main Results

WP3: Drought hazard, vulnerability and risk; and the influence of climate Change

- Meteorological climate scenarios for Africa and specific case study regions of the Nile and Niger River basins
- Hydrological climate scenarios for Africa and specific case study regions of the Nile and Niger river basins
- Report on impact of climate change on drought hazard across the whole of Africa and at the regional case study scale, describing the analysis of different climate change scenarios and the expected impact on drought hazard

WP4: Drought forecasting at different temporal and geographical scales

- Report and Data: Meteorological drought forecasting (monthly to seasonal forecasting) at regional and continental scale across Africa. Data will be delivered to partners
- Downscaled and tailor made hydrological models for the Limpopo and Niger case study basins, including user manuals

WP 6: Implementation of improved methodologies in comparative case studies

- Testing of drought indicators at Pan-African level. Report and maps.
- Integration of drought vulnerability and hazard into risk maps at the Pan-African level . Report and maps.
- Integration of drought forecasting tools for Africa into the Pan-African map server. Report and web-tools.
- Evaluation of the performance of the proposed improved drought forecasting methods applied to selected river basins in Africa

WP7: Stakeholder participation, knowledge dissemination and capacity building

- Project Knowledge Sharing Platform
- Final reports and materials from training courses
- List of scientific publications produced by the project participants and external presentations
- Policy briefs, released in appropriate sub-regional languages

A large herd of cattle is crossing a river, with people standing on the bank. The scene is very dusty and hazy, with a yellowish-brown tint. The cattle are in the water, and people are on the bank. The background is a flat, open landscape under a bright sky.

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