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INTEGRATED FLOOD MANAGEMENT

CASE STUDY

MALI: *FLOOD MANAGEMENT - NIGER RIVER INLAND DELTA*

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MALI: *FLOOD MANAGEMENT - NIGER RIVER INLAND DELTA*

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1. Location

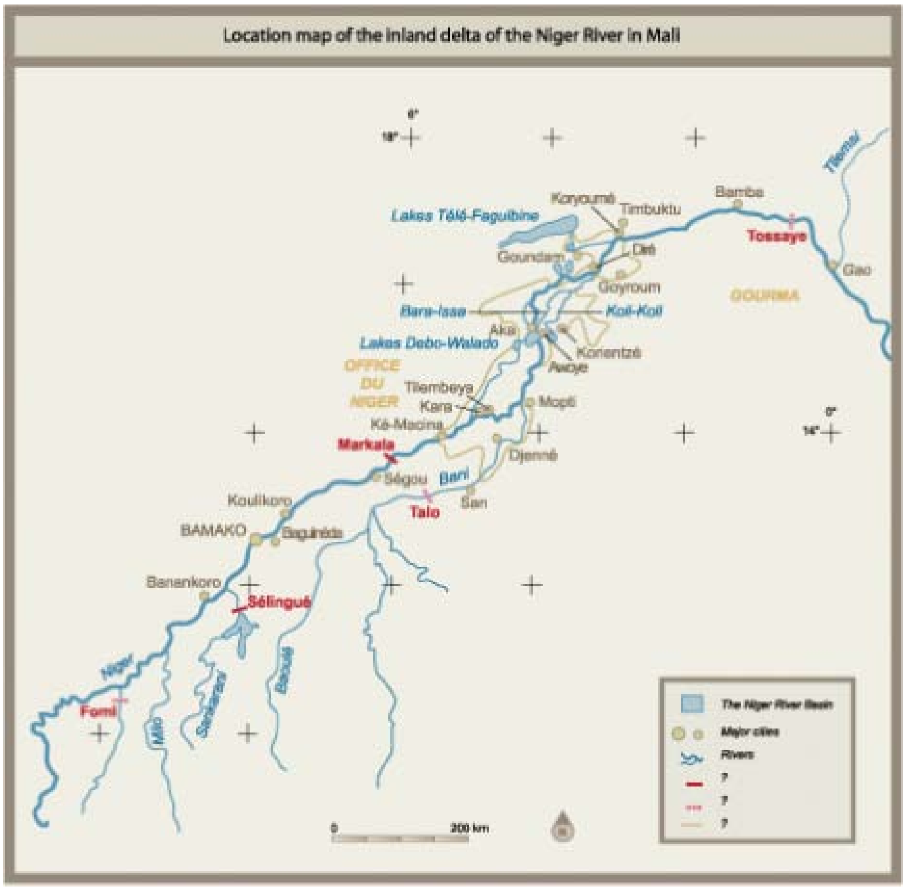
1.1 Relative location of the flood prone area and its coordinates.
The Niger River Inland Delta constitutes one of the largest wetlands in the world and is situated in the sahelian zone in Mali. It is located between 13° 30' and 17° 00' latitude North and 2° 30' and 5° 30' longitude West.

1.2 Land and water resources

1.2.1 Physical features

- Climate

The Niger River Inland Delta receives about 200 to 600 mm of rain. South of Mopti (map 1), the area corresponds to the sahelian zone, while north of Mopti the climate can be characterised as semi-arid. The rainfall regime is characterised by a long dry season of about 9 months and a wet season of about 3 months, starting in July and finishing in September. Rainfall is often abrupt and violent with intensities reaching sometimes 150 mm in only 2 to 3 hours.



Map 1. Location map of the Inland Delta of the Niger River in Mali.

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The droughts of the Sahel, which have started in the 1970s have caused rainfall deficits of about 30% and a "descent" of the isohyets by about 200 km towards the south. At the same time, the river flows have diminished even more than the rainfall. The droughts have further impacted on the groundwater tables in the area.

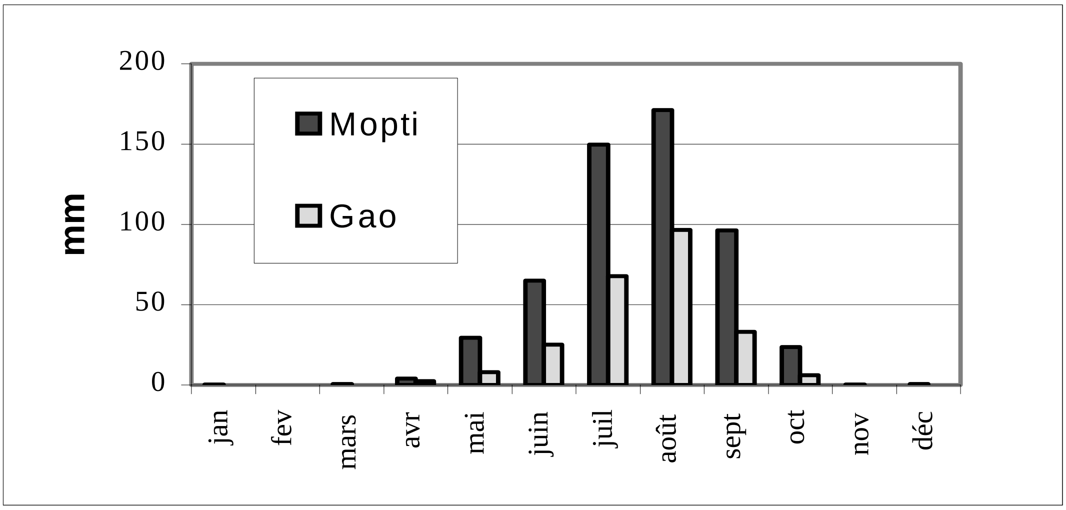


Figure 1: Histogram with monthly rainfall at Mopti and Gao for the period 1951-1980

During the dry season, strong northerly winds blow from the Sahara – referred to as the Harmattan -, while during the wet season southerly winds bring the monsoon rains from the Guinean Gulf.

The highest temperatures are observed in April and May, while the lowest are measured in December and January. The average annual temperature ranges from 28 to 30°C, the annual relative humidity is lower than 40%.

The annual rate of evapotranspiration is higher than 2000 mm, and is particularly elevated during the period March to May, caused by very high temperatures, a low relative humidity and the strong winds.

Table 1: Some climatic parameters for the stations of Ségou and Mopti (source: Olivry, 1994)

Parameter	*Ségou*	*Mopti*
Average annual temperature (°C)	28.6	27.7
Temperature °C x month (x) *	(4) 41.2	(5) 40.0
Temperature °C n month (n) *	(1) 15.4	(1) 14.0
Üx ann % **	74	75
Ün ann % **	32	30
½ (Üx + Ün) % March	31	30
½ (Üx + Ün) % August	80	78
P (Annual rainfall) mm	650	415
Number of dry months***	8	8 to 9

* Between parentheses, the number of the month having the maximum (x) and minimum temperature (n).
** Üx et Ün are respectively the maximum and minimum average annual relative humidity; (Üx + Ün)/2 correspond to the average relative humidity of the driest (March) and wettest month (August).
*** Following the definition of Gaussen, a month is qualified as dry when Pmm < 2T°C.

- Topography

The Niger River Inland Delta covers more than 60,000 km^2. Its southern and northern parts are often distinguished for their geo-morphological characteristics:

- o The southern part (*cuvette lacustre*) is constituted by a vast alluvial plain subject to wide-spread flooding. It is estimated that in wet years, more than 20,000 km^2 are inundated. It is bordered in the south by the towns of Ké-Macina (272 m altitude) and Douna and in the north by the central lakes of Débo (262 m altitude), Walado and Korientzé. The slope of the river during the flood season is very small here – about 3 cm per km – resulting in flow velocities ranging from 0,3 to 0,6 m s^{-1} in the major rivers.
- o In the northern part (*erg de Niafounké*) the rivers twist around the dune formations and the inundated areas concern principally the main river beds. The slope of the river further decreases to only 1 cm/km between Niafounké and Diré. However, in case of sufficient river floods a number of temporary lakes in the periphery of the Delta receive water. On the left bank of the river a maximum area of 10,400 km^2 is covered by the lakes Tanda, Kabara, Tagadji, Horo, Fati, Télé, Gouber and Faguibine. On the right bank, the lakes Aougoungou, Niangaye, Do, Garou et Aribongo cover a maximum area of 4,000 km^2.

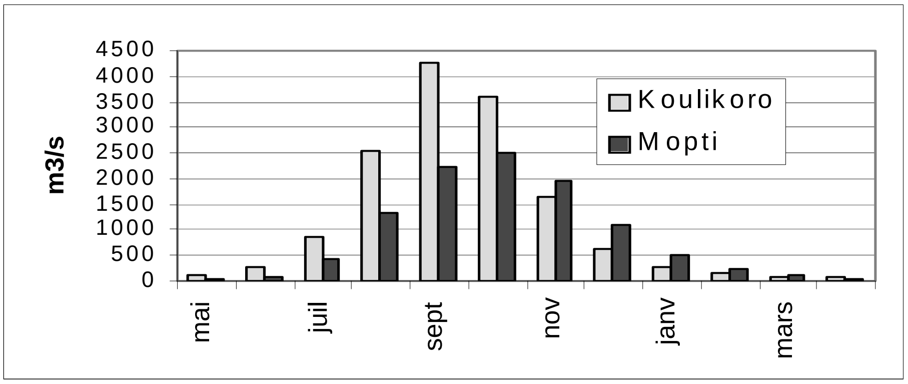
- Hydrology

The Niger River constitutes the third longest river in Africa with its 4,200 km. Originating on the northern slopes of the Guinean dorsal in the Fouta Djalon, the Niger River follows initially a north-eastern course until it meets the Sahara desert. It then makes a large semi-circle from Mopti onwards and find its way to the Guinean Gulf in Nigeria. The water resources of the Niger River emanate principally from Guinea: in Gouala (Mali), 70 km upstream of Bamako, the Niger River receives the Sankarani, draining mainly the Guinean hills. In Mopti, it receives the Bani River, which drains the south of Mali and the north of Ivory Coast. The rainfall regime in its catchment area is less generous than that in Guinea, making the Bani a less important contributing tributary.

In the Niger River Inland Delta, the hydrographical network is relatively complex. The Niger River diverts part of its water (up to 1/3) during the flood season at Tilembeya towards the north through the Diaka. These waters converge at the central lakes (Walado, Débo, Korientzé), but at this point 3 major rivers carry the Niger's water during the flood season. The Issa Ber constitutes the main river, draining more than 80% of the annual volume. With about 10% of the annual volume, the Bara Issa is a smaller river, while the Koli Koli drains less than 5% of the annual volume. Just upstream of Diré, these rivers converge. Apart from these main water courses, there are a multitude of secondary rivers and streams diverting water to or draining water from different lakes and plains.

The Niger River and its main tributaries (Sankarani, Bani) upstream of the Inland Delta have witnessed an average annual discharge of 1704 m^3/s during the period 1952-1999, or about 54 billion m^3. A maximum value of 2704 m^3/s or 85 billion m^3 was observed in 1967 and a minimum value of 706 m^3/s or 22 billion m^3 in 1984.

The average annual discharge of the Niger River at Diré at the exit of the Delta is 926 m^3/s for the same time period, which amounts to 29.2 billion m^3. The maximum and minimum values were observed to be 1070 m^3/s (33.7 billion m^3) and 462 m^3/s (14.6 billion m^3), respectively.



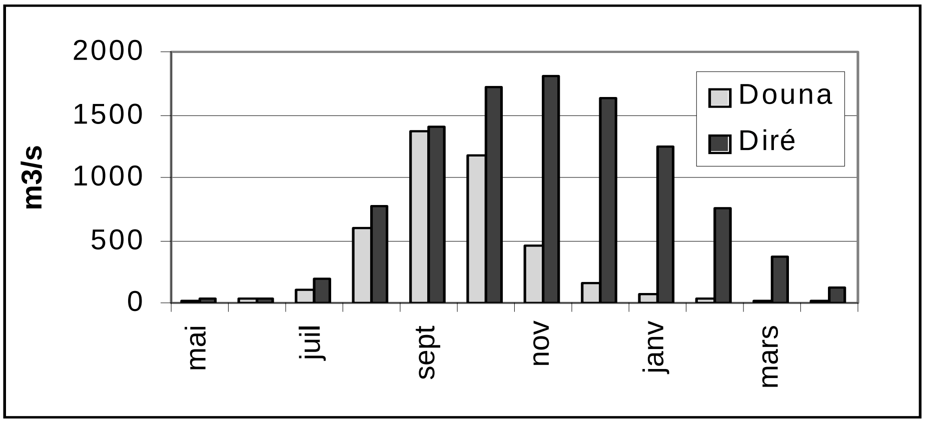


Figure 2: Average monthly discharges at the main measuring stations of the Niger River in Mali

On average about 25 billion m^3 of water is consumed in the Niger River Inland Delta. Part of this water infiltrates or evaporates from the water surface, but a large part of it contributes to the yearly reconstitution of the grazing grounds for several millions of cows, sheep and goats and the cultivation of rice, millet and sorgho.

The extent of the annual floods ranges since 1950 with a factor 1 to 5. In very dry years like 1984, only 3,600 km^2 is inundated, while in wet years this exceeds 20,000 km^2.

- Soils

Hydro-morph soils, linked to the frequent inundations, are found in the lower parts (channel beds, lakes, depressions) of the area. The soils in these parts are silty and clayey alluvial deposits, reducing the infiltration. Makaske (1998) indicates that the sedimentation rate of the upper Delta is relatively low - about 0.25-0.54 mm/year – due to the slow rise of water in the area. The author ads that the deposits are characterized by a very low organic matter content. The Eolian dune deposits can be found especially in the “Erg de Niafounké”. These sandy soils contain a considerable clay fraction.

1.2.2 Land and water use patterns

- Land-use in flood prone areas

(map depicting types of land-use - homesteads, industrial works, infrastructure, agricultural lands, etc.)

The Niger River Inland Delta is inhabited by about 1 million people. Its main towns are Mopti (75,000 inhabitants), Ké-Macina, Ténenkou, Sofara, Djenné, Youvarou, Korientzé, Niafounké, Tonka, Diré and Timbuktu. However, its main land uses are rural and the Delta represents one of the major producing areas of the country. The three main production systems relate to livestock, agriculture and fisheries.

About 2 million cows stay every year for almost 8 months in the Delta (and as much sheep and goats), in quest of the grazing lands provided by the annual inundations. Three qualities of pasture of interest to **livestock** are identified for the inundated areas according to vegetation types : (1) Vetiverae (about 40% of the inundated area), (2) Oryzae (20%), (3) Bourgou (*Echinochloa stagnina*, *Vossia cuspidate*, 10% of the inundated area). The carrying capacity is not the same for the different vegetation types: bourgou has a capacity almost five times higher than the vegetation of the exondated area.

The **agricultural production** is mainly concerned with rice, millet, sorgho, wheat and horticulture. Different production systems can be distinguished:

- Deepwater rice (*Oryza glaberrima*) covers during wet years an area of about a 100,000 ha in the natural flood plains of the area. Yields are modest, generally below 1 ton/ha.
- Deepwater rice is equally grown in the polders developed by the government on an area of about 30,000 ha. The advantage of the polders is that the dikes protect the crops from quick rises in water level and that water can be maintained in the fields even after the recession of the floods. However, yields have not improved much.
- Irrigated agriculture is practiced in the large-scale "Office du Niger" irrigation scheme (75,000 ha), diverting water at the Markala dam upstream of the Delta and in the small-scale village schemes using motor pumps (about 20,000 ha in the Delta). Yields can go up to 6-7 tons/ha for rice. In addition, horticulture (onions, tomatoes) is possible during the cool season.
- Recession agriculture using the soil moisture occasioned by the river floods on its banks is mainly concerned with sorgho, millet and horticulture.

Fisheries constitute an important source of revenue for the inhabitants of the Delta and contribute 4.2 % to Mali's GDP. Its annual production varies between 45,000 to 100,000 tons. The extent of the floods determine how well the reproduction and growth of the juveniles and adult fish takes place. Fishermen concentrate their efforts after the peak of the floods when the quantity of fish is at its maximum and it becomes easier to catch these fish with the recession of the floods.

- Changes in land-use in flood prone areas over the last 30 years

The hydrological regime, the dynamics of the natural resources and the human activities (fisheries, agriculture, livestock) are closely associated. The production of natural resources is sometimes linearly related to the extent of the floods. This makes it a rather variable production environment. On the other hand, the ecosystem of the delta is resilient and used to large inter-annual fluctuations in the availability of water resources. Its natural resources have adapted to these fluctuations. After the abundant floods of 1994, for example, the annual fish production tripled. An estimated 100,000 tonnes of fish were captured in the delta, three times the amount of fish captured in 1993, despite the droughts in the 1970's and 1980's. The traditional production systems in this ecosystem take this variability into account and peasants have different strategies to cope. Firstly, they have a great mobility and make use of the resources wherever they are available in this ecosystem. Secondly, families have more than one professional activity, which allows them to select those activities in a given year that are likely to procure them sufficient revenues or food.

During the years of the sahelian droughts, the scarcity of the natural resources have led to several conflicts between the different users. Farmers have constructed small dikes, bunds and channels to lead water to their fields, often obstructing the migration paths of cattle. At present, the bourgou (*Echinochloa stagnina*, *Vossia cuspidata*) is often harvested and transported to urban centres to cater for the cattle kept in these centres, leading at times to speculation and conflicts between rural and urban dwellers.

- Land-use upstream of the flood prone areas

(including changes in land-use patterns over the last 30 years)

Several irrigation schemes have been developed upstream of the Delta, the most important of which is the “Office du Niger”, see table 2. In addition, Mali’s cotton belt, situated in the southern part of the country, covers a large part of the river basin of the Bani (102,000 km^2).

Table 2: Characteristics of the irrigation schemes along the Niger River upstream of the Inland Delta (IWACO, 1996).

Name	*Area (ha)*	*Crops*	*Water requirements*
Opération Haute Vallée du Niger (OHVN)	25,000	Tobacco, rice, cotton	-
Projet de réhabilitation du périmètre de Baguineda (PRB)	3,000	Rice, maize, millet, sorghum, groundnut	10 m^3/s during the season
Office du Riz de Ségou (ORS)	15,000 – 29,000	Rice	5 – 6 l/s/ha
Office du Niger	75,000	Rice, sugarcane, horticulture	2,5 billion m^3/an
Office pour le Développement Rural de Sélingué	1,500	Rice, horticulture, maize, tobacco	3 m^3/s during the season

Several developments threaten the functioning of the Niger river inland delta. Just upstream of the delta a large-scale 67,000 ha irrigation scheme, operated by the Office du Niger, diverts annually about 10 % of the Niger supplies. Currently, there are a number of projects underway to extend the irrigated area by about 13,700 ha in the coming years. In addition, the master plan of the scheme envisages ultimately an irrigation infrastructure for over 250,000 hectares. The governments of Guinea and Mali are also planning the construction of a number of dams on the upstream catchment areas for the generation of hydropower or the development of irrigation schemes. The ecosystem of the Niger River inland delta as well as the traditional farming systems that exploit its natural resources in the flood plains and the lakes (fisheries, agriculture, livestock) depend directly on the extent of the annual river floods. Any extension of the irrigation schemes upstream of the delta or the installation of dams is, therefore, going to have an impact on the ecosystem and thus on the traditional farming systems.

- Utilization of water ways

(include modifications to flow regime - eg. river straightening)

Navigation is especially developed on the reach Koulikoro-Gao (1308 km) during the flood season (July-December). The “Compagnie Malienne de Navigation” (COMANAV) operates several medium-sized boats with an annual trafic estimated at 15,000 passengers and 25,000 tons of goods. In addition, about 75 medium-sized pirogues have a net load capacity of 25-120 tons. Finally, there are a lot of small sized pirogues in the study area; in the beginning of the nineties, an estimated 10 to 15,000 pirogues were present in the delta of which 80% are fishermen’s boats. These pirogues play an important role for the transport of people and goods from the rural villages to the urban centres and in the organisation of the weekly markets in the larger villages of the Delta.

- Utilization of surface water resources

The following table resumes the water consumption of the Niger River in Mali (Kuper et al., 2002). Only agricultural water use is represented, other uses are very minor as compared to these uses. The drinking water provision for Bamako (the biggest city on the Niger River in Mali), for example, is about 3 million m^3 per month.

Diversions	January	February	March	April	May	June	July	August	Sept	Oct	Nov	Dec	Total
Inflow at Koulikoro	568	380	339	368	444	745	1759	4455	8571	7794	3483	1311	30218
Irrigated agriculture													
Sélingué	2,2	3,9	5,0	5,1	2,8	0,5	0,7	1,7	2,9	4,4	2,8	1,5	33,6
Baguinéda	18	18	18	18	18	18	18	18	18	18	18	18	215
Office du Niger	151	151	167	166	200	218	219	235	321	321	254	160	2562
Controlled submersion schemes (ORM, ORS)	0	0	0	0	0	0	0	230	33	56	53	26	398
Traditional deepwater rice	0	0	0	0	0	0	0	979	140	237	225	97	1678
Evaporation Sélingué	65	66	77	54	39	25	13	16	37	53	62	62	569
Total	236	239	267	243	260	262	251	1480	552	689	615	365	5458
Losses as a % of the inflow	**42**	**63**	**79**	**66**	**59**	**35**	**14**	**33**	**6**	**9**	**18**	**28**	**18**

Source : Hydroconsult, 1996 (diversions Sélingué, evaporation) ; SERP, Office du Niger (diversions Markala)

- Utilization of floodwaters

The flood water plays a determinant role in the regeneration of the Delta's natural resources (vegetation, soil fertility, fish etc.), which form the basis of the different production systems, described hithertofore (livestock, agriculture, fisheries). In addition, it makes the navigation on the major rivers and channels possible, thus facilitating the access to the different rural areas.

Upstream of the Delta, part of the flood waters (2,17 billion m^3) are stored during the flood season in the Sélingué dam. This water is used for power generation and irrigated agriculture during the dry season.

2. Description of floods

2.1 Type of flood (eg. seasonal, floods on large rivers - resulting from rainfall, flash floods, urban drainage floods, storm surge flooding, snow melt floods, ice jam flooding, etc.)

The inundations in the Inland Delta follow the hydrograph of the Niger River and its tributaries, occasioned by the monsoon rains in the upper catchment areas in especially Guinea and also in Ivory Coast, Mali-South, Liberia, Sierra Leone and Burkina Faso. The seasonal inundations, from August-September to December-January, are caused by the flat slopes in the Delta area, leading to a large spread of the water.

In the southern part of the Delta, the water is mainly contained in large flood plains (each one of them covering several hundreds of km^2), filled during the flood season and emptying themselves during the recession of the floods. In the northern part of the Delta, the floods mainly inundate the major beds of rivers and channels in between sand dunes. In addition, a number of temporary lakes on the left and on the right bank of the Niger River are filled in case of high floods. The water reaching these lakes is not returned to the river during the recession of the floods due to the presence of some sills.

2.2 Incidence of extreme events and a brief description of historical flood events

The definition of extreme flood events has a double meaning in the study area.

1. *Extremely low floods do not allow a satisfactory extent of the inundated area with adverse effects on the natural resources and the production systems*

These type of flood years have occurred frequently during the sahelian droughts since 1973 with a minimum attained in 1984, when the inundated area covered only 3,600 km2 and the Niger River fell dry downstream of the Delta. These minor floods have serious repercussions on the regeneration of the natural resources (vegetation, fertility, fish etc.), on the environment (flora and fauna), and on the socio-economic activities in the area. Indeed, recession and flood agriculture decreases considerably, while the fish production declines almost linearly with the retreat of the flood extent. Livestock does not find sufficient fodder with the dramatic consequences that we have seen in the various television documentaries at the time.

In addition, the different villages and hamlets of the Delta are difficult to access in case of minor floods and suffer from the provision of first necessity products such as medicines.

2. *Extremely high floods may cause the submergence of deepwater rice and the destruction of habitats*

Exceptional floods occur following exceptionally high discharges in the Niger River and its tributaries. The rainfall regime (quantities, intensities, timing etc.) in the upper catchments determine the timing and the discharge of these rivers. Recent research indicates that the loss of vegetation cover in the upstream catchments is causing a modification in the rainfall-runoff relationships with sharper discharge peaks following more quickly after important rainfall events. This creates some occasional problems in the major cities located along the Niger River upstream of the Delta (Bamako, Ségou).

In case of exceptionally high floods, the seedlings and young rice plants of the *Oryza glaberrima* deepwater rice are submerged in some of the lower lying flood plains and farmers are obliged to abandon the cultivation in fields located in those areas. Some habitats can also be attained in times of high floods, obliging settlers to rebuild their houses. Exceptionally, livestock or more rarely human beings can drown due to these floods.

2.3 Brief description of flood disasters if any (give reasons for classifying the flooding as having taken on "disaster" proportions?)

The highest floods have occurred in 1967 with some of the adverse effects described above. However, it would be difficult to classify the event as disastrous. On the other hand, the minor floods that have occurred, for example in 1984, can be truly qualified as disastrous due to the famine, the dramatic loss of livestock etc.

3. Flood management strategies

3.1 Describe the flood management strategies that exist in your country (please emphasize the strategies that are in place to manage floods within the context of IWRM - i.e. integrated flood management).

- Traditional flood management

The “Dina” of the Peulh leader Sékou Amadou (1818) has codified the exploitation of the natural resources in the Delta, on the basis of which herdsmen, peasants and fishermen share the land and the flood water in time and in space. Fishermen can exploit, for example, the inundated plains when the water is high. After the recession of the water, this land will then be used for pasture. Farmers will try to harvest their rice crops before the arrival of the livestock. These fields are then accessible for the herds. The location of villages, hamlets and temporary camps takes the flood levels into account.

The Inland Delta plays the role of a natural buffer for the populations and countries downstream. Any excessive flood event is levelled off as the excess water is channelled off to the main lakes in the northern part of the Delta. During the dry season it releases part of the water stored in the flood plains to the Niger River, providing drinking water and irrigation supplies to riparian populations in Mali and Niger. This functioning ensures a natural management of exceptional floods liable to cause substantial damage.

- Integrated water resources management

Policies aiming at an integrated water resources management are currently elaborated in Mali in the framework of the National Programme of Rural Infrastructure. However, there exists already a national water policy, which dedicates a chapter to the management and prevention of inundations, water shortage and accidental pollution.

The following measures are envisaged:

- Reinforcement of the hydrological forecasting and early warning system to avoid damage to vulnerable zones, related especially to the effects of flooding and droughts; the system will also allow to determine the role of the main reservoirs for a rational water management for upstream and downstream users,
- Identification and mapping of flood-prone areas and the development of an early warning system for inhabitants of these risk zones,
- The redefinition of the rules in the attribution of habitat construction permits for frequently inundated areas,
- Inciting local communities to construct small-scale hydraulic infrastructure, close to their villages and easy to maintain, for the evacuation of rain water and sewage,
- Mobilising financial resources and training people to flush and maintain sewage systems,
- Anticipate the management of droughts that can be predicted through different measures of economizing water and information campaigns to the populations,
- Permanent observation of the water quality in order to minimise the effects of accidental pollution.

In addition, a number of protection programmes have been defined in the context of the national environmental policy. The water resources management programme is particularly relevant to this case study. Its third objective concerns the protection and the sustainable management of rivers and their catchment areas, including those shared with other countries (international rivers).

The law n° 02-006 of January 31, 2002 related to the Water Code, envisages in its third chapter different measures to fight “undesirable effects” of water. In the second section of this chapter, the problems related to flood management are mentioned and the responsibilities of the government defined.

The decree n° 95-447 institutes a coordination committee for the water and sewerage sector and defines its mission. This committee has mainly an advise function. In addition, the inter-ministerial decision n° 96-1596/PM-MMEH of October 15, 1996 defines the attributions, the composition and the functioning of two relevant committees: the “water management” and the “environment and health” committees. These committees will follow the implementation of national water related programmes and promote the exchange of data and information between different organisations for the benefit of all users.

3.2 Critically examine the efficacy of these strategies

The different reforestation efforts in the upper catchment areas are not explicitly mentioned in the different policies quoted in 3.1, whereas this appears to be an effective way of contributing to flood management. Since the Niger river and its tributaries cover several countries, the flood management would have to be taken up with the different riparian countries of this basin.

3.3 Briefly describe flood mitigation strategies under the following points:

- Structural measures (types, how effective they were, etc.)

The structural measures that can be observed in the Niger River Inland Delta depend on the geo-morphological characteristics of its spatial entities (inundation plains, temporary lakes…) and have either been locally constructed and managed or have been constructed by the government with exogenous material and construction methods. The following constructions for regulating the floods are found:

- Traditional dikes without intake or outtake structure delimit a low-lying area or temporary lake. These dikes are destroyed by the populations after the floods whenever they want to evacuate the water for agriculture. In some cases, dikes are built following the contour lines to allow the planting of specific crops or (improved) varieties. Similar dikes are also constructed by fishermen. They will evacuate the water after the recession of the floods in order to capture the fish.
- Traditional dikes with intake or outtake structure. These local structures have generally been constructed with the help of NGO's and may or may not be effective depending on the level of the floods. Those constructed during the sahelian droughts, for example, may be under-dimensioned for the actual wetter conditions. When correctly designed and constructed these structures help to regulate the inflow and the outflow of flood plains, temporary lakes etc.
- This technique has been implemented at a larger scale for the large schemes of Opération Riz Ségou and Opération Riz Mopti. Large dikes, using Gabion techniques, protect about 30,000 ha of agricultural land for the cultivation of improved varieties of deepwater rice. In years of low floods, these schemes do not receive enough water for their rice crops, which was the case during most of the 1980s. In years of high floods, these dikes protect the land and allow a regular increase of the water level and the maintaining of a sufficient water level. Some of these dikes are also used for the protection of urban areas.
- The development of irrigation schemes (large and small-scale) either through gravity irrigation or through pumping allows the inhabitants of the delta to grow crops independently of the flood levels attained.
- Finally, two reservoirs have been constructed on the Niger River and its tributaries; Sélingué on the Sankarani River stores up to 2,17 billion m^3, which amounts to 30% of the average inflow of this river (1982-1998). However, the stored volume constitutes only 7,6% of the average inflow of the Niger River at Koulikoro and thus does not play a very effective role in the flood management of the Niger River. However, it does play an important role during low water, sustaining the discharge at Koulikoro at an average of 100 m^3/s. The management of the Sélingué reservoir needs to take several uses into account: power generation, water for irrigated agriculture, navigation, drinking water for riparian populations, environmental needs etc. Markala on the Niger River just downstream of Ségou, serves to maintain a relatively constant water level in order to divert water to the Office du Niger irrigation schemes. It does not store a significant amount of water and does not contribute to the flood management of the Niger River.

- Non-structural measures (types, how effective they were, etc.)

The non-structural measures relate mainly to the forecasting and early-warning system. Two types of systems can be distinguished:

- Traditional forecasting systems based on climatic and biological indicators. The strength and direction of winds, the timely appearance of migrating birds, the flowering of herbs, the proliferation of insects etc. allow the local population to anticipate the yearly flood season.

- Hydro-meteorological analyses have largely improved and allow a reliable forecasting of floods. These methods have been introduced in West-Africa since 1998 through a multi-partite collaboration (ACMAD, ABN, CBLT) in the context of the PRESAO programme (Seasonal forecasting in West Africa). PRESAO will shortly be institutionalised.

- Relative importance of both types of measures

The structural measures are efficient in ensuring to a certain extent the agricultural production, but are not always adapted to the highly variable hydro-climatic conditions of the Delta. Indeed, the local populations have always maintained a high degree of spatial mobility, in addition to annually reconstructed local low-cost infrastructure. Improving the design and concepts of this infrastructure constitutes a big challenge for the rural development of this area. Local forecasting techniques help the local populations in selecting the production sites and constructing the temporary infrastructure. When the new forecasting and early warning techniques will be reliable and the local populations will have access to this information, this may constitute an important breakthrough in preparing the different stakeholders in preparing their production seasons and protecting their habitat.

3.4 Briefly describe modifications to flood mitigation strategies following extreme flood events under the following points:

- Changes made to existing structural and non-structural measures
- New flood mitigation measures adopted (distinguish between structural and non-structural)
- Changes in the relative importance of both types of measures

During the extremely limited floods in the 1970s and the 1980s, a number of hydraulic structures were not operational in the Delta. Conceived for average hydrological conditions, water did not even reach the polders that were supposed to regulate the inflow-outflow and to protect the agricultural systems. In a reaction to that, small-scale irrigation systems were largely promoted in the Delta, and up to 20,000 ha of village schemes are now functional.

The management of the existing reservoir of the Sélingué dam can only partly contribute to flood management given its limited capacity as compared to the annual inflow. However, it provides water for different socio-economic uses during low water. In addition, more attention is now given to the environmental aspects. The Niger River Inland Delta is, for example, recognised by the international Ramsar convention of 1971 relative to the protection and management of wetlands.

The droughts but also the relative abundant floods of the middle and late nineties have brought about an increasing demand for information from the administration as well as the populations regarding flood forecasting and an early warning system. It is expected that shortly these systems can be made operational for the Delta.

4. Flood and water management instruments

4.1 What are the mechanisms in place for information/data collection and exchange

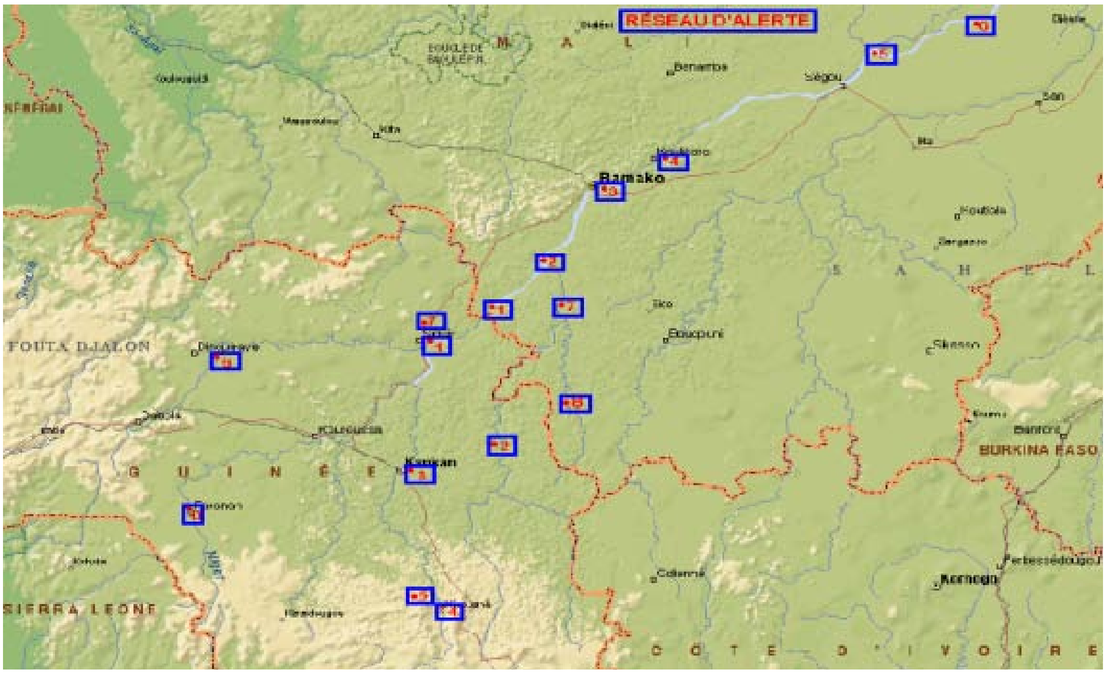
The information/data collection of surface waters is carried out by the National Hydraulic Administration (DNH-Direction Nationale de l'Hydraulique) in close collaboration with its regional antenna (Mopti and Timbuktu, for example). In order to do this, the DNH manages the national network of hydrological stations (see annex 1), constituted of 90 stations on the Niger and Senegal Rivers. The oldest station is Kayes on the Senegal River, observations started in 1903. Daily water level readings are taken by observers. The transmission of data is done by radio or telephone to the DNH in the capital, Bamako.

All stations are composed of a series of gauges, installed at different levels. 24 stations are equipped with a telemetry system through the HydroNiger project. However, this equipment is not operational for several stations, due to its age. The hydro-ecological project on the upper part of the Niger River (Ghenis) installed 8 automatic stations MeteoSat, of which 6 replaced HydroNiger equipment. These stations allow the measurement of the water levels, the electronic conductivity, the turbidity, dissolved oxygen and the water temperature. It constitutes an early warning system for floods and pollution in the upper Niger River basin. Their location is indicated in table 3.

Table 3: Location and justification of the choice of the measurements points on the Upper Niger River Basin – early warning system.

	Location	Longitude	Latitude	Justification
RSM 01	**Kémacina** (Macina downstream)	5.350527778	13.9595278	Agricultural & domestic pollution, early warning system
RSM 06	**Markala** (reservoir)	6.080722222	13.669	Diversion point, early warning system
RSM 14	**Koulikoro quai**	7.556166667	12.8647222	Downstream of the HUICOMA factory
RSM 18	**Bamako 2** (Barrage des Aigrettes)	7.957333333	12.6431111	Industrial pollution (ITEMA)
RSM 25	**Kéniéroba**	8.335444444	12.0914444	Orpaillage ?
RSM 27	**Banankoro** (at gauge station)	8.665305556	11.6889722	Control point after the border with Guinea
RSM 28	**Sélingué** downstream of the irrigation system	8.201916667	11.7252222	Agricultural pollution, early warning system
RSM 33	**Djibenda**	7.957341667	12.6431111	Gold mine of Kalana, early warning system

The locations of these stations are also indicated on map 2.



Map 2: Location of the early warning system, project Ghenis.

4.2 Describe the allocation and use of resources for integrated flood management

The annual operating budget of the DNH is 20 million F CFA (30,000 €). A very small part of this amount goes to increasing the knowledge of Mali's water resources. This budget is increased by a special investment allocation of 650 million F CFS (about 1 million €) put in place in the context of the PPTE of the World Bank for the period 2003-2005.

There is an on-going debate to finance the observation and knowledge of Mali's water resources through the IWRM programme financed by the World Bank through the National Rural Infrastructure Programme (PNIR) and through water taxes in this context.

4.3 Describe mechanisms in place for the effective use of floodwaters and floodplains

These mechanisms are based on the traditional farming systems (livestock, flood & recession agriculture, fisheries) and have been in place for centuries. The use of water and land is managed through an access to these resources in time for different uses. Inundation plains may be exploited by fishermen during the floods, taken over by farmers and herdsmen upon recession of the water.

These traditional systems have evolved over time and adapt relatively quickly to outside events. Fishermen, for example, have equipped their traditional pirogues with outboard motors, and farmers have largely adopted the plough.

Different hydraulic equipment (dikes, intake-outtake structures) has been put into place to better control the floods for the traditional production systems.

Some equipment has been installed for navigation during the flood season (quay, buoy), navigation channels have been deepened, while the use of small draught boats are privileged.

4.4 Describe efficacy of law enforcement mechanisms, incentives and sanctions (eg. related to the location of activities in "off-limit" frequently inundated areas and flood defence works such as bunds)

In the Niger River Inland Delta, traditional customs and rules, some of which have been codified in the Dina of 1818 by Sékou Amadou, are governing the life and production activities of its inhabitants. In addition, there are state laws and rules concerning the protection, the use, the development and the conservation of water resources, instituted by the law n° 90-17 AN-RM of February 27, 1990. This law defines water as state property and indicates that individuals, local administrations and public and private enterprises cannot purchase the right to use water resources. However, this law recognises and guarantees the customary rights to use "public" water. The law further defines the standards for surface and groundwater intake, the measures to guarantee maintaining the water quality and the standards for hydraulic infrastructure. The application texts and the water code are being elaborated at this moment. This is particularly challenging in the context of the decentralisation process that is on-going in Mali.

The halieutic resources are governed by the law n° 95-032, which defines the general conditions for the conservation, the protection and the exploitation of these resources. The responsibilities for the management of these resources are shared between the state, the local administrations and the private sector.

In practice, the different stakeholders are juggling between customary rules and state law. While the fishermen have to obtain a fishing permit from the government, it is the local "water master" (maître des eaux) who determines the opening and closure of the fishing season in the different landscape entities (inundation plains, river, lakes) and the type of fishing gear that can be used. The protection and conservation of fish resources play a certain role in his decision-making. Judges posted in the rural towns often refer their cases back to the customary dignitaries.

5. Policy

5.1 Briefly describe policies (if any) on water resources management, flood management, land management, development planning and disaster prevention and response.

The laws and regulations related to the management, development and planning of water resources are recorded in the following texts:

a) The national water policy

This policy has been defined in the Master Plan on the uses of water resources, approved in February 1991. This Master Plan aims through the exploitation of water resources to improve the food security, living conditions, environmental protection, and the regional integration with neighbouring countries (Uemoa, Cdeao).

The general objectives of this policy are:

- To satisfy the needs of the populations as regards drinking water and sewerage;
- To satisfy the water needs of the following sectors: agriculture, livestock, fisheries, navigation, industry and the hydro-power generation;
- The protection and conservation of water resources.

A new national water policy is currently elaborated and will be based on the principles of integrated water resources management.

b) The Code of Decentralised Territorial Communities

Through the promulgation of the law **n°95-034 of April 12, 1995** (modified through the laws N°98-010 of June 15, 1998 and N°98-066 of December 30, 1998), the Code of Decentralised

Territorial Communities transfers to the Communal Councils the supervision of the construction of communal equipment in the field of hydraulics and sewerage.

c) The Water Code

The water code has been promulgated through the law n° 02-006 of January 31, 2002. It is clearly inspired by the objectives of the National Water Policy. It is a legal instrument that covers all aspects of management, territorial planning and development of the national water resources. It defines the principles of a global, sustainable and equilibrated water resources management. The Water Code takes the recent developments related to the decentralization, including the transfer of responsibilities from the state to local communes related to the management of local natural resources.

d) The decree N°02-315/P-RM of June 4, 2002

This decree defines the details of the transfer of competences from the state to Territorial Communes relating to urban and rural hydraulic equipment. The competencies that have been transferred include:

At the level of the Commune

- The elaboration of a communal development plan for urban and rural hydraulic infrastructure of communal interest;
- Implementation and construction of hydraulic infrastructure;
- Control and verification of the official organisations managing the drinking water infrastructure;
- Selection of the operating firm for the management of the drinking water infrastructure.

At the level of the district ("cercle")

- The elaboration of a district development plan of urban and rural hydraulic infrastructure of district interest;
- Implementation and construction of hydraulic infrastructure;

5.2 Were any policy changes made in response to extreme flood events? If so, give reasons for the changes and briefly describe these changes.

None

The recent changes in the Water Code indicate that the flood water management is not only a state responsibility, but may also be (partly) the responsibility of decentralised units such as communes, district councils and regional councils. It is expected that these units react rapidly to extreme flood events and organise a general mobilisation to limit the extent of the damage caused by these floods.

5.3 Do these policy changes reflect the fact that floods should be managed within the context of integrated water resources management?

Legislative texts and rules related to the management of water exist, as was shown in the previous sections, but need to be adapted to provide a more comprehensive and integrated view of the constitution and the uses of water resources. In addition, the on-going process of decentralisation with the creation of communes will modify some of the responsibilities related to water resources management, which needs to be reflected in the laws and regulations.

6. Institutions responsible for flood management

6.1 List all the agencies involved in various aspects of flood management, briefly describe their respective responsibilities, and mention the role of each institution in dealing with extreme flood events.

The decree n° 058/P-RM of February 21, 2000, defines the specific attributions of the different ministries, their different administrations and services as well as the public organisations depending on these ministries.

The Ministry of Rural Development is responsible for the elaboration and implementation of the national policies in the sectors of agriculture and animal production. On the basis of this, this ministry:
- Constructs rural infrastructure (hydraulic structures, small dikes etc.)
- Implements measures to ensure the rational management of the rural territories to save the agro-ecological patrimony.

This ministry has four central services of which three are of interest here:
- The National Administration of Support to the Rural Sector (DNAMR)
- The National Administration for the Area Planning and Rural Infrastructure (DNAER)
- The National Administration for the Regulation and Control of the Rural Development Sector

The DNAMR and the DNAER play an important role in the use of water resources, particularly related to fisheries and pisciculture.

The Ministry of Equipment, Territorial Planning, Environment and Urbanism elaborates and implements national policies in the field of basic infrastructure and collective equipment, territorial planning, the protection of the environment and nature, preservation and improvement of the life style, and urbanism and habitat. The ministry is thus responsible for:
- Ensuring a rational territorial management through the implementation of Master Plans related to the territorial planning and infrastructure at the national, regional and local levels;
- Ensuring the coordination and the implementation of measures in the context of the fight against desertification;
- Defining and implementing measures and means for preventing major natural risks;
- Preventing and curing all types of pollution and nuisances that can affect adversely the health of the populations;
- Elaborating and applying the rules and regulations related to urbanism and construction.

This ministry includes the National Administration for Sewerage and the Control of Nuisances (DNACPN) and the National Administration for the Conservation of Nature (DNCN). Lately, an independent Ministry of Environment has been created.

The Ministry of Industry, Commerce and Transport elaborates and implements national policies in these fields to enlarge and diversify the production basis, to connect and open up the country to the other countries, to rationalise the commercial circuits and improve the economic competitiveness of the country. It is also responsible for the production, the processing and the dissemination of meteorological data. This ministry includes the National Administration of Meteorology (DNM) and the National Administration of fluvial transports.

The Ministry of Territorial Administration and Local Communities elaborates and implements policies aiming at the administrative organisation of its national territory and the development of communes. It ensures the management of the relations between these communes and the state. The National Administration for Local Communities is part of this ministry.

The Ministry of Health Care is in charge of public health matters and the implementation of government policies in the field of populations. In its National Administration for Public Health there is a Division Hygiene and Sewerage. The Ministry is responsible for:
- The extension of the sanitary coverage of the country;
- The promotion of the policy “health for all”;
- The sanitary education of the populations;

- The fight against endemic and other diseases causing problems to public health.

The Ministry of Economy and Finance is in charge of the implementation of the economic, financial and monetary policies of the state. It coordinates economic reform programmes and ensures the coherence of these policies for a continued growth of the national economy and a sustainable development. The National Administration for Planning and that for Statistics and Computer Sciences are part of this ministry. The ministry is responsible for:

- The planning, scheduling and control of economic development policies in the mid and long term;
- The preparation and implementation of financial laws;
- The financial guardianship of local communes;
- The financial control of services and public establishments;
- The application and control of the regulations of public tenders.

The Ministry of the National Domain and Land Property Affairs is in charge of:

- The determination of the public and private goods of the state and the decentralised units such as communes;
- The management of the goods of the domain of the state;
- The control of the management of the goods of the domain of decentralised units and other public entities;
- The acquisition and expropriation of real estate for the state.

The Ministry of Mines, Energy and Water elaborates and implements the national policies related to the development of mineral, energetic and water resources. It is responsible for:

- Elaborating and controlling the application of the regulations related to mines, energy and water;
- Ensuring the development and management of water resources to cover the water needs of the country;
- Undertake studies and works for the development, conservation and protection of surface and groundwater resources with the exception of infrastructure related to irrigated agriculture.

This ministry includes the National Administration for Geology and Mines, the National Administration for Energy, and the National Administration for Hydraulics (DNH). The DNH has decentralised units at the level of the "Région", represented by the Regional Administrations for Hydraulics and Energy.

6.2 Describe the extent to which institutions involved in flood management cooperate with each other (describe cross-sectoral, regional cooperation and international cooperation if any).

Cell for the implementation of the concept of IWRM

A cell for the implementation of the concept of Integrated Water Resources Management (IWRM) has been created by decision N°02-0222/MMEE-SG on May 15, 2002, by the National Administration for Hydraulics (DNH). It has been created in the context of the National Programme for Rural Infrastructure (PNIR) and is included in the part on "support and methodological assistance for an integrated management of resources". The cell is attached to the Division "Inventory of Hydraulic Resources" and will be active during the life of the PNIR programme. The cell is mandated to coordinate and facilitate the process of initiating and following through on the implementation of IWRM in Mali, and more particularly:

- Elaborate in collaboration with all actors and donors action and investment plans for the implementation of IWRM (evaluation of needs and resources; planning, impact studies, protection of resources, prevention of nuisances);
- Facilitate the process of preparation of legislative texts and regulations on the basis of the IWRM concept (institutional framework, transferring competencies, capacity building);

- Promote the concept of financial structures and cost recovery for water management.

The Niger River Basin Agency

This agency has been created by the Ordinance N°02-049/P-RM of March 29, 2002 to safeguard the Niger River. It is responsible for:

- The preservation of the river, its terrestrial and aquatic ecosystems;
- Reinforcing capacities for the management of the river;
- Contributing to the prevention of natural risks (inundation, droughts, erosion), and the fight against pollution and nuisances;
- Conceiving and managing a financial mechanism for the reception of water taxes from users and polluters.

On the coordination between the different national administrations, it is interesting to note the creation of the inter-ministerial coordinating committee for the water sector and the sewerage to reflect the multitude of the administrations responsible for different components of the water resources management. In the past, there has often been duplication between these different administrations, a sectorial approach to water related problems, the dispersion of time and energy, and the wasting of money allocated to this sector.

6.3 Were there perceptible changes in the level of cooperation following extreme flood events?

none

6.4 Is there a central authority that coordinates the activities of the institutions?

The inter-ministerial coordinating committee for the water sector and the sewerage has been created by decree n°95-447/P-RM on December 27, 1995. It is responsible for coordinating the actions of the different institutions involved in water management. Its specific attributions are to:

- Follow the government policies in the field of water and sewerage;
- Provide advice on legislative texts and regulations related to the water and sewerage sector;
- Give a technical opinion on international conventions, protocols and accords in these sectors;
- Provide an annual activity report;
- Suggest corrective measures and adjust strategies and objectives in the short, medium and long term;
- Propose administrative, institutional and financial measures that are likely to ensure a greater effectiveness and better impact of different activities;
- Ensure a coherence between the different national water related programmes.

The committee is constituted by the ministers of the following thematic areas:

- the Ministry in charge of Hydraulics (president)
- the Ministry in charge of planning (vice –president)
- the Ministry in charge of International Cooperation
- the Ministry in charge of Public Health
- the Ministry in charge of Agriculture
- the Ministry in charge of Livestock
- the Ministry in charge of Environment
- the Ministry in charge of Territorial Administration
- the Ministry in charge of Finances
- the Ministry in charge of Industry
- the Ministry in charge of Artisans

The committee has two commissions, composed of the directors or presidents of the technical services of the state, the development services, users organisations involved in the water management.

- the **commission "Water Management"**
- the **commission "Environment and Health".**

The commission on Water Management is mandated to:

- Follow the implementation of programmes exploiting the water resources;
- Promote the exchange of data and information;
- Obtain the views of different actors for a rational water management;
- Provide technical advice or make suggestions on the different water management programmes and verify their coherence;
- Advice the decision makers on the incidence of water management at a national and regional (West Africa) scale.

The commission on **"Environment and Health"** is mandated to:

- Follow the implementation of programmes exploiting the water resources;
- Promote the exchange of data and information on environment and health;
- Ensure the integration of environmental protection activities and the improvement of the life style in water resources related national programmes;
- Appreciate the risks of pollution from natural or technological origin and suggest ways to prevent those;
- Suggest legislative, regulatory, institutional or technical measures that can protect the environment and improve the lifestyle around water resources;
- Give a technical opinion on international conventions, protocols and accords in the sectors of environment and health;
- Advice the decision makers on the incidence of water management at a national and regional (West Africa) scale.

6.5 To what extent are interest groups involved in flood management activities?

Regional and local water councils

Regional and local water councils are mandated to give their opinion on all water related issues that are submitted by the Administration responsible for water resources. They:

- Formulate proposals on the management of water resources of the hydrographic (sub-) basin and groundwater aquifers;
- Formulate proposals for the resolution of all water use related conflicts;
- Propose changes to the Master Plan for the Area Infrastructure Planning and Water Management, ensure its implementation and evaluate its impact at the regional and local levels.

Water (sub-) basin committees

The Water (Sub-)Basin Committees are mandated to guarantee a concerted management of water resources at these levels. They are expected to:

- Formulate proposals on the management of water resources of the hydrographic (sub-) basin and groundwater aquifers;
- Propose changes to the Master Plan for the Area Infrastructure Planning and Water Management, ensure its implementation and evaluate its impact at the regional and local levels.

Village organizations, municipalities

- **The populations** through village organisation, management committees of drinking water supply pumps, water users associations are generally active at the local level and may interact with municipalities, communes etc.

- **The regional and local bodies**
  - **The municipal council** is responsible for the control and reception of works of hydraulic infrastructure, for the local water policies and local sewerage ;
  - The **district council** approves the projects of the municipalities with the help of the regional technical services.
  - The **regional assembly** verifies the coherence of elaborated projects with respect to national programmes.

The private sector

- Consultancy firms, construction companies are often involved in the execution of works related to rural infrastructure.

Development partners (NGOs, donors) are involved in the financing and execution of works related to water resources development. The village irrigation schemes in the Delta, for instance, have relied heavily on NGOs.

7. Lessons learned

What are the main lessons that can be derived with respect to integrated flood management? (Please provide a comparative assessment of which kinds of strategy proved successful and which failed, and give reasons for your analysis).

Bibliography

Breman H. and de Ridder N., 1991. Manuel sur les pâturages des pays sahéliens. Karthala, Paris, 485 pp., maps.

Breuil C. and Quensière J. 1995. *Eléments d'une politique de développement durable des pêches et de la pisciculture au Mali.* Food and Agriculture Organization of the United Nations, Rome, 35 p.

Brunet-Moret Y., Chaperon P., Lamagat J.P., and Molinier M., 1986. *Monographie du Niger*. Collection Monographies Hydrologiques n° 8, ORSTOM, Paris. Volume I – Niger supérieur, 396 p, Volume II – Cuvette lacustre et Niger Moyen, 506 p.

CIPEA-ODEM, 1983. Recherche d'une solution aux problèmes de l'élevage dans le delta intérieur du Niger au Mali. Ministère chargé du Développement rural, Addis-Abeba, Bamako, 5 volumes. Volume I, Les pâturages de la zone d'étude, 54 p. + annexes, Volume II, Le cheptel de la zone d'étude, 193 p., Volume III, Les leyde du delta intérieur du Niger, 390 p., Volume IV, Les unités agro-pastorales, 236 p., Volume V, Rapport de synthèse, 151 p.

Gallais J., 1967. Le delta intérieur du Niger, études de géographie régionale. IFAN-Larose, Dakar-Paris. Two volumes, 621 p.

Hassane A., Kuper M., Orange D., 2000. Influence des aménagements hydrauliques et hydro-agricoles du Niger supérieur sur l'onde de la crue du delta intérieur du Niger au Mali. Sud Sciences et Technologies, 5 : 16-31.

Kuper M., J.P. Tonneau (sc. eds.). 2002. L'Office du Niger, grenier à riz du Mali : succès économiques, transitions culturelles et politiques de développement. Cirad/Karthala, 256 p.

Kuper M., C. Mullon, Y. Poncet, E. Benga. 2003. Integrated modelling of the ecosystem of the Niger river inland delta in Mali. *Ecological Modelling vol 164/1: 83 - 102*.

Makaske B. 1998. Anastomosing rivers, forms, processes and sediments. Netherlands Geographical Studies n° 249, Utrecht, The Netherlands, 287 pp.

Marieu B., Bamba F., Briquet J., Cissé N., Gréard M., Henry des Tureaux T., Mahé G., Mahieux A., Olivry J.-C., Orange D., Picouet C., Sidibé M. and Touré M., 1998. Actualisation des données hydrométriques du fleuve Niger au Mali pour EQUANIS. ORSTOM-DNHE, Bamako, Mali, 82 pp.

Olivry J.C., 1995. Fonctionnement hydrologique de la cuvette lacustre du Niger et essai de modélisation de l'inondation du delta intérieur. In J.C. Olivry and J. Boulègue (Editors), Grands bassins fluviaux périatlantiques : Congo, Niger, Amazone. ORSTOM, Paris, pp. 267-280.

Orange D., Arfi R., Kuper M., Morand P., Poncet Y. (sc. eds.) 2002. Gestion intégrée des ressources naturelles en zones inondables tropicales. Actes du séminaire international, 20-23 juin 2000 à Bamako, Collection Colloques et Séminaires, IRD Éditions, Paris, 987 p.

Quensière J. (Editor), 1994. La pêche dans le delta central du Niger. IER-Orstom-Karthala, Paris. 495 pp., maps.

Annex 1: Location of the hydrological stations on the Niger and Senegal Rivers and their tributaries in Mali

Main stations

N°	Stations	River	Latitude Longitude	Drainage area (km²)	Start year	Published
1	Bamako Zero 316.40m ign	Niger	12°37'N 08°00'W	117000	1949	water levels
2	Banankoro Zero 329.09m ign	Niger	11°41'N 08°40'W	71800	1967	water levels discharge
3	Koulikoro Zero 290.08m ign	Niger	12°52'N 07°35'W	120000	1907	water levels discharge
4	Mopti Zero 260.62m ign	Bani	14°29'N 04°12'W	--	1922	water levels discharge
5	Dire Zero 256.85m ign	Niger	16°16'N 03°23'W	340000	1924	water levels discharge
6	Douna Zero 270.72m ign	Bani	13°13'N 05°54'W	102000	1922	water levels discharge
7	Sélingue Zero 328.85m ign	Sankarani	11°35'N 08°10'W	34200	1964	water levels discharge
8	Bougouni Zero 311.72m ign	Baoulé	11°24'N 07°27'W	15700	1956	water levels discharge
9	Kirango Zero 274.99m ign	Niger	13°43'N 07°03'W	137000	1925	water levels discharge
10	Pankourou Zero 285.34m ign	Bagoé	11°25'N 06°34'W	31800	1956	water levels discharge
11	Gao Zero 245.08m ign	Niger	16°15'N 00°03'W	350000	1947	water levels
12	Ansongo Zero 242.22m ign	Niger	15°40'N 00°30'W	--	1949	water levels discharge
13	Koryoumé Zero 256.19m ign	Niger	16°40'N 03°02'W	342000	1975	water levels discharge
14	Kayes Zero 20.16m ign	Sénégal	14°27'N 11°26'W	157400	1903	water levels discharge
15	Oualia Zero 108.16m ign	Bakoye	13°36'N 10°23'W	84400	1954	water levels discharge
16	Bafing Makana Zero 220.50m ign	Bafing	12°33'N 10°16'W	21700	1954	water levels discharge
17	Daka Saidou Zero 307.13m ign	Bafing	11°57'N 10°37'W	15500	1952	water levels discharge
18	Gourbassy Zero = not known	Falemé	13°23'N 11°38'W	15000	1954	water levels discharge
19	Manantaly upstream Zero 150.53 m ign	Bafing	13°12'N 10°27'W	27800	1986	water levels discharge

NB 1 The 10-daily information bulletin of the DNH reports the water levels and discharges of these 19 stations.
NB 2 ign = Institut National de Géographie (french national geographic institute)

Other stations

N°	Stations	River	Latitude Longitude	Drainage area (km²)	Start year	Published
20	Akka zero 258.38 m ign	Issa Ber	15°24'N 04°14'W	--	1955	water levels discharge
21	Awoye zero = not known	Bara Issa	16°07'N 03°30'W		1990	
22	Bamba zero 253.27 m ign	Niger	17°02'N 01°24'W		1967	water levels discharge
23	Bananso zero = not known	Bafini	10°53'N 06°02'W	7175	1976	water levels discharge
24	Banantou zero = not known	Bagoé	12°28'N 06°34'W	41520	1987	water levels
25	Beneny kegny zero = 265.89 m ign	Bani	13°23'N 04°55'W	116000	1949	water levels discharge
26	Bintagoungou zero = not known	L Faguibine	16°45'N 03°44'W		1976	water levels discharge
27	Bougoubery zero = 257.16 m ign	Bara issa	16°05'N 03°28'W		1954	water levels
28	Bourem Sidey zero = 258.20 m ign	M. de Kondi	16°21'N 03°22'W		1954	water levels discharge
29	Bowara zero = not known	Kobi	11°07'N 06°04'W	280	1976	water levels discharge
30	Daladougou zero = not known	Yamé	14°40'N 04°05'W	5050	1990	water levels
31	Dinso zero = not known	Ouassoulou	10°28'N 08°05'W	830	1953	water levels
32	Dioila zero = 278.42 m ign	Baoulé	12°31'N 06°48'W	32500	1953	water levels discharge
33	Finkolo zero = not known	Farako	11°16'N 05°30'W	745	1976	water levels
34	Fourou zero = not known	Bagoé	10°43'N 06°13'W	9800	1975	water levels discharge
35	Gouala zero =not known	Sankarani	11°58'N 08°14'W	-	1953	water levels discharge
36	Goundam zero 253.27 m ign	M. de Goundam	16°25'N 03°39'W		1937	water levels discharge
37	Gourma Rharous zero 253.88m ign	Niger	16°53'N 01°55'W		1954	water levels
38	Kankela zero = not known	Kankelaba	10°49'N 06°40'W	7200	1971	water levels

Other stations

N°	Stations	River	Latitude Longitude	Drainage area (km²)	Début	Published
39	Kara zero =267.16m ign	Diaka	14°10'N 05°01'W		1952	water levels discharge
40	Ke macina zero =268.86m ign	Niger	13°57'N 05°22'W	141000	1952	water levels discharge
41	Kéniéroba zero =324.00m ign	Niger	12°06'N 08°19'W	113000	1953	water levels
42	Klela zero =not known	Lotio	11°41'N 05°35'W	3685	1976	water levels
43	Kokala zero =not known	Baoulé	12°04'N 07°10'W	22125	1971	water levels
44	Kolondiéba zero =not known	Banifing	11°04'N 06°51'W	3050	1971	water levels discharge
45	Konna zero =262.75m ign	Niger	14°55'N 03°53'W		1975	water levels
46	Korientze zero = 257.23m ign	Coli Coli	15°23'N 03°47'W		1959	water levels
47	Korodougou marka zero =not known	Banifing	12°06'N 06°16'W	18200	1971	water levels
48	Kouakourou zero =262.28m ign	Niger	14°13'N 04°30'W	142000	1955	water levels
49	Kouro zero =not known	Banifing	12°01'N 05°41'W	14300	1957	water levels discharge
50	Labbezanga zero =226.63m ign	Niger	14°58'N 00°41'W		1977	water levels
51	Lelehoye zero =not known	Niger	14°32'N 00°30'W	3685	1979	water levels
52	Loulouni zero =not known	Kobafini	10°54'N 05°37'W	762	1976	water levels
53	Madina Diassa zero =not known	Baoule	10°48'N 07°40'W	7900	1971	water levels discharge
54	Manankoro zero =not known	Degou	10°28'N 03°27'W	1640	1975	water levels discharge
55	M'piela zero =not known	Banifing	12°06'N 07°31'W	2950	1990	water levels
56	Nantaka zero =260.78m ign	Niger	14°32'N 04°13'W	282000	1953	water levels
57	Niafunke zero =257.66m ign	Issa Ber	15°56'N 03°59'W		1922	water levels

Other stations

N°	Stations	River	Latitude Longitude	Drainage area (km^2)	Start year	Published
58	Sah zero =258.54m ign	Bara Issa	15°37'N 04°03'W		1976	water levels
59	Sarafere zero =259.01m ign	Bara Issa	15°49'N 03°42'W		1954	water levels discharge
60	Segou zero =278.46m ign	Niger	13°27'N 06°17'W	134000	1945	water levels
61	Sofara zero =262.76m ign	Bani	14°01'N 04°15'W	129000	1952	water levels discharge
62	Tamani zero =282.36m ign	Niger	13°21'N 06°50'W	130000	1952	water levels
63	Tienkongo zero =not known	Bagoé	11°09'N 06°26'W	24800	1971	water levels
64	Tilembeya zero =266.32m ign	Niger	14°00'N 04°59'W		1939	water levels discharge
65	Tindirma zero =257.02m ign	Issa Ber	16°07'N 03°38'W		1955	water levels
66	Tondifarma amont zero =257.29m ign	Issa Ber	16°04'N 03°48'W		1955	water levels
67	Tondifarma aval zero =257.12m ign	Issa Ber	16°05'N 03°48'W		1955	water levels
68	Tondigarmé zero =259.81m ign	lac Fati	16°15'N 03°39'W		1955	water levels
69	Tonka zero =257.62m ign	Issa Ber	16°08'N 03°45'W		1955	water levels discharge
70	Tossaye zero =251.63m ign	Niger	16°56'N 00°35'W	348000	1954	water levels discharge
71	Tyo zero =not known	Bagoe	12°27'N 06°33'W	41470	1971	water levels
72	Zaniéna zero =not known	Dekorobougou	11°15'N 06°25'W	736	1976	water levels discharge
73	Zantiebougou zero =not known	Banifing	11°23'N 07°17'W	1665	1975	water levels discharge

Other stations

N°	Stations	River	Latitude Longitude	Drainage area (km^2)	Start year	Published
74	Ambidedi Zero =17.67m ign	Sénégal	14°35'N 11°47'W	159000	1909	water levels discharge
75	Baoulé Gare Zero =not known	Baoulé	12°53'N 8°38'W	3310	1977	water levels
76	Diangola Zero =not known	Bakoye	12°47'N 09°28'W	12100	1967	water levels
77	Dibia Zero =not known	Bafing	13°14'N 10°48'W	33000	1956	water levels discharge
78	Fadougou zero =119.03m ign	Faleme	12°31'N 11°23'W	9300	1952	water levels discharge
79	Felou zero =23.51m ign	Sénégal	14°21'N 11°21'W	131000	1932	water levels
80	Galougo zero =69.24m ign	Sénégal	13°51'N 11°03'W	126900	1904	water levels discharge
81	Gouina zero =47.60m ign	Sénégal	14°01'N 11°06'W	127000	1956	water levels
82	Kabaté zero =not known	Kolimbine	14°31'N 11°13'W	25000	1968	water levels discharge
83	Mahina zero =89.55m ign	Bafing	13°45'N 10°51'W	37000	1904	water levels
84	Missira zero =not known	Baoule	13°45'N 08°30'W	11400	1969	water levels
85	Moussala zero =not known	Falemé	12°31'N 11°18'W	7420	1968	water levels discharge
86	Nioro du Sahel zero =not known	Fhaka	15°14'N 09°36'W	32	1977	water levels
87	Siramakana zero =23.51m ign	Baoulé	13°34'N 09°53'W	58000	1954	water levels discharge
88	Toukoto zero =161.05m ign	Bakoye	13°27'N 09°53'W	16000	1954	water levels discharge