A&W ECOLOGISCH ONDERZOEK

Ecological aspects of polder development in the Senegal Delta

Section ecology for the Masterplan of the ORIO-project 'Fight against weed pests in the Senegal River Delta'

A&W-rapport 1810

in opdracht van

DHV

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Typha in the Senegal Delta, December 2006 E. Wymenga

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Inhoud

1 Introduction

Senegal river Delta
The Senegal river in Mauritania and Senegal is one of the large river basins in the Sahel, typically with a seasonal flood and a large inter-annual variation in precipitation and consequently river flow. The river is a lifeline to local communities for its natural assets and sources, and plays a pivotal role in communication lines and transport. To enhance the possibilities for irrigation (enlargements of rice production), energy production (hydropower) and navigation two dams have been constructed in the Senegal river in the 1980s, downstream (Diama dam, 1984) and upstream (Manatali dam, 1987). These hydrological structures allow for an artificial management of the river flow. Since the eighties the Senegal delta and river valley have been cultivated, mostly for irrigated rive cultivation. Presently the rice production and sugar cane plantations in the delta are a backbone in the rural economy of Senegal and Mauritania.

Next to the socio-economic assets, the Senegal Delta is rich in natural resources, thanks to the natural dynamics of the river flow and its transport of nutritional elements. The basin is one of the hotspots in the Sahel regarding its biodiversity and hosts international important numbers of migratory waterbirds (Zwarts *et al*. 2009). Two National Parks have been established, namely the Djoudj NP in Senegalese part of the delta (since 1971) and the Diawling NP in the Mauritanian part of the delta (since 1991). These national parks host the major elements of the biodiversity in the Senegal delta.

Cattail problems
The reverse side of the hydrological interventions in the Senegal basin is a fundamental change in the hydrology and consequently ecology of the system. The Diama dam blocks the (former) salt water intrusions form the seaside while the Manatali dam reduces flood dynamics significantly. These less dynamic, often stagnant water level conditions in the lower basin (e.g. the Diama Basin), in combination with the absence of saltwater intrusion, formed a red carpet welcome to invasive plant species, in particular Cattail *Typha dominguensis.* Today more than 30,000 ha of former floodlands in the basin are invested by Cattail. These dense Cattail stands pose serious obstacles and threats to the local communities (habitat for vectors of water born diseases, less or no access to fishing grounds, clogging of waterways etc.) and are a threat to the characteristic biodiversity of the delta.

ORIO-project 'Fight against pest weeds in the Senegal River Basin'
Managing organizations in the Senegal Basin, in particular the OMVS, are dedicated to control Cattail, mostly via manual or artificial removal of stands in water ways and near villages. Also studies have been undertaken to explore the economic exploitability of Cattail. Much focus in this respect has been give to the principle waterways in the water system in the Senegal Basin.

Recently, under the Dutch ORIO-fund, a project has been launched by the OMVS to deal with Cattail on the former floodplains *in* the Diama Basin. The project in case focuses on the transformation of Thypa-stands into polder areas, which provision agricultural services to local communities and support the ecological function of the delta. The ORIO-project includes two phases:

A) Formulation of a Strategic Integral Masterplan covering the Diama basin,
B) Transformation of a number of former perimeters in the Diama basin, into polder areas with new landuse functions, elaborated in a Polder Masterplan.

Masterplan and objectives of this study

In Phase A of the project the Strategic Masterplan (MPA) is developed, covering the Diama Basin between Dagana at the entrance of the Lower Delta upstream and the Diama dam downstream. The general objectives of the Strategic Masterplan are twofold:

1) Scoping the project area by addressing on a global level and per discipline relevant factors which steer the choice of polder transformation,
2) To develop, on the basis of this information, a general strategy for the transformation of typha stands in the Diama Basin, and develop criteria for the selection of polder areas for transformation.

The Strategic Integral Masterplan covers by its integral nature a broad spectrum of relevant socio-economical, ecological and hydrological factors, including river functions and social aspects of the local communities. These factors are clearly interwoven. In the framework of the Strategic Masterplan four options for polder development – on presently Cattail invaded soils - in the Diama Basin are being considered:

- Development of drained polders with agriculture (rice production, vegetables), produced by local farmers
- Development of drained polders with highly productive agriculture (sugar cane, vegetables), produced by co-operations
- Development of polders with a dynamic water management (artificial flooding), with traditional agriculture landuse (fisheries, floating rice, fodder, herding), managed by local communities
- Development of polders with a dynamic water management (artificial flooding), with habitat restoration of natural vegetations (flood forests, floating grass, marshland), with limited ecosystem services to local communities (fish fry, fish production, herding)

The spatial configuration of different types of polder transformation in the Diama Basin is an important part of the Masterplan. In the Masterplan a number of polders will be selected to be transformed in the framework of phase B of the ORIO-project. The choice and motivation – on the level of the Masterplan (phase A) as well as on the level of polders (phase B) - will be based on different criteria, amongst which are the ecological gains and losses. In this study, the ecological aspects of the proposed polder development are presented as input for the Masterplan (an ecological impact assessment is at stake for phase B).

Outline of this study

In this study we provide, as input for the Masterplan, succinct information on:

- Chapter 2. Protection status of areas in the Senegal Basin
- Chapter 3. Ecological values of the Senegal Basin
- Chapter 4. Ecological aspects of polder transformation
- Chapter 5. Ecological criteria for localization of different types of polder transformation
- Chapter 6. Recommendations

2 Protection status of areas in the Senegal Delta

2.1 Legal framework

Both in Senegal and Mauritania there is a legal system of protected areas designated to conserve landscape, habitats, biodiversity and (inter)natural heritage in general.

In Senegal the policy and organization of nature conservation is under ministerial responsibility of the Ministère de L'Ecologie et de la Protection de la nature. The actual implementation reside under the Direction des Parcs nationaux and the Direction des Eaux, Forêts et Chasses et de la conservation des Sols. In Senegal there is a system of National Parks (Parc nationaux), nature reserves (reserves naturelles) and other protected areas, like protected hunting zones and protected forests (forets classées). National Parks have highest protection, which means that hunting is prohibited and every form of exploitation is prohibited or regulated. The legal protection is implemented via code, amongst which are the Code de L'environnement (2001), Code de la chasse et de la protection de la faune (1986) and the Code forestier (1998).

Mauritania has a similar system of legal protection, under ministerial responsibility of the Ministère de L'Environnement et de la Développement durable and carried out by the Direction de la Protection de la Nature. There is a system of National Parks (Parc nationaux), nature reserves (reserves naturelles) and other protected areas (réserves pour la faune, réserves intégrales).

2.2 Protected areas in the Senegal Delta

Figure 1 provides an overview of the Senegal Delta and the protected areas (National Parks, classified forests and reserves). Almost the entire study area is part of the UNESCO Man and Biosphere reserve *Réserve de Biosphère Transfrontière du Delta du Sénégal the Senegal delta (RBTDS)*, commonly declared by the two bordering countries, Senegal and Mauritania, and recognised by the United Nations since 27 june 2005. Biosphere reserves are not themselves protected areas, but regions that may contain protected areas as well as areas where education, research and sustainable economical activity supplement the ecological and cultural diversity. The concepts and ideas behind the RBTDS are further explained in Borrini-Feyerabend & Hamerlynck (2011) .

Within the RBTDS there are three National Parks, Djoudj NP, Diawling NP and PN de Langue de Barbarie. The entire coastline is designated as Marine Protected Area, there are five Classified Forests and three reserves. Important wetlands without formal protection status, apart from the lakes Lac de Guiers and L'Kriz , are the Trois Marigots, Chat Boul and Aftout as Saheli. Especially relevant for this study are those areas that are nearby, and within comparable position in the former floodplain as the Typha areas (*Typha dominguensis* = cattail) under study. These are the Djoudj NP and the Diawling NP and to a certain extent also the Ndiael and the area Trois Marigot (the three elongated and parallel situated basins between Ndiael and Saint Louis). The Trois Marigot area is a hunting site (hunting on lease by the government).

The study area, e.g. the Cattail stands within the Diama basin between Dagana and Diama, overlaps partly with the two National Parks. This is the case in the part of the Diama Basin just north of the barrage (figure 1). These are areas with restrictions related to the use of natural

resources and the realisation of new infrastructure. The Parks are managed by the DPN (Direction Parc Nationaux) in Senegal and the Direction de la Protection de la Nature in Mauretania, in cooperation with local inhabitants. Their protection is formally arranged in several codes, laws and agreements (see before).

The larger part of the Cattail stands in the Diama Basin has no specified protection for conservation purposes as far as not part of the National parks. There is however one exception, the classified forest Ndiao overlaps almost completely with a polder near between Rosso and Richard Toll (sub-area 34 in the Masterplan). The protection of such forests is formally arranged in the Code Forestier.

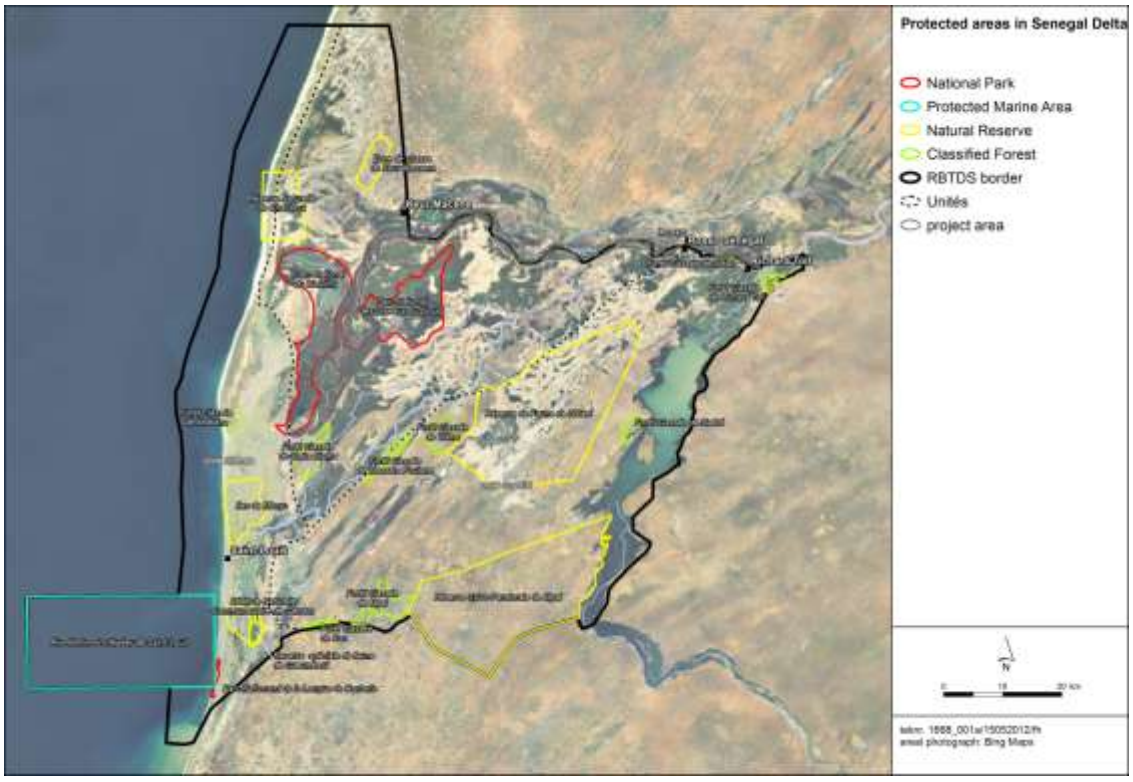


Figure 1. An overview of the project area and the protected areas (National Parks, classified forests and reserves). Sources: Peeters (2003), maps Direction Parc Nationaux (Sénégal), Ch. Diagana (in litt).

3 Ecological values in the Senegal Delta

The Senegal delta is one of four huge Sahelian wetlands, together with the Inner Niger Delta (Mali), Lake Chad and the Sudd (Zwarts et al. 2009). These wetlands used to play a pivotal role in the lives of local communities, offering a rich source of fish, fertile soils for flood recession agriculture and grazing grounds for nomadic pastoralists. All of these wetlands have changed, amongst other due to human impact and climatic variability and so has their use by man. Nonetheless, the Sahelian wetlands still provide extremely important habitat for a host of species, making them globally important areas for conservation. One of the outstanding features is their role as staging area for millions of (Palearctic) birds, migrating between Africa and Europe, with the Senegal Delta being one of the pillars. In this chapter we summarize the current presence of ecological values in the Senegal delta, and in particular we focus on the value of the cattail stand in the Diama Basin.

3.1 Wetland habitats and land use in general

Map 2 provides a global habitat map of the Diama basin between Dagana and Diama dam. The delta consists of a wide array of habitats, including an estuary, artificial floodplains, marshes, lakes, the Diama basin, embanked basins with irrigated agriculture, dried-out saline *sebkha*-like plains and patchy marshland in former tributaries and depressions. These wetland habitats are described in more detail in Zwarts et al (2009) and so is their historical development.

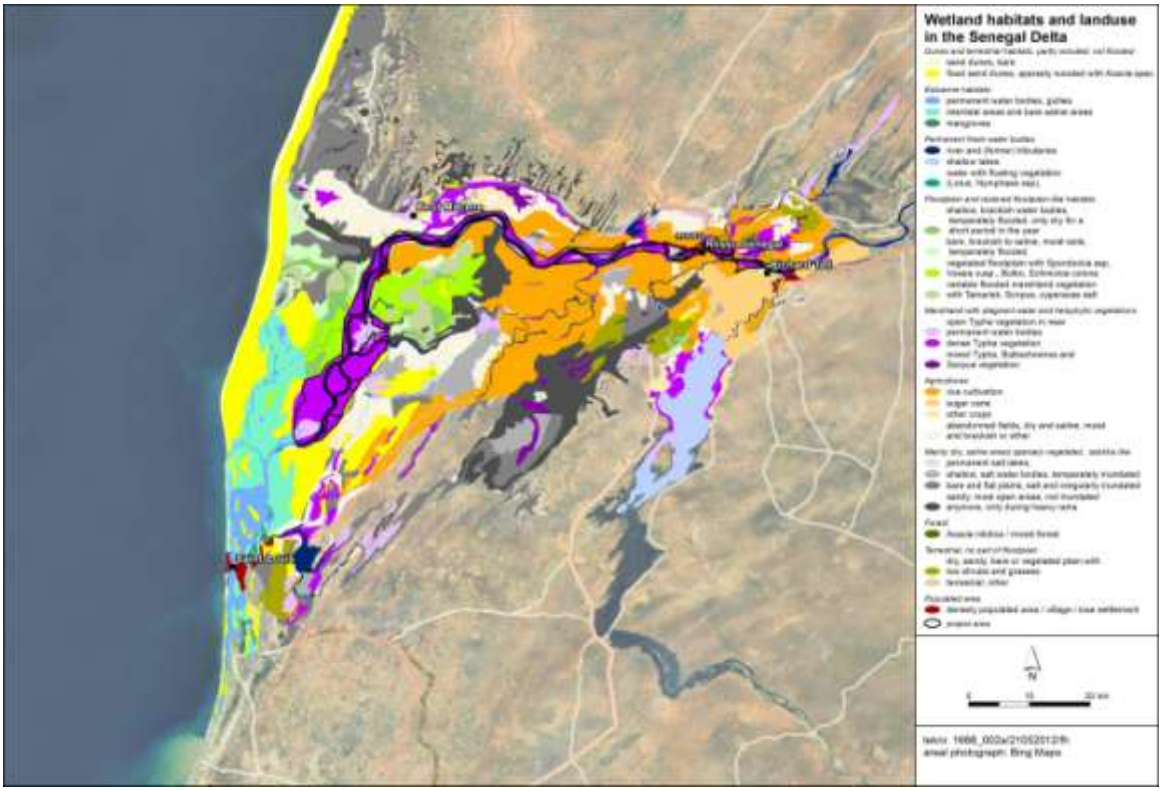


Figure 2. Wetland habitats and land use in the Senegal delta, based on data of the SAED, Wulffraat (1993), Duvail & Hamerlynck (2003), Peeters (2003), satellite images and field observations in 2003-2005 (E. Wymenga unpubl.). Habitats are distinguished on the basis of hydrological features and vegetation communities (from Zwarts et al. 2009). Dense Cattail stand are purple.

Large areas in the delta are under agriculture, dominated by irrigated rice fields but also sugar cane and horticulture. The irrigated cultures are situated in embanked basins. It is important to note that the actual cultivated area is only a part of the potential area for cultivation and fluctuates. A large surface area has been abandoned in the past, especially in the western part of the basin (region Keur Macéne). Proximate causes for this are problems of salinisation and also insufficient labour may have been a factor (SAED 1997; Peeters 2003). Abandoned plots are often saline and arid, but they may regain a wetland character if inundated regularly. When permanently inundated they become overgrown by Typha rapidly.

Floodplains can be bare or vegetated, with herbs and grasses (*Sporobolus* sp., *Vossia cuspidata*, *Scirpus* sp. *Cyperus* sp.). Flood forests are scarce in the delta, although they are typical and valuable habitat. Their existence depends on a proper water management and a sustainable use. Floodplain habitats, and restored floodplain-like habitats are found in the Djoudj and the Diawling NP's. The NP's cover 34.000 ha which is almost 15% of the surface area of the lower delta. The National Parks are subject to artificial flooding, fed by the Diama reserve during the former flooding season. The flood restoration in the two major basins of Diawling NP started in 1994 and is considered a major success. It is one of the rare examples in Africa where the state of the environment has improved over the last decennia (Borrini-Feyerabend & Hamerlynck 2010). Downstream of the Diama dam are the (remainders of) estuarine habitats. With the creation of dam, the estuarine gradient became strongly affected and so did the creation of a new rivermouth south of St. Louis. Artificial flood releases from Diawling NP led to local restoration of this gradient (Hamerlynck & Duvail 2003).

Embanked basins that are not irrigated can still be inundated after exceptionally heavy rains, but have lost their wetland character. They are now arid and saline plains and can for example be found in the east and south of the road from Saint Louis to Richard Toll. There is a huge former inundation zone, the Ndiael. This area is now a dry depression, acting as retention basis for run off water and drainage water from the cultivation north of the road.

3.2 Wetland habitats and land use in the study area

In this study we pay special attention to the Diama Basin since the potential transformation of Cattail stand in the framework of the ORIO-project is aimed at these habitats. The Diama basin mainly consists of marshland with stagnant water and halophytic vegetation, either open dense or mixed Typha vegetation. On the map in figure 2 it stands out as purple artery through the delta, with a width of 1-2 km in the eastern part (running west – east) and 6-8 km in the broader part north of the Diama dam (running north – south). At present, next open water Typha rules this part of the delta. In the Senegal Delta as a whole Typha covers at high density an estimated area of 53.000 ha and is abundant in another 21.600 ha, a total area representing ca. 50% of the delta wetlands.

The study area consists of almost homogeneous Typha habitat in many of the vegetated areas in the western part of the Diama Basin. Some of the old perimeters[1] in the east are not, for example site 31 and 34 (numbers see Masterplan). They are complexes of river dunes with palm trees, shrubs (*Tamarix*), Typha, Reed (*Phragmites australis*) and horticultural areas.

[1] Before the creation of the Diama and the Manatali dam in the early 1980s parts of the floodplains near the River proper were cultivated. These cultivations originate from the period after the embankment of the left bank of the river in the early 1960s (see Zwarts *et al*. 2009). After creation of the Diama Basin parts of these old perimeters became permanently inundated and invested with Cattail. Often, the old structures of dikes can still be recognized in the field or on aerial photographs.

Homogenous Cattail stands on the left bank of the river near Djoudj NP (upper panel), and road (piste) on the dike between the Diama basin (left) and the Djoudj NP (right). Near the dike Tamariks bushes are growing. E. Wymenga, December 2006.

3.3 Ecological values and specific hotspots of biodiversity

The presence of water, and its dynamics, strongly determine the current abundance and diversity of biological organisms, next to the forms of land use in the delta. Waterbirds provide a clear and relevant example. The Senegal delta is world famous for its importance for water-bird population from Eurasia. Most of them are concentrated in the National Parks, because they hold water in the essential period and have suitable vegetation. Detailed information on species of birds and their trends is given in Triplet *et al.* (2010) and Zwarts *et al.* (2009). Artificial flooding in these national parks provided the essential habitat that host these birds, as well as a diverse fauna of insects, shrimp, fish, amphibians, reptiles and mammals.

Arid and saline plains are inhospitable to many species. Areas invaded by Typha also appear of limited value for biodiversity. Dense stands of the invasive plants are assumed to reduce both plant and animal diversity. Peeters (2003) mentions Typha vegetation as feeding habitat for herons, rails and passerines, and as huge roosting sites for Sand Martin and Yellow wagtail. These roosts also occur in the Diama Basin. Typha vegetation may be of substantial importance for a few specialist reed birds (including rails), but otherwise, there are few birds in comparison to other freshwater habitats (Bruinzeel *et al.* 2006; Flade 2008, Flade *et al*. 2010).

Rice fields, especially when wet, constitute and important habitat for wintering birds (e.g. Wymenga & Zwarts 2010). Most bird species however belong to the more common species. In comparison to natural floodplains the rice fields do poor in terms of diversity and numbers. Within the irrigated rice fields, a scattering of pools with Water Lily and Typha provide (temporary) shelter to birds, amphibians, reptiles and mammals.

The Cattail stand in the study area are known to host species as Warthog *Phacochoerus aethiopicus*, python *Python sebae* and Nile monitor lizard *Varanus niloticus*, while for the right bank (zone Diawling NP) also Nile crocodile *Crocodylus niloticus* is reported. In the Senegal river itself incidentally West African manatee *Trichechus senegalensis* (VU) may occur, especially more upstream. Other mammal species like ungulates and primate species may occur more or less rare in the National Parks, but do not frequent the cattail stands in the Diama Basin due to their wet nature. However, an occasional Jackal *Canis aureus* may stroll along the edges.

Bird densities

There is some quantitative information on the value of different habitats for birds. Here, we show the information for migratory birds, since these are the most numerous. The bird data serve as a good proxy for biodiversity in general, at least for the more global scale of the Masterplan.

Typha areas are considered of limited ornithological value, with densities approaching zero birds per ha. Along the edges the densities may be considerable, though (Bruinzeel *et al.* 2006). In wet rice fields the densities of birds may add upp to 8 birds per ha. In the original floodplain habitat the densities may almost double that, along with a greater diversity in species See figure 3 and 4. When areas are left dry bird densities are generally low, and only a limited number of species, for example the Crested Lark, can cope with such conditions. Combined with estimates of available surface of habitat under different scenarios of development, such data can be input for quantitative assessment of effects in phase B of the Masterplan. It also can be used to assess the ecological values of areas under different forms of management (land use, water management). See Chapter 4.

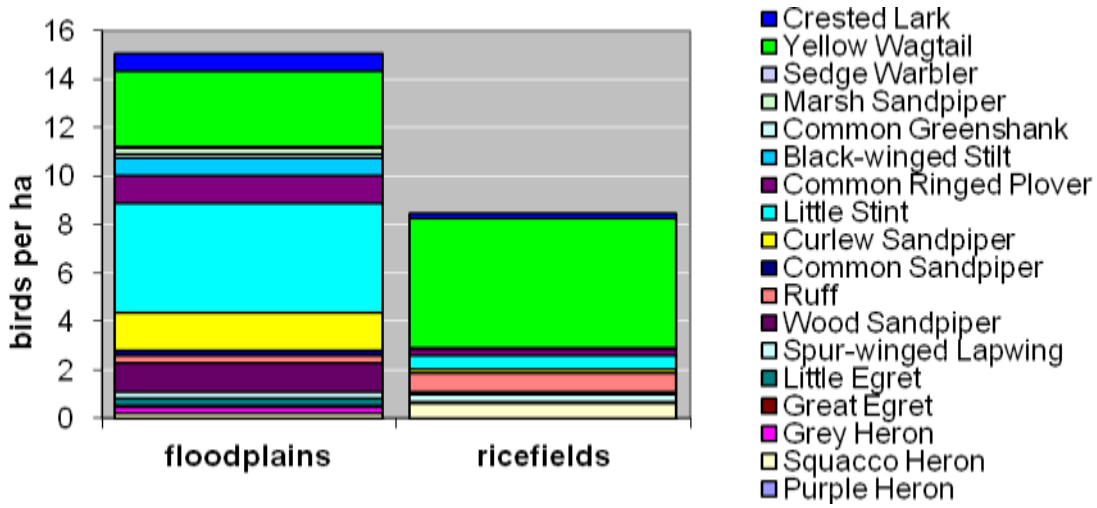


Figure 3. Densities of migratory birds in original floodplain habitat and floodplains converted to rice cultivation (unpublished data).

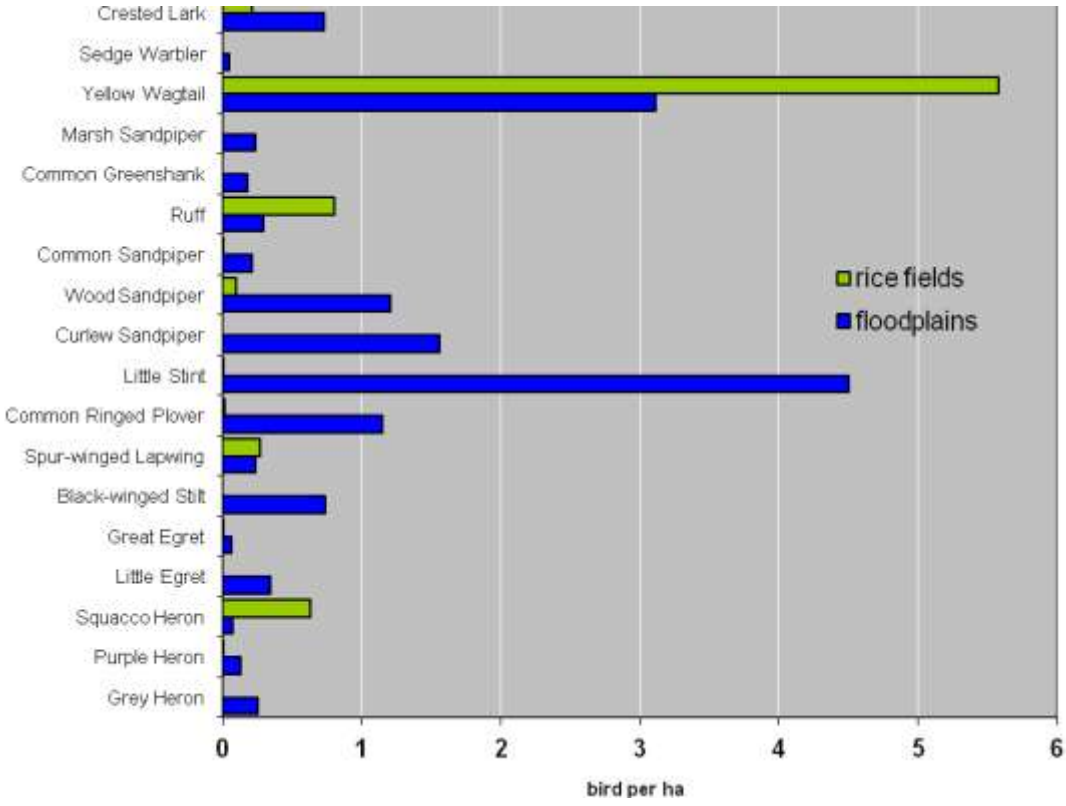


Figure 4. Densities of migratory birds in original floodplain habitat and floodplains converted to rice cultivation (same unpublished data as figure 3).

Ecological hotpots

Clear hotspots are the roosting sites of birds and breeding colonies. Known breeding colonies are given in figure 4 and are largely confined to the protected National Parks. Safe feeding and breeding habitat (mostly flooded forests) are almost a prerequisite for the presence of breeding

colonies. The flood rehabilitation in Djoudj and Diawling has been vital to the preservation of breeding waterbirds in the delta, in combination with the partial recovery of rainfall, protection from poaching and the return of bushes and trees. We do not have recent information on the geographic location of roost sites. Based on observations in 2006-2009 we expect that important roost sites of Yellow wagtail and Sand Martin are located in the region of Ille de Teng, in the broader part of the Diama Basin in hte western part of the Senegal Delta. However, roost location may shift through the season and between years, which makes it necessary to do a field check in the polders which may come under transformation in phase B.

In the study area of the ORIO project, the Diama Basin, no large breeding colonies are found. Smaller breeding colonies may occur near forested parts, as is the case with a small Cattle egret colony on the right bank of the river near Richard Toll. Note that there is a lack of recent field information about this.

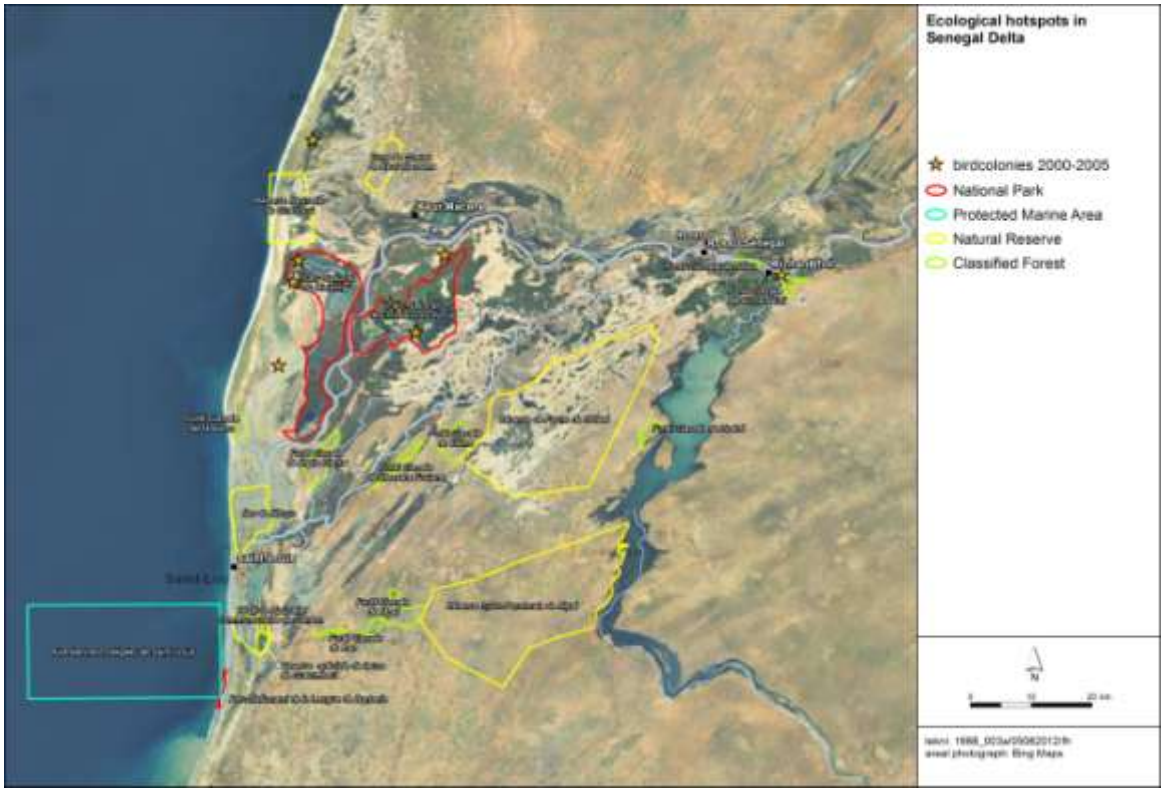


Figure 4. Location of breeding colonies of pelicans, cormorants, herons, egrets, spoonbills and ibises in the Senegal delta in the period 2000-2005 (Zwarts et al 2009), and of breeding colonies in the Diawling NP (data from Diagana et al. 2006). The delineation of the areas subjected to artificial flooding (green) – with concentrates of being ecological values - largely overlaps with the National Parks of Diawling and Djoudj. Note that next to the NP's all seasonal inundated parts in the Senegal Delta are essential to water related biodiversity (for example Ndiael, Trois Marigots etc.).

4 Ecological aspects of polder transformation

4.1. Transformation of Typha stands

In Strategic Integral Masterplan a conceptual framework is developed for the transformation of the Cattail stands in the Diama Basin between Dagana and the dam. In the current ORIO-project it is envisaged to actually implement this transformation in a limited number of areas for budgetary reasons (phase B). Next to the baseline situation – rather homogeneous Typha stands - four options for polder development – on presently Cattail invaded soils - are being considered. In the Strategic Masterplan a global indication is given to where these options would be appropriate. Based on this conceptual framework a selection of areas is made where to implement the transformation in phase B using criteria developed in the next Chapter.

In this Section the four options are briefly sketched in order to assess the general ecological impact of the different options. For the assessment of the actual transformation of selected areas in phase B an ecological impact assessment is needed (being part of a broader Environmental Impact Assessment), based on recent field data from the areas concerned.

In general, the type of habitats that may develop in the target areas, once being transformed into polder, will mainly be determined by the intensity of land use in combination with the water management which is chosen. Polders may either be drained permanently or seasonally flooded, The duration of flooding is an important driver of ecological development and may rise constraints to different types of land use. The interaction between land use and water management is illustrated in Fig. 5. Change in land use from an area dominated by Typha implicates changes in water management and input of labour and possibly input of fertilisers and pesticides. The type of habitat and the resulting ecological values will differ along these lines. The four options considered involve two options without flooding (drained polders) and two options with seasonal flooding; first we describe the initial situation as baseline.

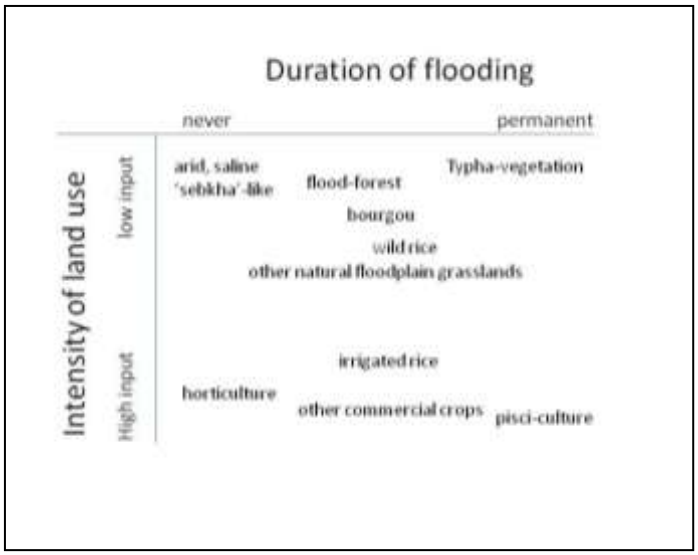


Figure 2 Graphical illustration of the occurrence of wetland vegetation in relation to intensity of land use and water management. Pisci-culture refers to intensive pisci-culture in fish basins. This is in contrast to the functioning of flood-forests and other natural floodplain vegetations as fish – nursery habitat and area for fishing, when flooded.

Cattail – Typha dominguensis – stands in the Diama Basin. Fishermen may still fish in the open parts of the water (left), and sometimes open areas are cut to fish for small fish (right).

Baseline situation – homogeneous Typha stands

The baseline situation can be considered as blank. This concerns rather homogeneous stands of Typha, on the borders – near the dike – often with Reed and Tamarisk bushes. The Typha stand can be very dense, but nearer to the river be more open, possibly related to water depth and wave action. Near the water edge also *Pistia stratiotes* (a pest species in the near past, see Fall *et al*. 2004) and *Nymphaea lotus* may occur. In general the vast stands of Typha in the broader part of the Diama Basin (north of the dam) are very dense and homogeneous. In the easter part of the Diama basin, east to Rosso and Richard Toll the vegetated areas in the Diama Basin are remnants of the heavy meandering river systems before the embankments, and higher levees and banks (sand, sandy clay) may occur. In particular on these higher parts within the Typha stands Tamarisk, Reed and other species are present.

Exploitation of Typha stands is very limited and very large parts of these areas in the Diama basin are not used by local communities. Fishermen may fish along the edges and on a small scale Typha is cut for roof covering. Locally Typha may be cut to open up the area for temporary fishing.

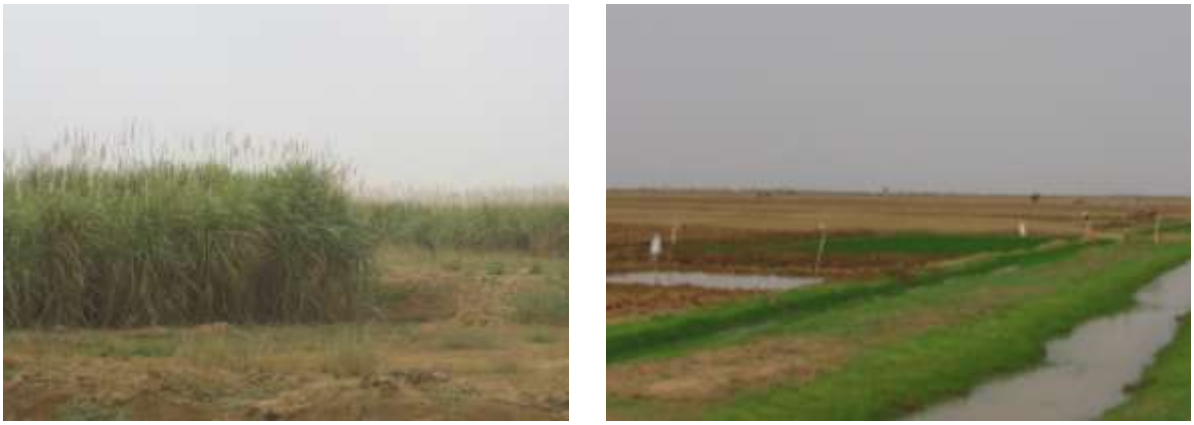
Embankment into drained polders with highly productive agriculture

One of the (potential) options in the framework of the ORIO-project is the transformation of the Typha stands into embanked and permanently drained polders, where highly productive agricultural are being initiated. Such intensive agricultural production systems would then be managed by a dedicated cooperation. Examples are sugar cane plantations, such as found near Richard Toll, or the cultivation of vegetables.

In this option the vegetated areas in the Diama Basin will be embanked and drained, comparable to the current polders in the hinterland. As such, these polders have no relationship anymore with the river system. The landuse of such polders is intensive, throughout a large part of the year. The use of pesticides may be a point of concern, related to (ground and surface) water quality.

Embankment into drained polders with agriculture by local farmers

Comparable to the former option, in this situation the vegetated banks in the Diama Basin will be transformed into polders which are drained throughout the year. Comparable to the rice cultivation in the hinterland, there is no relation with the river system anymore. The agricultural setting in this option is the exploitation by local farmers, chiefly focusing on rice cultivations and partly on vegetables (tomatoes, onions) in a double crop system. The cultivation is less



Sugar Cane south of Richard Toll (left), and sometimes open areas are cut to fish for small fish (right), and rive cultivations (rainy seasons, plant season) in the region of Richard Toll (July 2006).

intensive than the former option, there is more individual variation in landuse and exploitation. Also in terms of exploitation, this option is very comparable to the current rice cultivations in the Senegal Delta.

Polders with artificial flooding and traditional agriculture landuse

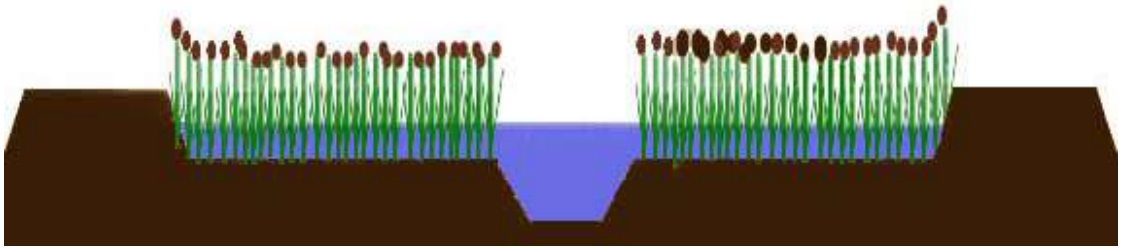
An alternative to embankment into drained polders is the introduction of artificial flooding in polders. This means that the embanked areas will be flooded during the flooding season (October to January, depending on the flood) and dry up in the dry season.

The basic concept of this option, first postulated by Kloff & Pieterse (2000), is that within the embanked areas Typha will be removed completely (burning, mowing, grazing and/or mechanical removal) and on the bare soil a new water management is installed. The water management will then be tuned to a semi-natural flood (Fig. 6), comparable to that in the Djoudj or the Diawling (Hamerlynck & Duvail 2003). This will be done via artificial water level management with resemblance to the annual flood. During the dry season the areas will be completely desiccated, as is the case under natural conditions.

The land use of polders with artificial flooding in this option is aimed at traditional exploitation by local communities. The flooded areas will be important to fish fry, and the polders will create a high potential for (controlled) fisheries. The grassland can be grazed after the flooding, or the grass (namely *Vossia cuspidata, Echinochloa sp.*) may be mowed for fodder. Also floating rice (Riz sauvage) could be grown, as was done in the past and still is practised in other floodplains in the Sahel.

Polders with artificial flooding and habitat restoration into natural habitats

This option is comparable to the former resembling a situation with semi-natural inundations. The main difference is, that in this option in the embanked areas natural habitats are restored. This refers to flooded riverine forests with *Acacia nilotica* and floating grass fields (mainly *Echinocloa longastaminata, E. colona, Vossia cuspidata*). Also the rehabilitation of *Sporobolus*-vegetations may be possible (this has to be investigated). Next to their crucial role for biodiversity these natural habitats offer a series of what we call today *ecosystem services*. Think of nurseries for fisheries, woodland for small-scaled use, grazing grounds etc. The Sporobolus vegetations are important to local communities for traditional handicraft (mats, baskets). The exploitation will be less intensive than in the former option (comparable to the National Parks).



A. Current situation with dense Typha stands in stagnant 1-2 m deep water

B. Construction of dikes around demonstration project (based on old perimeters) and removal of Typha. Manual planting of Acacia nilotica (flood forest) and floating grassland.

C. Introduction of an artificial dynamic flood (resembling natural flooding) with a dry period (January – June) and a flood during July-December.

Fig. 6. Concept of Typha control via artificial flooding in the Diama Basin (adapted after Kloff & Pieterse 2006). This situation may not be fully representative for all parts of the Diama Basin depending on the water level management in the basin and altitude of the embanked areas.

4.2. General ecological impact of polder transformation

The ecological impact of transformation of Typha stands into polders depends on 1) the method, 2) the scale onto which these options are implemented, and 3) the position of the areas in the Senegal Basin. The last aspect is in particular important in relation to the localization of protected areas (Chapter 2).

To get an impression of the ecological impact of the different options (1), in this Section we make a general assessment of the options described in the previous Section. For this we use a set of ecological values and, based on field research and published information, assess the significance of the different options for these values. Apart from data on bird densities, this is a qualitative assessment (for the actual EIA in phase B quantitative data are needed). Both expected negative and positive effects are considered. We look at:

Vast Typha stands in the Diama Basin (upper panel), floating grassland vegetation (Echinochloa longastaminata) and flood forest in the Inner Niger Delta (resp. left and right panel). E. Wymenga.

- Presence of natural habitats: are natural habitats characteristic to the Senegel Delta - flood forests, floating grasslands, Sporobolus marshes and waterlilly fields - restored or present
- (Potential) habitat for vulnerable bird species: To what extent habitat for vulnerable species are being restored. This is in particular relevant to the Aquatic Warbler *Acrocephalus paludicola*, a vulnerable species on the IUCN Red data list.
- Potential function as roost for migratory species: To what extent the areas will serve a function to migratory species, breeding in Eurasia, and which are under threat (Zwarts *et al*. 2009). In particular this is relevant to waders (for example Black-tailed godwit *Limosa limosa*, Ruff *Philomachus pugnax)*, herons (e.g. Purple Heron *Ardea purpurea*) and several passerines.
- Potential function as location for breeding colonies: To what extent the areas will be suitable for the settlement of breeding colonies of African species (herons, ibises, cormorants, spoonbills), typical to the Senegal Delta.
- Bird densities: On the basis of quantitative data the significance of the options for transformation can be compared. Information on bird densities is obtained from Wymenga & Zwarts (2010) and unpublished data of A&W ecological consultants.
- Function as fish habitat: To what extent do the transformed areas offer fish habitat. In particular this refers to spawning areas, fish fry habitat and general habitat for fish communities.
- Habitat for other fauna than birds and fish: To what extent do the transformed areas offer habitat for other ecologically valuable species characteristic to the regional biodiversity. In the Senegal Delta this is relevant in particular for Warthog, Python, Nile monitor lizard and incidentally Nile crocodile.
- Overall contribution to the ecosystem and biodiversity of the RBTS: As explained in Chapter 2, the Senegal Delta is designated as UNESCO Man and Biosphere reserve *Réserve de Biosphère Transfrontière du Delta du Sénégal the Senegal delta (RBTDS)*. To what extent do the transformed areas contribute to the ecosystem and biodiversity

of the RBTIS. Although there is a certain overlap with the other aspects, this refers to the overall image.

The results of the qualitative assessment are presented in Table 1. The Typha stands serve as blank. Their ecological function with the Senegal Delta is limited, although the function as roosts for Sand Martin and Yellow Wagtail is significant. This refers however to only as few selected location, where there is no disturbance. Bird densities are moderate to relative high along the edges (up to c. 49 birds/ha, edges 2-5 m) to almost zero in the interior of dense Typha fields (Fig. 7). Also the margins of the Typha stands may house some species or be of limited significance to fish communities. The overall contribution to the RBTS ecosystem is limited and mainly relies on the function for roosts and habitat for some species of fauna.

The options of embankment and transformation into drained polder with intensive cultures of agriculture or contemporary agriculture by local farmers lack a hydrological connection with the river system (no fish habitat). In particular the intensive form (1) may have a negative impact on the level of the RBTS as the ecological functions of the Typha stands, although limited, disappears in the case of transformation to option 1, and will not be replaced by comparable functions, as is the case in 2. Also in option 1 there is concern about the use of chemicals to maximize agricultural production. Within option 2, which refers in principle to rice fields (or with vegetables as double crop), we expect a function for migratory birds - although limited - as some migratory birds (and also residential birds) may profit from the rice cultures: the bird density assessed in the Senegal Delta in 2005-2006 amounted 7,6 birds per ha. The overall contribution to the RBTS ecosystem is limited in parts of the season, and mainly relies on the function as foraging area for a number of bird species (including migratory species as Pintail, Quail, some raptors as Marsh Harrier, wader species).

Table 1. Qualitative assessment of different option of transformation of Typha stands in the Diama basin, compared to the Typha stand which are dominant in the present situation. The assessment uses the following indicators:

- - negative function for the specified habitat or negative contribution (negative impact)
- no function for the specified habitat (no presence) or no contribution
+ limited function for the specified habitat or limited contribution
++ moderate function for the specified habitat or moderate contribution
+++ strong function for the specified habitat or strong contribution

Ecological aspect / Option	Typha	1 – drained sugar cane	2 – drained rice	3 - flooding	4 - flooding
Presence of natural habitats	-	- -	-	++	+++
Potential habitat for vulnerable species	-	-	-	+	+++
Potential roost for migratory species	+	-	-	+++	+++
Potential habitat for breeding colonies	-	-	-	+	+++
Bird densities per ha	<< 1	<< 1	8	15-19	15-27
Function as fish habitat	+	-	-	+++	+++
Habitat for other fauna than birds and fish	+	-	+	++	+++
Contribution to ecosystem & biodiversity RBTS	+	- -	+	+++	+++

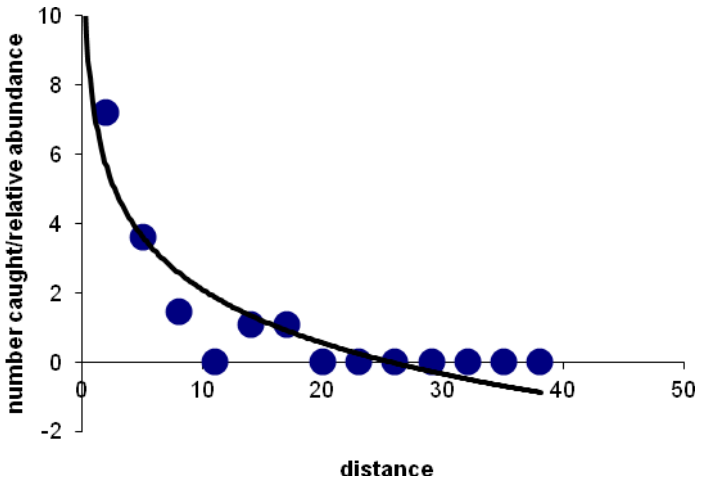


Fig. 7. *Number of African Reed Warblers caught as a function of the distance towards the edge of the* Typha *fields. From Bruinzeel et al. (2006).*

It is obvious that both options which artificial flooding stand out where it comes to ecological values. In option 3 the focus is on floating rice vegetations, bourgou (in this situation *Vossia cusp*. and *Echinochloa sp*.) and water vegetations and open water. They serve most of the ecological functions mentioned, and contribute highly to the RBTS ecosystem and biodiversity. The restoration of natural habitats (option 4) scores highest since one of the focal habitats will be flooded forests, a habitat which is now rather scarce in the Senegal Delta. The bird density in both options is high. For the natural habitats we have only limited data, but densities range between 15-27 birds per ha. During parts of the season, the bird density in flooded forests may even be much higher (for example Zwarts et al. 2009).

The qualitative assessment shows, that transformation via artificial flooding results in a significant ecological gain, but not so for option 1 and 2. For these options with irrigated rice or other commercial crops the contribution to biological diversity depends on the details of implementation. For all of these habitats we can state that any use of pesticides or artificial fertilisers should be considered negative. For option 2 the ultimate results depends on scale and the localisation in the delta; option 1 has an overall negative impact.

Local farmers in rice cultures in the Senegal Delta (July 2005, Jan van der Kamp, A&W).

5 Ecological criteria for selection of options and areas

5.1 Context

In the framework of the Dutch ORIO-project investments will be done in the future development of the Senegal Delta. Next to ecological aspects other functions and needs play a role in this initiative, in particular the social and economical development of the (local) communities in the delta. The basic line of thought is that the transformation of Typha-areas in the Diama basin will be done to the benefit of the delta and local communities. Within the present initiated ORIO-project a limited number of areas will transformed with an emphasis on agricultural development.

The choice of which areas should be (or not be) transformed into polders as well as the selection of options for each of these areas should preferably be based on an integral and sustainable management plan of the entire delta, including a strategic spatial planning. In absence of such a Delta-plan, in phase A of the ORIO-project a Strategic Masterplan is developed for the Diama Basin as a whole, in a selection is made for areas and options. A development in which Typha habitat is converted to another form of land use should be judged on the basis of its contribution to biological diversity, tourism, economical development, agricultural diversification and food security. The spatial allocation of these areas should result from a process of stakeholder consultation (national, regional, local) and applying criteria diverted from the functions and objectives of the Diama Basin and surrounding areas within the Senegal Delta. These subjects are dealt with in the Strategic Masterplan, and or no part of this study, which focuses on the ecological criteria as input for the masterplan.

5.2 Criteria

For the development of ecological criteria for the selection of target areas and transformation options we have to consider the ecological functioning of the Senegal Delta, the position and role of the Diama Basin – the study area – within the delta and the ecological values of the target areas themselves. Next to these aspects we have to consider the expected ecological impact of the different options of transformation, ranging from a strong ecological gain to a negative impact on the ecosystem (Section 4.2, Table 1).

The Senegal Delta is of paramount importance to the biodiversity of the Sahel ecosystem, hosting qualitatively and quantitatively a representative part in this part of Senegal and Mauritania, and is equally so to migratory bird populations breeding in Eurasia. The National Parks and protected areas, designated and installed with a strong international support and today rooted in the Senegalese nature conservation policy, play a pivotal role in the conservation of these ecological values. Hence, the presence of protected areas is an important criterion for selection. As has been shown in Chapter 2, large parts of the Diama Basin in the broad southern part (north of the dam) are part of the National Parks (in particular the right bank). For these parts option 4 (artificial flooding to restore natural habitats) is appropriate while large parts may remain untouched where roosts of migratory birds are presented (to be located in the field). Options 1 and 2 (embankment and draining) are no options for here.

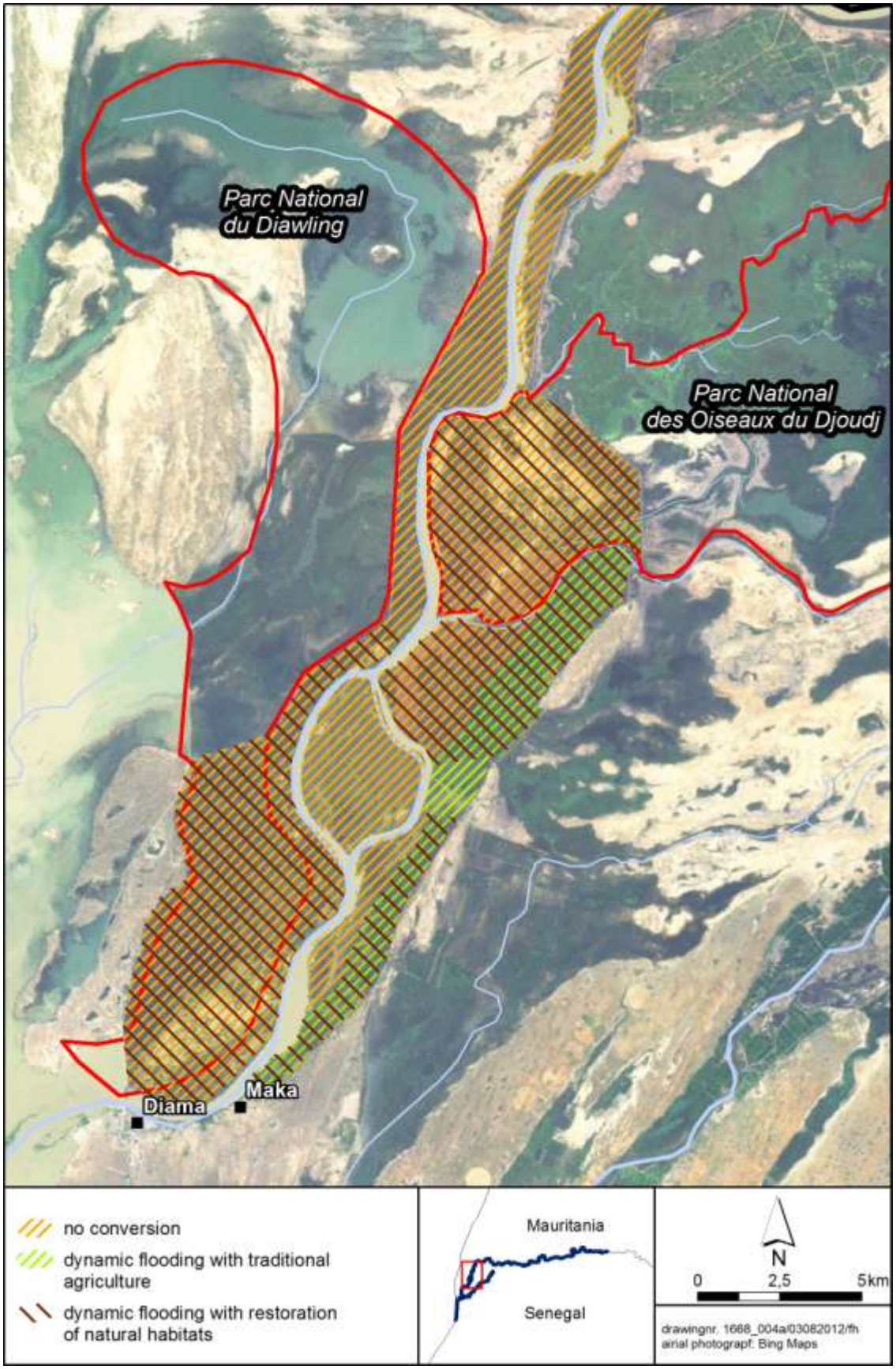


Fig. 7. Possible spatial allocation of Typha transformation in the lower Diama Basin.

When located outside protected areas, the potential impact on protected areas is an important criterion for spatial allocation. This can refer to a negative impact, in particular the case in option 1 and 2 near the National Parks and nature reserves, and a positive impact. Conversion of Typha areas into natural or semi-natural habitats in the peripheral zone of the National parks may contribute significantly to the cohesion and connectivity of both NP´s, and as such contribute strongly to the RBTS. If such developments are being considered, local communities would benefit in particular when option 3 – traditional agricultural land use systems under flooding conditions – would be allocated to areas near the villages (Diama, Maka, Diam Diam III). Fig. 7 shows a possible spatial configuration of different management and transformation options in the southern part of the Diama basin. Partly, there are reasons (roosts, narrow strip, diversity of wetlands habitats within Typha stands) to maintain the present situation. In other parts conversion to polders with artificial flooding and restoration of natural habitats may be a promising option. It goes without saying, that such a development would be designed in narrow conjunction with the local and regional stakeholders, in particular the OMVS, the villages and managers of the National Parks.

From the inventory of protected areas in the Senegal Delta (Fig. 1, Chapter 2), it appears that east of Keur Macéne, thus the less width west–east running part of the Diama Basin, no protected areas are found along the river. There is one exception, being the Foret Classée de Ndiao (see below). The river basin between the dikes is relatively narrow in this section, while in the hinterland on the left and right bank rice cultivations are found, and east of Richard Toll sugar cane plantations. Important villages in this section are Rosso and Richard Toll. The ecological value of this section is found in the presence of natural habitats (limitedly present), which serve as (relatively) safe havens for birds, fauna and other biodiversity. These natural remnants may serve functions as roosts for birds, breeding areas etc. For the impact assessment this means that the target areas must be inventoried in detail in the field. Also, for the selection of target areas and allocation of option, important criteria are the local ecological values.

The Foret Classée de Ndiao, near Richard Toll, is protected under the Code Forestier. These forests are designated to preserve the forests (including soil protection) in Senegal, and any exploitation is prohibited or regulated. It is stated in this code, that any actions in such forest should be consulted with the Service des Eaux et Forets. As far as can be seen on satellite images, the area within the dikes (thus bordering the river) is intersected by a higher sandy levee which is partly forested. Also local exploitation is present here. This occupation pattern is relevant for more areas along the river in this section. Option 1 (intensive agriculture) is not feasible and possible in these areas; a choice for option 2 asks for a detailed design adapted to the local situation (and see below); both option 3 and 4 would be possible.

On a larger scale the natural habitats in this section are essential elements for the longitudinal connectivity of the river system. The Senegal river in the Sahelian environment is crucial ecological structure, connecting the hinterland in Mauritania, Mali and Senegal to the coast. For a variety of species, amongst which are threatened, near – threatened and vulnerable species – especially those related to wetland habitats - this longitudinal connectivity is a lifeline for the maintenance of viable populations. Think for example of Manatee, Monitor Lizzard and small mammal species. An optimal longitudinal connectivity means that there are no impassable bottlenecks for species migrating along the rivers' edge, and there are sufficient safe stepping stones for shelter. This means that at least on one side of the river natural habitat is found on an significant surface area. Significant could be translated in terms of function as shelter habitat, breeding habitat etc., but the minimal habitat requirements imply that fauna is not disturbed on these stepping stones.

The conversion of Typha areas along the river's axe, in particular in this section, must be considered in this context. Conversion into polders with a strong ecological gain (option 3 and 4) may strengthen the longitudinal connectivity, acting as stepping stones. On the other hand, the conversion into permanent polders without flooding may pose bottlenecks in the longitudinal connectivity. This depends on the scale, the detailed design of the polders (are there areas reserved within the polders with an ecological function?) and the surrounding environments (villages, intensive farming like sugar cane plantations).

Near villages it would be more appropriate to opt for an emphasis on agricultural development, either option 2 (no flooding) or 3 (flooding with traditional agriculture). Intensive agriculture will have a negative impact in all situations. Development of high ecological values (option 4) near villages may induce an ecological sink, and is more appropriate in areas with less disturbance. The criteria mentioned above are summarized in table 2.

Table 2. Criteria for spatial allocation of target areas and transformation options of Typha areas in the Diama basin. The following indicators are used:

- - - this option is highly unsuitable in relation to this criterion, or has a very negative impact
- - this option is unsuitable in relation to this criterion, or has a negative impact
- this option may be unsuitable or has a negative impact, depending on design and scale
+ this option may be suitable or has a positive impact, depending on design and scale
++ this option is suitable in relation to this criteria, or has a positive impact
+++ this option is very suitable in relation to this criteria, or has a very positive impact

Ecological criterion / Option	0 – Typha	1 - drained	2 - drained	3 - flooding	4 - flooding
Situated in protected areas (NP's, reserves)	- /+	- - -	- - -	++	+++
Impact on protected areas (NP's, reserves)	- /+	- - -	- - -	++	+++
Contribution to the transboundary RBTS	- /+	- - -	- - -	++	+++
Local ecological values (in target areas)	+	- - -	-	++	++
Function in the longitudinal connectivity	+	- - -	-	++	+++
Situated near villages	-	- -	+	+	- /+

Summarising

To summarize, the spatial allocation of different options of transformation of Typha areas in the Diama Basin has to be based on several criteria, amongst which are ecological aspects. This analysis shows, that option 1 (intensive agriculture, for example sugar cane plantation) do not fit within the Diama Basin due to the negative ecological impact on the ecosystem. Option 2 (permanently drained polders managed by local farmers, most rice) is not appropriate for the lower Diama Basin (areas 1-14, see Fig. 8) nor for the middle area (15-28, Fig. 8), as the ecological function of this part runs through the heart of the RBTS, and may influence the National Parks. In the lower Diama Basin option 3 and 4 are appropriate (Fig. 7), although parts of the basin remain preferably untouched. The allocation in this part should be founded with field data on ecological values (roosts, breeding places, wetland habitats).

In the Upper area (areas 29-36), options 2-4 are possible, taking into account that the actual allocation and detailed design should incorporate the longitudinal ecological connectivity and should as well take care of the locale ecological values. For that reason area 29 seems less suitable to develop into option 2.

Fig. 8. For the purpose of the Straegic Masterplan (Royal Haskoning DHV in prep.) the Diama Basin is split into three parts, the lower basin (areas 1-14), the middle basin (areas 15-28) and the upper basin (areas 29-42).

6 Recommendations

In the context of this ecological study, and based on practical experience in this field (Senegal, Mali), the following recommendation seem appropriate to consider in the Strategic Masterplan:

- Involve local communities in the preparation and management of the areas, depending on the objectives and possibilities. These objectives and possibilities may vary in space and time.

- Start with a pilot project. The success of the proposed approach for the control of vast areas of Typha depends for a large part on the acceptance and support of the managing authorities and the local communities. Therefore a large-scale project to start with may not be a fruitful strategy. First of all, small scaled results must be shown in practise to convince the relevant stakeholders that the current step this is a favourable approach, which has potential in a large part of the basin. This also allows for *learning by doing* and optimise the engineering and (hydrological) management of the pilot areas.

- To stimulate the restoration of natural habitats it is recommended to plant *Acacia* woodlands and grasslands directly after removing the Typha stands. Positive experience with planting of flood forests and floating grasslands has been gained in the Inner Niger Delta in Mali.

- Implement a monitoring programme that comprises the management, the hydrology, the abiotic situation and the biodiversity.

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