Altenburg & Wymenga ECOLOGICAL CONSULTANTS

Ecological hotspots in the Upper Niger Basin and Inner Niger Delta

I. Methods and preliminary assessment

A&W-report 2253a

Commissioned by

Wetlands INTERNATIONAL

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Inner Niger Delta, photo: Leo Zwarts

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Content

Summary/Résumé

Summary

Framework and objectives
In 2015 the Dutch-funded BAMGIRE project was launched to support the IWRM-process in the Upper Niger Basin, in particular in Mali and Guinea. IWRM refers to Integrated Water Resources Management in which an integrated approach is taken, accounting for all sectors (economy, energy, environment, ecology, food) and balancing the water need and availability. In the framework of this project, an analysis of ecological hotspots in the Upper Niger Basin and Inner Niger Delta was performed.

The general objective of the hotspot analysis is the identification and mapping of the hotspots of ecosystem services and biodiversity. The study is focussing on two sub basins of the Niger River, in particular the Upper Niger Basin and Inner Niger Delta.

Available methods
The hotspot analysis started with the selection of methods and criteria which are suitable in this context and the preliminary identification of the ecological hotspots in the Inner Niger Delta (high resolution) and the rest of the Upper Niger Basin (low resolution). These are presented in the current report. A separate report provides an overview of existing knowledge on biodiversity and ecosystems in both basins, knowledge gaps and data needs.

Several approaches for defining hotspots are available, overlapping in the criteria used, but also with some clear distinctions. The approaches assume a reasonable amount of sufficient and detailed information on the distribution and abundance of species. 'Important Bird Areas' and 'Critical Sites Networks' focus on bird species, but other approaches add other taxa. The 'Key Biodiversity Areas' recently introduced by the IUCN combine all relevant taxa.

Upper Niger Basin
A map of preliminary hotspots is presented in this report, based on Key Biodiversity Areas and completed with Critical Sites, Important Biodiversity Areas for fish and information of national protected areas (e.g. National Parks, Faunal reserves) with a high biodiversity. The current map is far from complete, as we miss important information on riverine habitats in the basin (floodplains, swamps, gallery forests etc). These areas, with high biodiversity, are found in most of the tributaries of the Niger and Bani, but without up-to-date field information we cannot make a spatial delineation nor prioritize these areas. Priorities in the need for filling knowledge gaps and collect additional data are identified.

Inner Niger Delta
The Inner Niger Delta is a hotspot itself, in many aspects: ecological, for ecosystem services, cultural and socio-economical. A map with preliminary key ecological structures in the Inner Niger Delta is presented, based on Areas with key habitats in the floodplain ecosystem, completed with water bird concentrations, breeding colonies and information on endangered and vulnerable species. It shows the flood forests, foraging zones and bourgou fields at four different flood levels, expressing the strong relationship with the flood extent and maximum flood level. As we added also ecological hotspots already identified on the higher abstraction level (Important Bird Areas), there is overlap with the key structures.

The dry forests are not included in this stage. The northern lakes are included and east of the delta the Reserve des Élephants. For now the Plain de Seri is lacking but needs to be added in a later stage for its significance as breeding area for Black-crowned Crane. The map needs to be completed with dry forests / wooded savannas in the delta (*centre vide, levees*) and the surrounding plains.

Résumé

Cadre et objectifs
En 2015, le projet BAMGIRE, financé dans le cadre du Programme Conjoint d'Appui à la Gestion Intégrée des Ressources en Eau (PCA-GIRE) par l'ambassade du Royaume des Pays-Bas au Mali, a été lancé pour soutenir le processus de gestion intégrée des ressources en eau (GIRE) dans le bassin du Niger, en particulier au Mali et en Guinée. La GIRE se réfère à la gestion intégrée des ressources en eau dans laquelle une approche intégrée est adoptée, tenant compte de tous les secteurs (économie, énergie, environnement, écologie, alimentation) et équilibrant les besoins en eau et la disponibilité de l'eau. Dans le cadre de ce projet, une analyse des points chauds écologiques du bassin supérieur du Niger et du delta intérieur du Niger a été réalisée. L'objectif général est l'identification des points chauds des services écosystémiques et de la biodiversité. L'étude se concentre sur deux sous-bassins du fleuve Niger, en particulier le bassin supérieur du Niger et le delta intérieur du Niger.

Méthodes disponibles
L'analyse des points chauds a commencé par la sélection de méthodes et de critères appropriés dans ce contexte et par l'identification préliminaire des points chauds écologiques dans le delta intérieur du Niger (haute résolution) et le reste du bassin supérieur du Niger (basse résolution). Celles-ci sont présentées dans le présent rapport. Un rapport séparé donne un aperçu des connaissances existantes sur la biodiversité et les écosystèmes dans les deux bassins, les lacunes dans les connaissances et les besoins en données.

Il existe plusieurs approches pour définir les points chauds, qui se chevauchent dans les critères utilisés, mais avec des distinctions claires. Les approches supposent une quantité raisonnable d'informations suffisantes et détaillées sur la répartition et l'abondance des espèces. Les «zones importantes pour les oiseaux» et les «réseaux de sites critiques» se concentrent sur les espèces d'oiseaux, mais d'autres approches en ajoutent d'autres. Les «Zones clés pour la biodiversité» récemment introduites par l'UICN regroupent tous les taxons pertinents.

Haut bassin du Niger
Une carte des points chauds préliminaires est présentée dans ce rapport, basée sur les zones clés de la biodiversité et complétée par les sites critiques, les zones importantes de biodiversité et informations sur les zones protégées nationales (par exemple, parcs nationaux, réserves de faune) présentant une grande biodiversité. La carte actuelle est loin d'être complète, car nous manquons d'informations importantes sur les habitats riverains du bassin (plaines inondables, marécages, galeries forestières, etc.). Ces zones, avec une biodiversité élevée, se trouvent dans la plupart des affluents du Niger et du Bani, mais sans informations de terrain actualisées, nous ne pouvons pas définir de délimitation spatiale ni donner la priorité à ces zones. Les priorités dans la nécessité de combler les lacunes dans les connaissances et de collecter des données supplémentaires sont identifiées.

Delta Intérieur du Niger
Le Delta Intérieur du Niger est un point chaud lui-même, sous de nombreux aspects: écologique, pour les services écosystémiques, culturel et socio-économique. Une carte présentant les structures écologiques clés préliminaires est présentée. Elle est basée sur les zones comprenant des habitats clés dans l'écosystème de la plaine inondable, complétée par les concentrations d'oiseaux d'eau, les colonies nicheurs et des informations sur les espèces menacées et vulnérables. Il montre les forêts inondées, les zones d'alimentation et les habitats de bourgou à quatre niveaux d'inondation différents.

Les forêts sèches ne sont pas incluses dans cette étape. Les lacs du nord sont inclus et à l'est du delta la réserve des éléphants. Pour le moment, la plaine de Seri fait défaut mais doit être ajoutée à un stade ultérieur pour son importance en tant que zone de reproduction pour la Grue à couronne noire. La carte doit être complétée par des forêts sèches / des savanes boisées dans le delta (centre vide, levées) et les plaines environnantes.

1 Introduction

1.1 Framework

Background
As a land-locked country in the Sahel-Sudan zone, the rural development of Mali hinges on the availability of water for the production of cereals, livestock and fish. Rainfall is seasonal, shows a high variation between years and is unpredictable. The demand for food and energy is increasing annually, going along with a growing population. To address these challenges a significant expansion of the irrigation potential is planned as well as the increase of energy production through hydropower. These policies are currently (2015-2017 and years to come) being elaborated. The Malian government initiated the PAPAM-project (*Project d'Accroissement de la Productivité Agricole au Mali*) to stimulate the agricultural production in the country in order to raise food security. Within this framework the PAHA-program (*Étude du Programme d'Aménagement Hydro-agricole de la zone Office du Niger, 2014-2016*) was developed to elaborate the extension of the Office du Niger (ON). The planned extension of ON means a large change in land use in central Mali. In the long run 3300 km^2 would be added to 1200 km^2 being already irrigated. Water availability during the dry season (étiage) will be realised by a dam (Fomi / Moussako) in the Niandan River, one of the main tributaries of the Niger River in Guinea. In the Upper Basin mining (including gold washing) is taking place, with potential impact on water quality and quantity.

The future of the flood-depending ecosystem and economy of the Inner Niger Delta (IND) is one of the focal issues in these near-future developments and the IWRM-process for the Upper Niger Basin. Upstream interventions, resulting in a decreased river flow during the wet season, impact directly on the hydrology (and ecosystem) and indirectly on the economy inside and around the IND. The economy of the IND is of national significance since the IND sustains the livelihoods of 3 mln people, and is a driver of the rural economy of Mali as far as fish production and livestock are considered. Moreover, the IND is one of the largest floodplain systems in Africa with high international ecological values.

The PAHA-process stresses the need for an IWRM-approach in the Upper Niger Basin. IWRM refers to Integrated Water Resources Management in which an integrated approach is taken, accounting for all sectors (economy, energy, environment, ecology, food) and balancing the water need and water availability. Next to information on economy, energy and production of natural resources, it is essential in a proper IWRM-process to have a good understanding of the requirements of the environmental flow, the spatial distribution, quality (state of affairs) and relation with water management of ecological hotspots and the spatial distribution and importance of ecosystem services linked to water management in the Upper Niger Basin. In 2015 the Dutch-funded BAMGIRE project was launched to support and coach the IWRM-process in the Upper Niger Basin. In the framework of this project, an analysis of ecological hotspots in the Upper Niger Basin and Inner Niger Delta is performed. This report (hotspot report I) deals with methods and a preliminary assessment of hotspots. A separate report (hotspot report II) provides an overview of existing knowledge, knowledge gaps and data needs.

BAMGIRE - project
In the framework of the BAMGIRE project (2015-2019), run by WI Mali, a coherent approach is needed to support and coach the implementation of Integrated Water Resources Management in the Upper Niger Basin. BAMGIRE encompasses the support of the political process and provides the science-based background and content to the process. Amongst others, the latter refers to

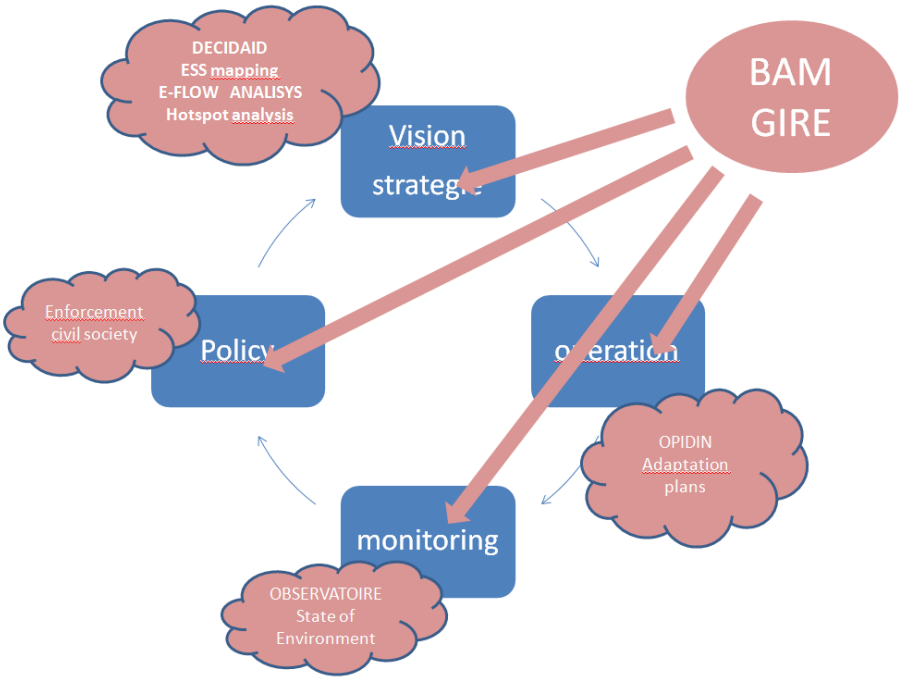

Fig. 1.1. Simplified schematization of the different components of BAMGIRE project, projected on a general management and policy cycle.

the hydrological modelling of the system including a detailed flooding model of the Inner Niger Delta (IND), the setup of an Observatory for the Upper Basin, an ecosystem services mapping of IND, an ecological hotspot analysis of the Upper Niger Basin, and a decision support system for IWRM in the basin (Figure 1.1).

In the project description of the BAMGIRE project (2015-2019) the objectives are formulated as: The overall Goal of the project is "*A living Inner Niger Delta, where livelihoods and biodiversity are secured in a changing environment*". The specific Project Objective is that "Government, decentralized institutions and community actions sustain the flooding regime and natural resources of the Inner Niger Delta so that livelihoods, biodiversity and the economy can adapt to a changing environment".

This Objective is delivered through three Outcomes:

- Outcome 1. By 2019, government, decentralised institutions and communities make better informed decisions about the management of the Upper Niger Basin and Inner Niger Delta, through access to knowledge on the environment and natural resources. This will be achieved through establishing an "Observatoire" of the Upper Basin, an evaluation and mapping of ecosystem services and the publication of a "State of the Environment" report.
- Outcome 2. By 2019, improved water sharing and management secures the flooding regime for food security and ecological integrity in the Guinean and Malian part of the Upper Niger Basin and the Inner Niger Delta. This will be achieved through a better understanding of the hydrological flow requirements, the implementation of a decision support system, the elaboration of relevant development scenarios and enforcement of the participation of the civil community in the water dialogue.

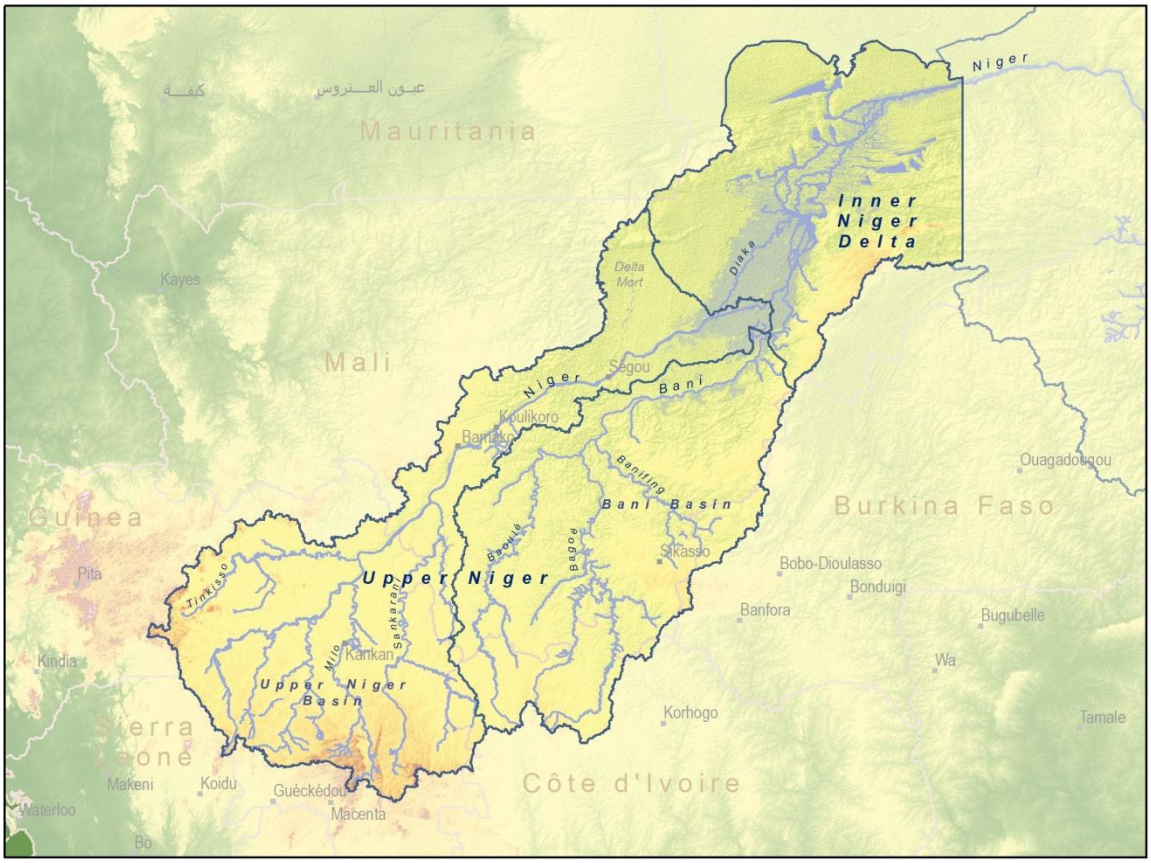

Figure 1.2. Outline of the study area, representing the Upper Niger Basin (shaded green) and the Inner Niger Delta (maximum flooded area in blue).

- Outcome 3. By 2019, community-based climate adaptation plans are developed and implemented for the Inner Niger Delta and ecological hotspot areas in the Upper Niger Basin, and ensures sustainable use/restoration of natural resources and biodiversity conservation.

1.2 Ecological Hotspot Analysis

The assessment and mapping of ecological hotspots is a priority module within the BAMGIRE project. In the Terms of References for the Ecological Hotspot Analysis the objectives are formulated as:

General objective

*The general objective of the overall hotspot analysis as part of BAMGIRE (2015-2019) is that by the end of the project period, the **hotspots of ecosystem services and biodiversity** are **identified** and **mapped**, and priorities are identified for protection and restoration.*

Detailed objectives and study area

The specific objectives of the study are:

- By the end of the study, the mapping of hotspots (locations and areas with a high ecological value) is available and validated by the partners in the Upper Niger Basin and Inner Niger Delta;

- By the end of the study, a database (GIS) is available and populated with data on biodiversity and ecosystem services. This database is known and available as a result of a participatory approach and previous results and output ;
- By the end of the study, a set of criteria for selection of pilot sites in districts in the study area has been developed, and allocated to prioritise ten (10) districts.

The study is focussing on two sub basins of the Niger River, in particular the Upper Niger Basin and Inner Niger Delta (Fig. 2.1.). Given the availability of data and information, the approach of the two basins is as follows:

- For the Inner Niger Delta the analysis and mapping will have a relatively high resolution
- For the Upper Basin the analysis and mapping will have a relatively low resolution

Approach

The hotspot analysis will go through different steps, starting with the selection of methods and criteria which are suitable in this context and the preliminary identification of the ecological hotspots in the Inner Niger Delta (high resolution) and the rest of the Upper Niger Basin (low resolution). This latter is based on an inventory of existing knowledge on biodiversity and ecosystems in both basins; this inventory is dealt with in a separate report. Based on this step it is possible to identify gaps in knowledge and information. Where data and information are lacking, new data are collected, notably in Guinea, and in the Inner Niger Delta, as far as the security situation is allowing field studies.

The next step will be the description and data collection, to gather insight in the quality of the ecological hotspots, the threats (local, regional, global) and the relationship with the water management in the Upper Niger Basin. Final step will be prioritizing of the ecological hotspots for which conservation and restoration measures have to be formulated and implemented. These will be worked out in another module: community based management and adaptations plans for ecological hotspots in the Upper Niger Basin.

The approach leads to the following products (situation end 2017):

I. Methods and preliminary assessment (this report);
II. Inventory of existing data and information (Wymenga *et al*. 2017);
III. Field study ecological hotspots Niger Basin in Guinea (Klop et al. In prep.).
IV. Other outputs to be defined (e.g. monitoring of indicators)

1.3 Objectives and outline of this report

This report (I) is the first step in the process of Ecological Hotspot identification and mapping in the Upper Niger Basin. It builds upon the work which has been done previously by other studies, either on a basin level (Brugiere & Kormos 2009, Thieme *et al.* 2006), the level of the Inner Niger Delta (Wymenga *et al.* 2002, Zwarts *et al.* 2009), or in the framework of the international assessment of important areas for biodiversity (Fishpool & Evans 2001, Birdlife International 2014, IUCN 2016).

For the study reported in this report, the following objectives and outputs were formulated:

- Development of an approach and method for the identification of ecosystems and key biodiversity for the IND and the Upper Niger Basin;
- Identification of criteria for determining ecological hotspots in the IND and the Upper Niger Basin;

- Prepare a preliminary mapping of ecological hotspots in the IND and the Upper Niger Basin for the Observatory and the State of the Delta (*Etat des Lieux*), using existing knowledge;

In a second report (II) the collection of existing data and information on ecological hotspots and ecological values in the IND and the Upper Niger Basin is addressed (Wymenga *et al*. 2017).

Outline of the report

Following these objectives, this report concentrates on the development of a consistent method for the identification and mapping of ecological hotspots in the Upper Niger Basin and in the Inner Niger Delta. In Chapter 2 we reflect on the approaches to indentify on global level important areas for biodiversity, and use this information to develop an appropriate method for the Upper Niger Basin in BAMGIRE (Chapter 3). In particular we pay attention to the inclusion and definition of regional (West Africa) and local (Guinea, Mali) criteria to determine ecological hotspots in the river basin. In the same Chapter we elaborate on the methods for collecting information and analysing the data, and rework the data to map the hotspots in a transparent way.

Chapter 4 and 5 focus on the preliminary ecological hotspots in the Upper Niger Basin and the IND respectively. The underlying data and information is presented in hotspot report II (Wymenga *et al*. 2017), including the state of knowledge, the current knowledge about the spatial distribution, quality (trends), threats, link with water management etc. In this report we summarise the need for additional data and actualisation of data, to better delineate ecological hotspots and to use this information for prioritising hotspot for which conservation and restoration measures have to be worked out. One of the first steps will be to acquire more relevant and recent data from the riverine areas in the upper reaches of the basin in Guinea (report III, Klop *et al*. in prep.).

Monitoring in the Inner Niger Delta, a global hotspot for water bird populations. Photo Leo Zwarts, A&W.

2 Ecological Hotspots: concept and approaches

In this chapter we present different approaches on the definition of hotspots and the criteria used to qualify as a hotspot. Most of the presented approaches are used to define hotspots on a global or continental level, and one study focuses on a regional level. For our study a sub regional level is required, so we address the issue of scale as well.

2.1 The concept of biological hotspots

The concept of biological hotspots dates from the 1980s and 1990s when, based on several international Conventions, the idea surfaced that conservation efforts should focus on areas with outstanding biodiversity or a high concentration of biological values. The concept is rooted in the observation that, all over the globe, biodiversity is subject to a high degradation (habitats, ecosystems) and extinction (species) while the means and willingness to save these areas and species are limited. A conservation approach in which efforts focus on a relative small number of areas - carefully selected on the basis of monitoring and inventories - and harbouring the key sites for biodiversity, would be much more effective than a generic protection system for biodiversity.

Although the approach of national parks, protected hunting reserves and for example Ramsar sites in principal adheres the same principles (concentrations of biodiversity, mostly in the form of wildlife en water birds), the first concrete proposal on ‘ecological hotspots’ was launched by Norman Myers in 1988 (Myers 1988). He first identified ten tropical forests "hotspots" characterized both by exceptional levels of plant endemism and by serious levels of habitat loss, later on extended to Mediterranean-type ecosystems. This idea took hold, amongst others in the NGO Conservation International. In the 1990s an extensive global review was done, going along with the introduction of quantitative thresholds for the designation of biodiversity hotspots: to qualify as a hotspot, a region must meet two strict criteria: it must contain at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics, and it has to have lost at least 70 percent of its original habitat (Myers *et al.* 2000). The result of this analysis was published in the book *Hotspots: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions* (Mittermeijer *et al.* 2000). This resulted in 25 global biodiversity hotspots

The concept of biological hotspots has been adopted by several international Conventions and has been used for birds, ecosystems and marine areas. In the next Sections we briefly summarize some approaches which are relevant to the biomes relevant to the Upper Niger Basin, in particular the Sahel zone, the Sudan zone and the forested regions in the upper catchment of the basin.

2.2 Key Biodiversity Areas

Recently IUCN launched the network of Key Biodiversity Areas, together with a Global Standard for the Identification of KBAs (IUCN 2016). The KBAs include, in particular, the Important Bird and Biodiversity Areas (IBAs) identified by BirdLife International (2014), and other relevant biodiversity sites (see IUCN 2016 for more information). IUCN presents five main criteria, some of which are subdivided in sub criteria. The KBA-criteria have quantitative thresholds to ensure that site identification is transparent, objective and repeatable.

Hotspots from different perspectives

The definition of hotspots of biodiversity and ecosystems can be addressed from different angles: ecological, cultural, from the perspective of ecosystem services or a combination of these. Ecological hotspots clearly focus on key biodiversity areas and/or concentrations of ecological values. The presence, abundance and variety of species are the key driver for identification and delineation.

A hotspot analysis can also look at cultural aspects like sacred places/areas and/or concentrations of cultural values ('biocultural' diversity, see Verschuren et al. 2011). Often, these places have a high biodiversity value, or, form rather undisturbed sites with a high potential for biodiversity (Metcalfe et al. 2009). On such cultural and undisturbed places in Mali often a relative high tree diversity is found (own observations). The mapping of such sites is much more complex, because spatial data is not or hardly available and most of these sites are scattered and, outside local communities, hardly known. In some cases, the actual mapping of sacred places may not be allowed for cultural reasons. More insight is needed to see how these aspects can be addressed in the BAMGIRE project.

Hotspots can also be regarded as areas were ecosystem services are concentrated (for example Shröter & Remme 2016). In a detailed ESS mapping session such areas should stand out. Schröter & Remme conclude that an ecosystem service hotspot can refer to either areas containing high values of one service or areas with multiple services. Both of these areas are of high value to the local communities. The mapping of ESS is a separate module in the BAMGIRE-project. The current report focuses on the ecological hotspots and does not include cultural hotspots or hotspots of ecosystem services.

If one or more elements of biodiversity (species or ecosystem types) meet one or more of the criteria, this area can be delineated as a Key Biodiversity Area (KBA). IUCN defines KBAs as sites contributing significantly to the global persistence of biodiversity. The five main criteria focus on:

1 Threatened biodiversity: This accounts for areas holding a significant proportion of the global population size of species facing a high risk of extinction and for ecosystem types facing a high risk of collapse Species facing a high risk of extinction are those mentioned in the IUCN Red List of Species as Critically Endangered (CR), Endangered (EN), or Vulnerable (VU). It can also be species which are regionally or nationally assessed as being threatened when these species are not globally assessed and are endemic. Ecosystem types facing a high risk of collapse those assessed as globally CR, EN or VU under the IUCN Red List of Ecosystems
2 Geographically restricted biodiversity. This criterion accounts for those areas that hold a significant proportion of the global population size of a geographically restricted species or groups of geographically restricted species. Geographically restricted species are those that have a restricted global distribution.
3 Ecological integrity. These are areas that hold wholly intact ecological communities with supporting large-scale ecological processes. Intact ecological communities support intact species assemblages and ecological processes in their natural state, relative to an appropriate historical benchmark, and are characterized by contiguous natural habitat with minimal direct industrial anthropogenic disturbance.
4 Biological processes. Areas qualifying as KBAs under this criterion hold a significant proportion of the global population size of a species
    a. during one or more life history stages or processes, where large numbers of a species aggregate i.e. to breed or feed in relation to their migration pattern,
    b. During periods of environmental stress, when their regular habitat becomes inhospitable and therefore lacks sufficient supply of food or water, i.e. during severe droughts.
    c. Or these are sites where a significant proportion of the global population size of a species is produced. In other words: where a large number of offspring is born. The juveniles disperse out of these sites in globally significant proportions.

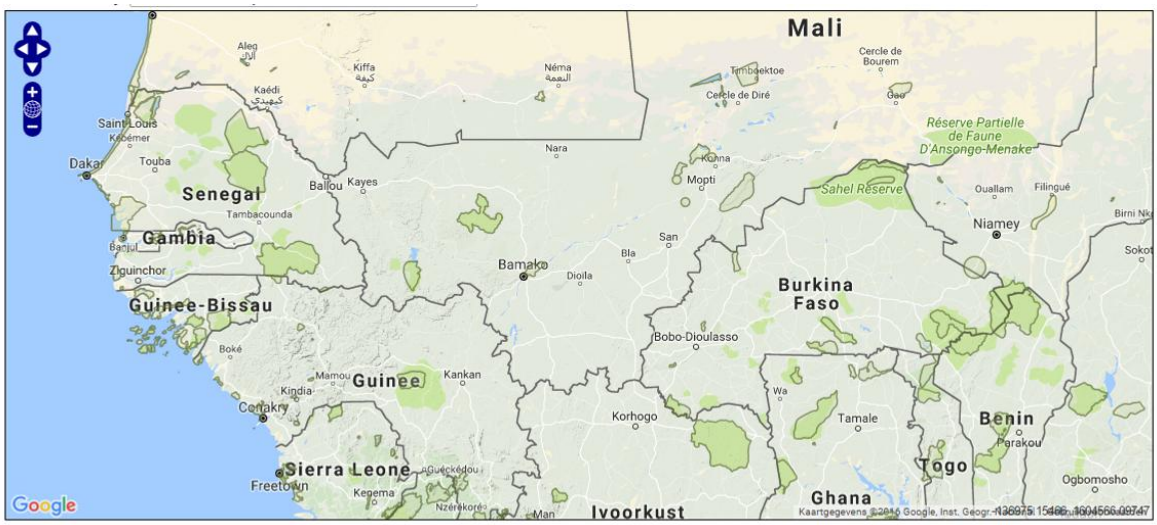

*Figure 2.1 Key Biodiversity Areas in West Africa (green delineation), covering the Upper Niger Basin and the Inner Niger Delta (*www.keybiodiversityareas.org/home*). Import Bird Areas (BirdLife International (2014) are incorporated in the KBA-network. The green areas in the background are protected areas.*

5 High irreplaceability. This accounts for areas that have a high value (≥0,9 on a scale of 0-1) for irreplaceability. Irreplaceability is a geostatistical derived measure of the importance of a site to the goal of protecting a set of species. Sites that are totally irreplaceable contain species that can be found at no other site. Less irreplaceable sites are not unique, and thus there are alternative sites that can be selected in their stead (Lawler *et al.* 2003).

Except for the criteria 3 and 5, the thresholds corresponding to the criteria are often a minimum proportion of the global population size of a species, eventually combined with a minimum amount of reproductive units (i.e. pairs or females), or the minimum proportion of the global extent of an ecosystem type. A preliminary map of KBAs is presented at: http://www.keybiodiversityareas.org/home. The map shows global KBAs, regional KBAs and those whose global/regional status is not yet determined. As explained, IBAs are incorporated in the network. The part of this map covering the Upper Niger Basin and Inner Niger Delta is shown in figure 2.1.

2.3 Important Bird Areas

As a follow up of the designation of Special Protection Areas, in the 1980s a programme was started to identify Important Bird Areas, which is nowadays hosted by Birdlife International. Initially, the programme mainly focussed on Europe but has expanded globally. Presently, it does not only cover birds but also biodiversity in general, hence its new name: Important Bird and Biodiversity Areas (IBAs). It takes into account several spatial scales: species with a global conservation concern as well as species with a regional conservation concern. Additionally international administrative and political collaboration (in case of Europe the European Union) form a third layer of a more restricted scale.

IBAs on the African continent and associated islands are presented in Fishpool & Evans (2001) and updated by BirdLife International (2014). In this approach only sites of global significance, at this stage, are identified. Using the global ('A') criteria, IBAs have been selected based on the presence of four categories of species:

A1: Bird species of global conservation concern
This category concerns bird species that are globally threatened according to the IUCN Red List of Species. The regular presence at a site of Critically Endangered (CR) or Endangered (EN) species is considered sufficient, regardless of their abundance. The other categories of threatened species (Vulnerable, Near threatened, Data deficient or Conservation dependent) have to meet quantitative thresholds in abundance for a site to qualify. These thresholds are regionally set.

A2: Assemblages of restricted-range bird species
A site under this category holds a significant component of a group of species whose breeding distributions define an Endemic Bird Area (EBA) or a Secondary Area (SA). An EBA is an area of land that contains the habitats of restricted-range birds, which are thereby endemic to them, and is formed where the distributions of two or more such restricted-range species overlap. A SA comprises the range of only one restricted-range species. In Mali, the Upper Niger Valley is a SA in which two IBAs are delineated (Bafing and Sirakoroni - Tyènfala).

A3: Assemblages of biome-restricted bird species
This category concerns birds whose distributions are completely or largely confined to a biome. As the (West African) biomes are larger than 50.000 km^2, the species don't meet the definition for endemic species. As with category A2, a network of IBA-sites is chosen to ensure adequate representation of all constituent species across the biome.

A4: Concentrations of numbers of congregatory bird species
This category is applied to those species that are vulnerable, at a population level, to the destruction or degradation of sites, by virtue of their congregatory behaviour at any stage of their life cycles. Four sub criteria are given of which one or more must meet its thresholds.

Using biomes as input, a more or less regional aspect has been brought into the selection criteria. For the Upper Niger Basin and the Inner Niger Delta, the relevant biomes are (from north to south): the Sahara-Sindian, Sahel, Sudan-Guinea Savannah, Guinea-Congo Forests. In the approach of IUCN's KBAs, the IBAs are included in the KBA network. Figure 2.1 shows the Important Bird Areas in the region of the Upper Niger Basin and the IND; see also http://datazone.birdlife.org/site/mapsearch.

2.4 Critical Sites (Wings Over Wetlands)

The Wings Over Wetlands (WOW) project was the first international, flyway-scale wetland and water bird conservation initiative that took place in the African-Eurasian region (2006-2010). The program was realized through a partnership, led by Wetlands International, of international conservation organizations and national governments, which aimed to improve and conserve healthy and viable populations of African-Eurasian migratory water birds. WOW focuses on a network of critical sites within the flyways of (groups of) migratory bird species. A site has been identified as 'critical' if it fulfils at least one of the two CSN criteria:

1 The site is known or thought regularly or predictably to hold significant numbers of a population of a globally threatened water bird species;
2 The site is known or thought regularly or predictably to hold >1% of a flyway or other distinct population of a water bird species.

The CSN criteria will be applied every four years to the updated data held in Wetlands International and Bird Life's databases. Recent information on a species level is found on the website: http://www.wingsoverwetlands.org/.

2.5 The Niger Basin Initiative: Areas of biological importance

Whereas the previous approaches took threats into account from the species perspective (i.e. threatened species based on the IUCN Red List) the next two approaches look at threats from the human perspective: which are the threats to biodiversity and where are they situated. Priority conservation areas are identified combining these threats with distinctiveness in biodiversity.

In April 2002 the Niger Basin Initiative (NBI) hosted a workshop in which regional and wetland experts identified and mapped the most important areas in the Niger basin for biodiversity based on their expert judgement. Important areas for fish, birds and other invertebrates as well as areas important for ecological and hydrological processes have been identified for the Niger basin (Autorité du Bassin du Niger 2007). These areas are shown in figure 2.2.

Overlaying these areas with planned developments and pressing socio-economic issues and accounting for bio-regions, nineteen priority areas for long-term conservation of freshwater biodiversity within the Niger basin were identified. These Priority Conservation Areas are shown in figure 2.3. The Niger Inner Delta, the Niger Delta (Nigeria), the flood plains of the Middle Niger and the sources of the Niger are more important biological areas and require the main priority actions recommended for the improvement of the sustainable use of natural resources in general and biodiversity conservation in the Niger basin in particular.

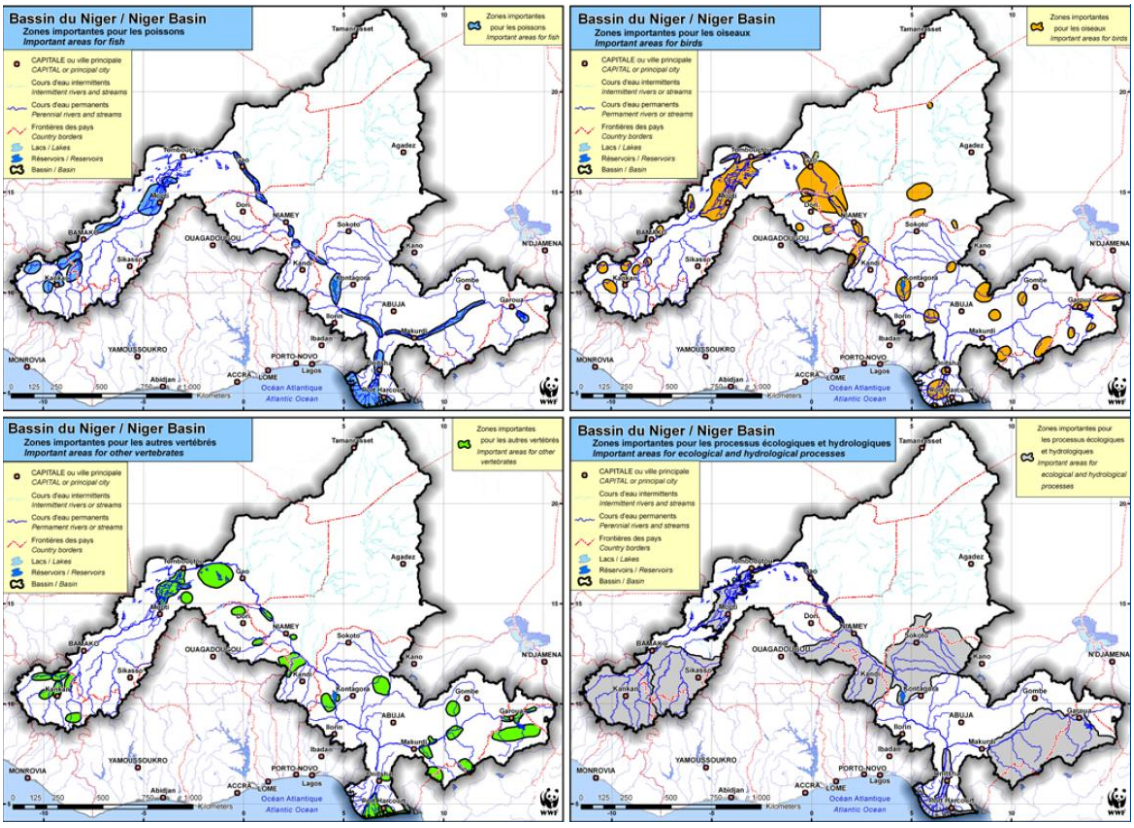

Figure 2.2 Important areas for fish, birds and other invertebrates as well as areas important for ecological and hydrological processes within the Niger basin (Autorité du Bassin du Niger 2007).

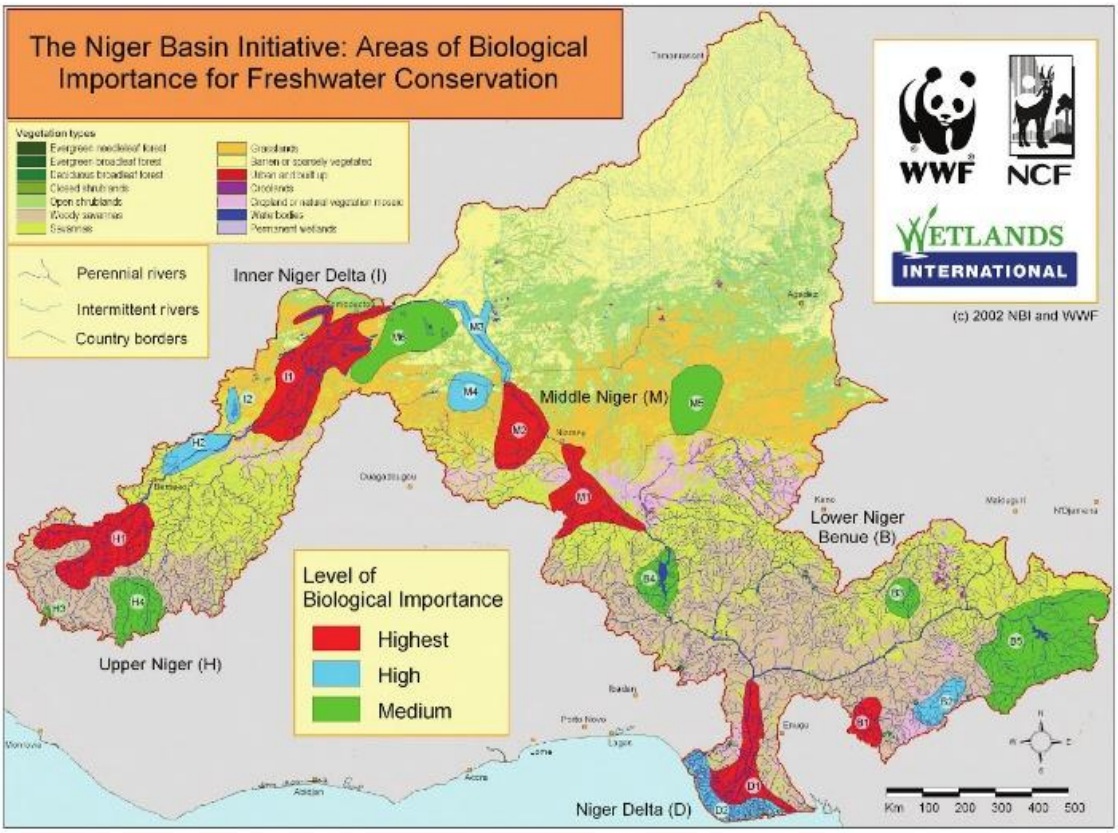

Figure 2.3 Priority areas for long-term conservation of freshwater biodiversity (Autorité du Bassin du Niger 2007).

Table 2.1 Integration matrix showing the priority classes of the Freshwater ecoregions of Africa and Madagascar (Thieme et al. 2005). The Roman figures correspond to the conservation priority; the numbers between brackets correspond with the amount of ecoregions within the distinguished categories.

Biological distinctiveness	**Final conservation status**				
	Critical	Endangered	Vulnerable	Relatively stable	Relatively intact
Globally outstanding	I (6)	I (5)	I (7)	III (1)	III (0)
Continentally outstanding	II (4)	II (3)	II (6)	III (5)	III (1)
Bioregionally outstanding	IV (2)	IV (14)	V (5)	V (3)	V (2)
Nationally important	IV (2)	IV (10)	V (7)	V (5)	V (5)

2.6 Freshwater ecoregions

A different approach regarding the delineation was followed by the project Freshwater Ecoregions of the World, collaboration between WWF and The Nature Conservancy. A Freshwater ecoregion is defined as large area encompassing one or more freshwater systems with a distinct assemblage of natural freshwater communities and species (Albell *et al.* 2008). A total of 93 freshwater ecoregions were distinguished in Africa and Madagascar. The Niger basin is split up into four ecoregions: The upper Niger, Inner Niger Delta, Lower Niger - Benue, and Niger delta (Thieme *et al.* 2005, Albell *et all*. 2008).

In their approach, Thieme *et al.* (2005) use an integration matrix to classify complete ecoregions in five classes of conservation priority identifying those that are believed that should be targeted for immediate conservation actions. The classification depends on the conservation status (severity of threats and stability and intactness of the hydrological / ecological system) and the biological distinctiveness of the ecoregion (table 2.1). The Inner Niger Delta is classified as class II while the Upper Niger has been classified as class V.

2.7 Critical habitats

One final approach mentioned here is the classification of specific habitats with high ecological value. Guidelines for the classification of so-called 'critical habitats' have been developed by the International Finance Corporation (IFC) with the goal of setting standards for Environmental Impact Assessments. The criteria are elaborated in Performance Standard 6 (Biodiversity Conservation and Sustainable Management of Living Natural Resources, effective January 2012). The requirements set out in this Performance Standard have been guided by the Convention on Biological Diversity, which aims at protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development.

The classification of critical habitat is based on the presence of high biodiversity values. Following IFC PS6, critical habitats are areas of high biodiversity value that may include at least one or more of the following five values:

- Critically endangered (CR) and/or endangered (EN) species
- Endemic and/or restricted-range species
- Migratory and/or congregatory species
- Highly threatened and/or unique ecosystems
- Key evolutionary processes

For example, gallery forests in a savanna landscape may be classified as critical habitat based on the following criteria:

- Importance to landscape and ecological processes, including dispersal of forest species, stream bank stability and nutrient flows;
- Uniqueness of the habitat in the region, with a small spatial extent and the presence of many biome-restricted species that are not found in the surrounding landscape;
- Function as a biological corridor of forest habitat in the wider savanna landscape.

2.8 The issue of scale

The issue of scale is relevant when defining and delineating hotspots. In most of the approaches mentioned in the previous Sections, the abundance of a species within a hotspot should be a minimal proportion of the global population or a minimal proportion of the population within a flyway. For a more localised approach, one could (in addition) use the minimal proportion of the population size within an ecoregion, or include areas where on a regional level a high biodiversity is concentrated (for instance breeding colonies or vulnerable species becoming rare in the region). The latter is relevant to the Upper Niger Basin. A important comment in this respect is the lack of data on population sizes for most species, which makes application difficult, in particular on a regional scale.

Another aspect is the scale of the surveys on which the data of species presence and abundance are based. This scale can be highly variable, varying from a fine scaled, local and multi taxa survey, including estimates of abundance per species, to regional or national surveys where only the occurrence of a species within a region is established (Brugiere & Kormos 2009).

With regard to delineating hotspots scale is also relevant. For example the Inner Niger Delta as a whole can be regarded as an outstanding hotspot, being a coherent spatial entity as flood dependent ecosystem. Key habitats and its specific functions can be used to zoom in on a finer scale. Practical boundaries, in relation to management, land-use, stakeholders, and geography have to be used in addition (IUCN 2016). The area of a typical hotspot may also vary greatly. On land, IBAs are typically 100–1000 km^2 but range from 0.01 km^2 to over 330,000 km^2 (IUCN 2016).

2.9 Conclusions

Several approaches for defining hotspots have been presented in this chapter. There is overlap in the criteria used, but also some clear distinctions:

- A hotspot should contain a minimal proportion of the global or flyway population;
- Attention for areas where (groups of) species aggregate during stages of their lifecycles;
- Additional focus on restricted area species;
- The incorporation of threats for identification of hotspots. Though, there is a distinction whether these treats are perceived from a species level (IUCN Red List) or from a threat to the area as such resulting from i.e. conversion of land, land-use, urbanisation, surface water abstraction.

Nevertheless the approaches assume a reasonable amount of sufficient and detailed information on the distribution and abundance of species. Important Bird Ares and Critical Sites Networks focus on bird species, but for the other approaches also add other taxa. Key Biodiversity Areas couple these, and couple all relevant taxa.

3 Approach and methods

3.1 Defining hotspots based on limited data

The larger the area of a protected area, the more likely relevant ecosystems and all species to be protected are incorporated within the network. However, if data for site identification are based on detailed surveys a far more accurate delineation is possible and the total area can be smaller compared with data built on presence/absence only, or on hardly any data at all. Nevertheless, low sampling effort data perform well in defining a protected site network in terms of species representation, also in case of restricted range species (Gaston & Rodrigues 2001).

In some cases, data may be so scarce that an alternative approach is necessary for defining a protected area network. In the case of Guinea the data on distribution and abundance are very scarce, so Brugiere & Kormos (2009) use data on threatened mammal species as a proxy for biodiversity because (1) this is the group for which the largest amount of data is available, (2) this group includes the largest number of globally threatened species in Guinea and (3) threatened mammals perform well as an indicator of terrestrial species diversity (Moore *et al.* 2003). The aim of the study of Brugiere & Kormos (2009) was to identify areas with high biodiversity that can be included in the national protected area network. Their starting point was the KBA methodology outlined in section 2.3 of this report. Due to scarcity of data only the first criterion was used (globally threatened species) and this was further limited to threatened mammal species, as they appeared to be an appropriate indicator for biodiversity in Guinea (and available data). To assess the KBAs thus obtained, a scoring system was used. In this scoring system points were given according to the conservation priority of the ecoregion of the KBA, and to the Red List categories of the mammal species present in the KBA. The latter score depends also on the other KBAs and existing protection areas in which these species are present, thus incorporating complementarily of the KBAs on a national level.

The ecoregion conservation score and the species conservation score add up to a relative conservation significance score for the identified KBAs. The identified sites were evaluated on their agreement with the 18 IBAs in Guinea. Overall, nine IBAs out of 18 correspond to the existing protected areas and newly identified KBAs, suggesting a moderate rate of congruence between the selected area network based on the occurrence of birds and the network based on threatened mammal species in Guinea.

3.2 Approach for the Upper Niger Basin

Study area

The study area for BAMGIRE encompasses the Upper Niger Basin and Inner Niger Delta (Fig. 3.1). Within this study area two regions with different approaches can be distinguished: (I) the Inner Niger Delta and (II) the catchment of the Niger and Bani rivers upstream of the IND, that we refer to as Upper Niger Basin (UNB). The project Freshwater Ecoregions of the World (Section 2.6) refers to the former as Inner Niger Delta and the latter as Upper Niger. The Inner Niger Delta is situated in Mali. The UNB is almost equally divided by Mali and Guinea, but part if the UNB is situated in Burkina Faso and Ivory Coast.

Approach for the Upper Niger Basin

As the approach of defining KBAs in Guinea by Brugiere & Kormos (2009) proved to be an efficient method in a situation with limited data, this study will be chosen as a starting point for

delineating hotspots in the Upper Niger Basin. We complete this with the KBAs defined by IUCN (2016), thus including all known IBAs. Fish fauna has not been accounted for in their study. The rich fish fauna specialized to live in the rapidly flowing streams in the upper reaches of the Niger is one of the distinguishing elements of the aquatic biodiversity of the UNB. The UNB hosts to about 150 species of fish, of which eight are endemics and one, the cyprinid *Garra waterloti*, is found only in this ecoregion. This has been one of the arguments to designate several Ramsar sites in this region (see hotspot report II, Chapter 2 on protected areas: Wymenga et al. 2017). The majority of this ecoregion's fish species are shared with the other ecoregions within the Niger River basin (www.feow.org).

Summarising, a four stage approach will be applied:

- *I. Identifying Key Biodiversity Areas*
  Starting point is the analysis of Brugiere & Kormos (2009) and the KBAs they identified in Guinea within the boundaries of the UNB. As far is relevant, these areas are completed with KBAs delineated by IUCN (2016), thus including IBAs (Birdlife International 2014). If needed the selection of KBAs will be further completed for the Malian part of the UNB by using the approach of Brugiere & Kormos (based on threatened mammals);

- *II. Completion with Critical sites (WOW)*
  Based on other bird surveys (Critical sites, Wings over Wetlands) this list of areas will be completed with important areas for threatened and endemic birds species, as well as known concentrations of birds (species) within the UNB;

- *III. Completion with Important Biodiversity areas for fish communities/species*
  We expect fish data to be the least detailed and relatively scarcely available, as these surveys cover only a small portion of the area. At least information can be used from the Ramsar sites and wetlands proposed as Ramsar sites (Chapter 4);

- *IV. Completion with areas with a high biodiversity in the region based on Protected Areas*
  Using the information of the Protected Area network in Mali and Guinea the identified areas will be completed, if appropriate, with areas which hold a high biodiversity in the region or sub region (for example breeding colonies or population of vulnerable species becoming rare in the region).

Defining and delineating hotspots is an iterative process (IUCN 2016). Using GIS, geographical data on presence/absence or, if available, abundance of mammal, bird and fish data will be made available for mapping and analysis. This includes their Red List status, global population size where appropriate, distribution status etc.

Approach for the Inner Niger Delta

From several studies it is clear that the IND as a whole is a globally recognised a as an ecological hotspot harbouring outstanding biodiversity and significant parts of globally threatened water bird populations. This has been the reason that the floodplain area has been designated as Ramsar site in 2004.

On the level of the Upper Niger Basin the IND will easily meet the criteria as defined above, and stand out as an ecological hotspot. The objective in this study is to add new information on vulnerable sites and key areas within the IND, which are crucial to its biodiversity. Is has to be stressed, that this does not imply that areas which are not selected as crucial to the key biodiversity, are not part of the ecological hotspot. The vulnerable sites and key areas are

identified to prioritise and stimulate an effective management of the ecological hotspot as a whole. This information for instance could be used to enforce the protection of specific sites or species in the area, given that the IND to date has not been assigned as legal protected area.

In order to account for vulnerable sites and key areas a four stage approach will be applied:

- *I. Identifying Areas with Key Habitats in the floodplain ecosystem*
  Some habitats in the IND play a key role in the ecosystem and are vital to preserve the biodiversity and to sustain the production of natural resources (for instance breeding zones for fish). This applies for instance to flood forests, moist forest around the delta, bourgou fields, mares, permanent deep water, shallow lakes etc.

- *II. Completion with Important with Water Bird Concentrations*
  Based on data from monitoring of water birds, areas and sites will be selected which hold large concentrations of water birds. This applies to roosts of water birds, large concentrations of foraging water birds and sites with a high densities of rare species (for instance Aquatic Warbler habitats);

- *III. Completion with Breeding Colonies*
  The IND holds a number of very large breeding colonies of herons, ibises and cormorant, which are amongst the largest in Africa. Next to that, there are sites where rare species breed in, like the endangered Black Crowned Crane;

- *IV. Completion with areas with a high biodiversity of endangered and vulnerable species*
  Areas which hold regularly endangered and vulnerable species like Hippos, Manatees, mammals etc, or are vital for these species during certain stages in the life cycle.

3.3 State of knowledge

The data and analysis presented in this report are based on the state of published (available) knowledge so far. We expect that in the next years surveys may become more adequate and better fit the needs for defining hotspots. Also data from past surveys may become more easily available. Apart from this, situations change and therefore it will be necessary to monitor biodiversity and temporarily update data. The approach is such that future data can be used in order to evaluate and, if necessary redefine, boundaries and goals for the hotspots. In chapters 4, 5 and 6 the limitations and gaps of the data used will be addressed.

Low water levels in the upper reaches of the Niger in February in the Mafou tributary in the Upper Basin in Guinea, Photo A&W.

4 Ecological hotspots in the Upper Niger Basin

4.1 State of knowledge

As explained in Chapter 1 the existing knowledge on biodiversity and ecological hotspots is inventoried in a separate report (hotspot report II: Wymenga *et al*. 2017). This concerns an inventory and mapping of protected areas (in many cases acting as important areas for biodiversity), and a rapid assessment of available (spatial) data on the distribution and occurrence of vulnerable habitats and vulnerable species in the Upper Niger Basin.

It is clear from this analysis and inventory, that information on a global level is present for several habitats and species, but detailed spatial information to delineate ecological hotpots is lacking. This has been the main reason for Brugiere & Kormos (2009) for their assessment, to rely on the distribution of large, vulnerable mammal species to perform a first delineation of key biodiversity areas in Guinea. For the Malian part of the Upper Niger Basin we can conclude from the inventory in report II, that the occurrence of large mammal species - including carnivores, primates and ungulates - is uncertain or confined to protected areas, if present at all. Also for these species in Mali we lack spatial data.

This preliminary assessment of ecological hotspots is based on existing knowledge and potential important habitats, as worked out in the approach in Chapter 3. As to potential important habitats we focus on riverine habitats, which are influenced by (changes) in water management and that are linked to the Niger River system. Mapping ecological hotspots in this stage can be done only preliminary (Fig. 4.1 and Fig. 4.2) and is largely confined to protected areas (see next Section).

4.2 Preliminary overview of ecological hotspots

Results of the chosen approach
As argumented in Chapter 3, we follow a four stage approach:

I. Identifying Key Biodiversity Areas
As a first step, the KBAs as indentified by Brugiere & Kormos (2009) in Guinea are included. The information on the distribution of threatened mammal species is – apart from information from protected areas - very global and does not allow focusing on specific areas. In general terms, threatened primate species are found in the well-preserved gallery forests in the very southern part of the basin, and the range of the Western Giant eland overlapping with the northern catchment of the Tinkisso.

For Hippos and Manatees the spatial distribution is confined to the rivers (Hotspot report II, Wymenga *et al*. 2017). Hippos are specifically reported from the Tinkisso, the Niger and the Milo, as well as the upper reaches of the Sankarani. Hippos are not reported from the Bani, but we do not know if this is because of lack of data or a real absence. As to Manatee, the Niger proper up to the diversion with the Tinkisso and Sankarani is indicated (IUCN-data), as well as the middle part of the Bani (up to the diversion with Banifing and Bagoé). As long as updated information is lacking, all these river parts should be considered as potential ecological hotspot. For the Bani tributaries this is uncertain (indicated with?), and more information is needed.

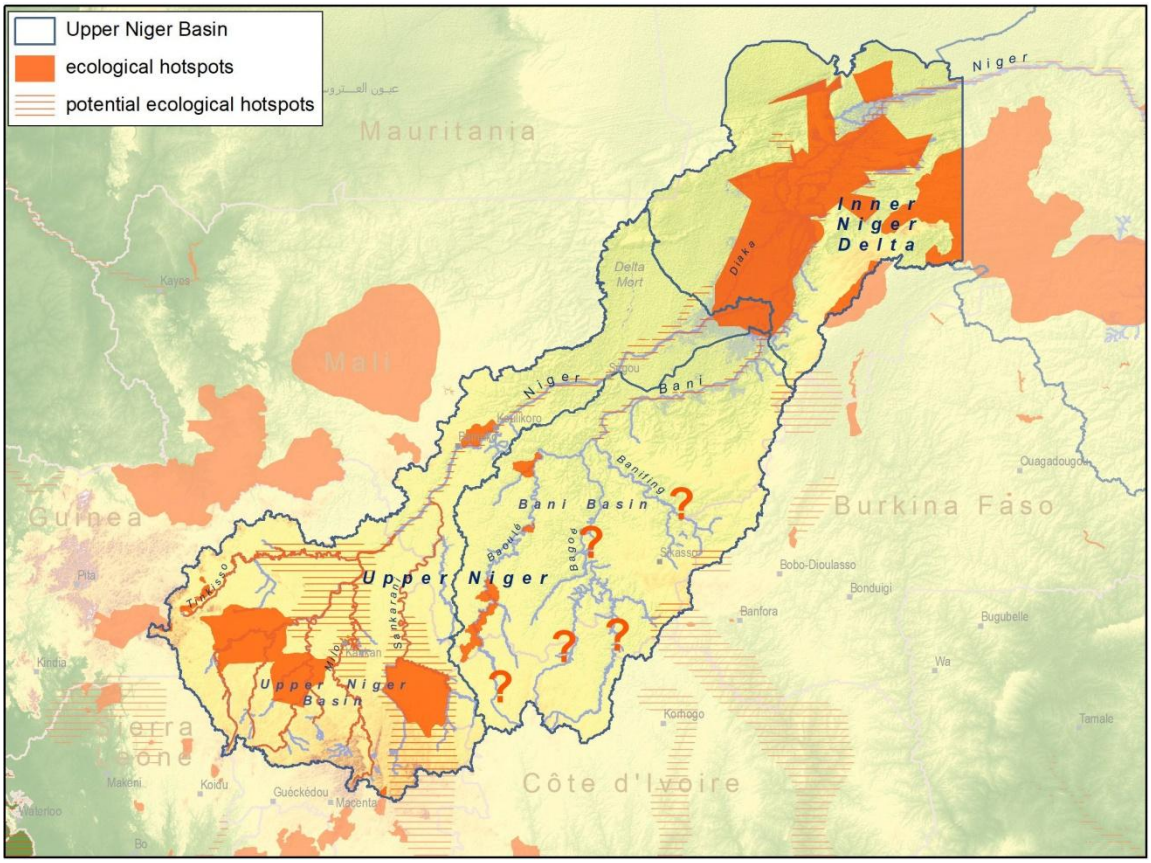

Fig. 4.1. Ecological hotspots and potential hotspots in the Upper Niger Basin and the Inner Niger Delta. See text for explanation. ? refers to areas where information is insufficient to give an indication of status.

II. Completion with Critical sites (WOW)

The second step in the approach is to add critical sites for birds, as indentified by the CSN (critical site network, http://csntool.wingsoverwetlands.org/csn). As explained in Chapter 4, there are no Critical Sites indicated in the Upper Niger Basin. Given the low level of detail and the lack of field information, we expect this inventory far from complete. As stated in the report on existing knowledge (hotspot report II), important areas for concentrations of birds as well as breeding bird colonies in general can be found in the riverine habitats, like flood forests and marshes. Also these are found for instance in the Selingué areas and the Falas in the irrigation zone of Office du Niger. In this stage however, this cannot be translated in a spatial delineation of ecological hotspots yet.

III. Completion with Important Biodiversity areas for fish communities/species

In this step the selected areas are completed with wetlands proposed as Ramsar sites, in particular on the bases of their importance for (endemic and/or threatened) fish species (see hotspot report II). This results in the inclusion of large parts of the tributaries of the Tinkisso, the Niger (Mafou and source), the Niandan-Milo and the Sankarani parts in Guinea (Fig 4.2). Partly these branches are also identified as habitat for Manatee and Hippo, and hold a high biodiversity in general, also threatened mammal species like in the Tinkisso range (www.ramsar.org).

These upper reaches of the Niger River system are pivotal to water quality and quantity for the resources downstream. The surface area of the designated sites is extensive (Section 4.1), but

the spatial delineation is not available. For this preliminary mapping of hotspots, we choose therefore to provide a very general indication.

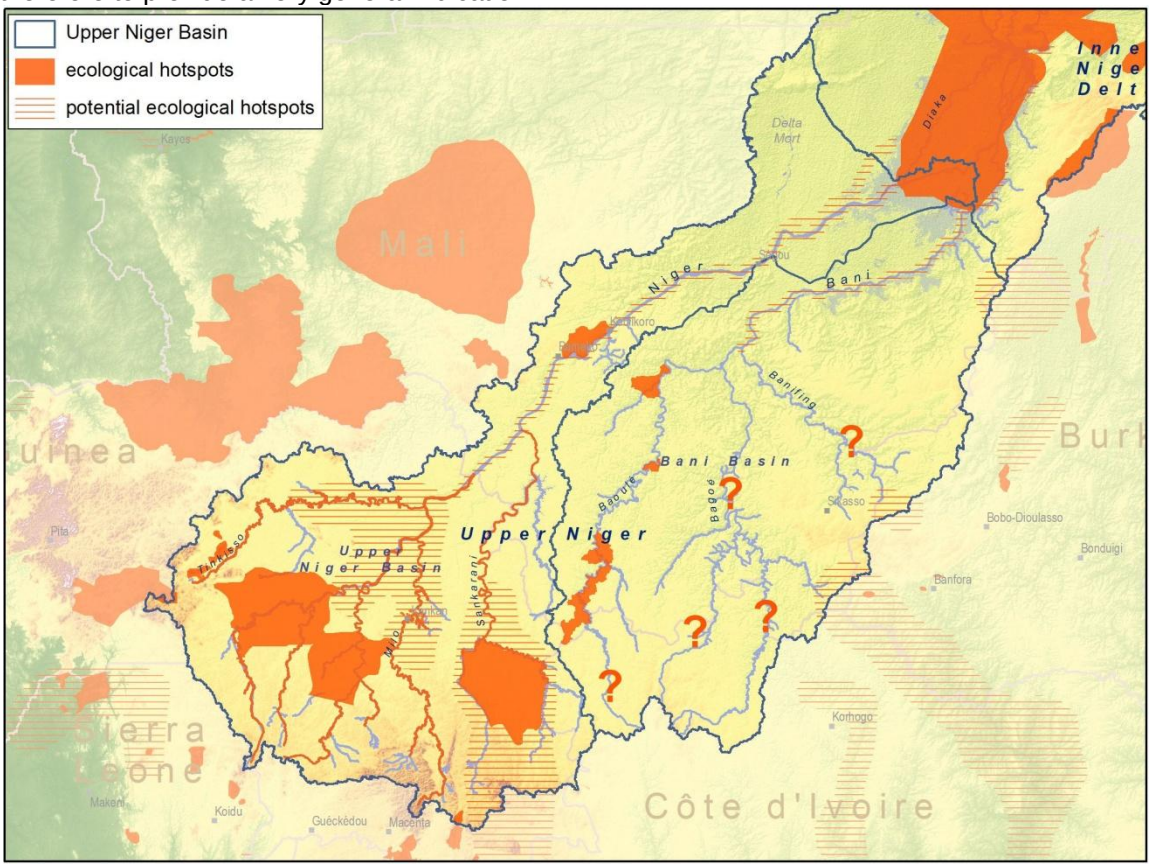

Fig. 4.2. Ecological hotspots and potential hotspots in the Upper Niger Basin. See text for explanation. ? refers to areas where information is insufficient to give an indication of status.

IV. Completion with areas with a high biodiversity in the region based on Protected Areas

As a last step for the preliminary assessment and mapping, we added information on the Protected Area network in Mali and Guinea. Areas which hold a high biodiversity in the region or subregion are added (see Appendix I in hotspot report II). Most of the areas which are part of the network of Protected Areas in Mali and Guinea are included; on the level of Classified State Forests relevant information is lacking.

Final preliminary map of ecological hotspots

The resulting map of preliminary hotspots is shown in Fig 4.2. We expect this map to be far from complete, as we miss important information on riverine habitats in the basin (floodplains, swamps, gallery forests etc). These areas, with high biodiversity values, are found in most of the tributaries of the Niger and Bani, but without up-to-date field information we cannot make a spatial delineation nor prioritize these areas.

4.3 Knowledge gaps and data need in 2017-2018

Based on the previous chapters and the inventory in hotspot report II (Wymenga et al. 2017), as well as the preliminary map of (potential) ecological hotspots, we can identify priorities in the need for filling knowledge gaps and collect additional data.

a) Collect (and digitise) spatial data on vulnerable habitats in the Upper Niger Basin, using (national) inventories and site inventories. Focus lies on the (riverine) zones which may be affected by changes in water management, and which have been included in the preliminary assessment of ecological hotspots.

b) Field missions to these habitats and areas for ground truthing and to collect additional information on the role and function of these habitats, their quality and threats. This includes all spatial data and observations (of local communities) in the Upper Niger Basin on vulnerable large mammal species, reptiles, endemic fish species and data on (colonially) breeding water birds, roosts and other bird concentrations.

c) A special focus is needed on the riverine habitats in the tributaries in Guinea and the Bani headwaters in Mali.

5 The Inner Niger Delta as Ecological Hotspot

The Inner Niger Delta is considered as coherent ecological hotspot in this report, easily meeting criteria on vulnerable habitats and species as defined in Chapter 2. The IND is a flood-dependent ecosystem and economy, and biodiversity and ecosystem services are primarily determined by the amount of flooding (maximum height of annual flooding and related extension of inundated areas). All key habitats are directly - or indirectly in the case of dry forests of Red Acacia - depending on the duration of the floods. That is why the area as a whole – the maximum extension of the floodplain as well as connected areas in the surrounding plains including the lakes on the north and west bank - must be considered as a coherent ecological hotspot. In this Chapter we work out the state of knowledge (summary of the conclusions in the inventory hotspot report II) and the key structures in the delta which are the backbone of the floodplain.

5.1 State of knowledge

As explained in Chapter 1 the existing knowledge on biodiversity and ecological hotspots is inventoried in a separate report (hotspot report II: Wymenga *et al*. 2017). The inventory report is summarising available (spatial) information on the distribution and occurrence of vulnerable key habitats and vulnerable species in the IND. Although this information is far from complete on a species level (and additional data is present in the sources mentioned) it shows that from the IND much more information is present than from other ecological hotspots in the region. Most detailed information is available on water birds and vegetation. From other species groups limited information is available.

5.2 Preliminary map of key structures

Results of the chosen approach

As argumented in Chapter 3, we consider the entire IND as ecological hotspot and within this hotspot we focus on key habitats and structures that are the pivotal to the ecosystem and biodiversity. We follow a five stage approach:

I. Areas with key Habitats in the floodplain ecosystem

Some habitats in the IND play a key role in the ecosystem and are vital to preserve the biodiversity and to sustain the production of natural resources (for instance breeding zones for fish). In hotspot report II the available information is presented, and can be summarised as follow:

Key habitat / key structure	Spatial information
Permanent (deep) water during the dry season	Represented by water level at 0 and 100 cm at Akka.
Lower floodplain with bivalves and mollusques	Represented by water level at 50+/-20 cm at Akka (30-70 cm). This covers the shallow zone during the receding flood where benthic fauna can be found.
Bourgou fields (bourgou, didere and wild rize)	Potential zonation of bourgou, didere and wild rice at different water levels
Flood forests and associated foraging zone of roosting and colonially breeding water birds	Locations of present flood forests, no spatial delineation of the individual forests. Potential foraging zone of 15 km
Dry forests (of mainly Red Acacia – *Acacia seyal*)	Limited areas analysed on woody cover. Spatial data needed

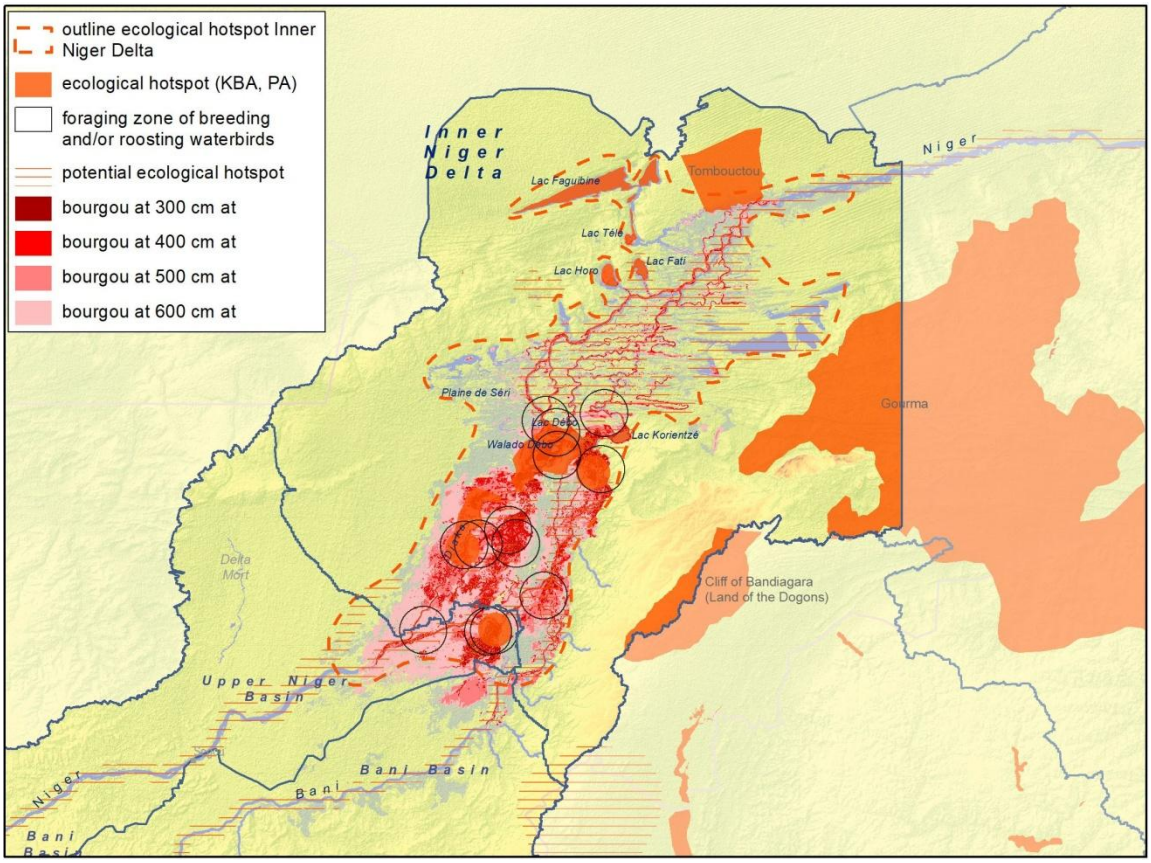

Fig. 5.1. Inner Niger Delta as a coherent ecological hotspot – next to the key structures in the delta proper the ecological hotspots east of the delta an in the north are indicated. See text for explanation.

II. Water bird concentrations

Next to the central lakes (Debo, Walado, Korientze), which are already covered in the previous criterion, all lakes on the west bank should be regarded as concentration areas for water birds (Lac Horo, Lac Fati, Lac Télé, Lac Faquibine). Roosts of large wading birds are covered by flood forests where roosts are found. Other concentrations of water birds are often found on the foraging grounds, represented by the flooded habitats (see previous criterion).

III. Breeding colonies

Large breeding colonies of herons, ibises and cormorant are present in a number of flood forests. Breeding birds rely on foraging areas in the flooded habitats around the breeding colonies, mostly within a radius of 5-15 km, especially when they have to feed the young. Roosting birds perform foraging flights over longer distances. Without these feeding grounds, the large breeding colonies cannot be sustained.

The floating bourgou vegetations are important as breeding habitat for the scarce Black Crowned Crane. The floodplains of the Plaines de Serie is a known breeding area for these vulnerable, ‘ground nesting’ birds, as well as the flooded areas south of Walado and Lac Débo. These areas are covered in the criterion for key habitats.

IV. Areas with a high biodiversity of endangered and vulnerable species

As elaborated in Chapter 5, areas within the IND which are important as key habitat for Hippos and manatees are permanent water bodies, and the surrounding floodplain (Hippopotamus) to forage during night. Manatees stay in permanent water bodies (see before). Apart from relatively

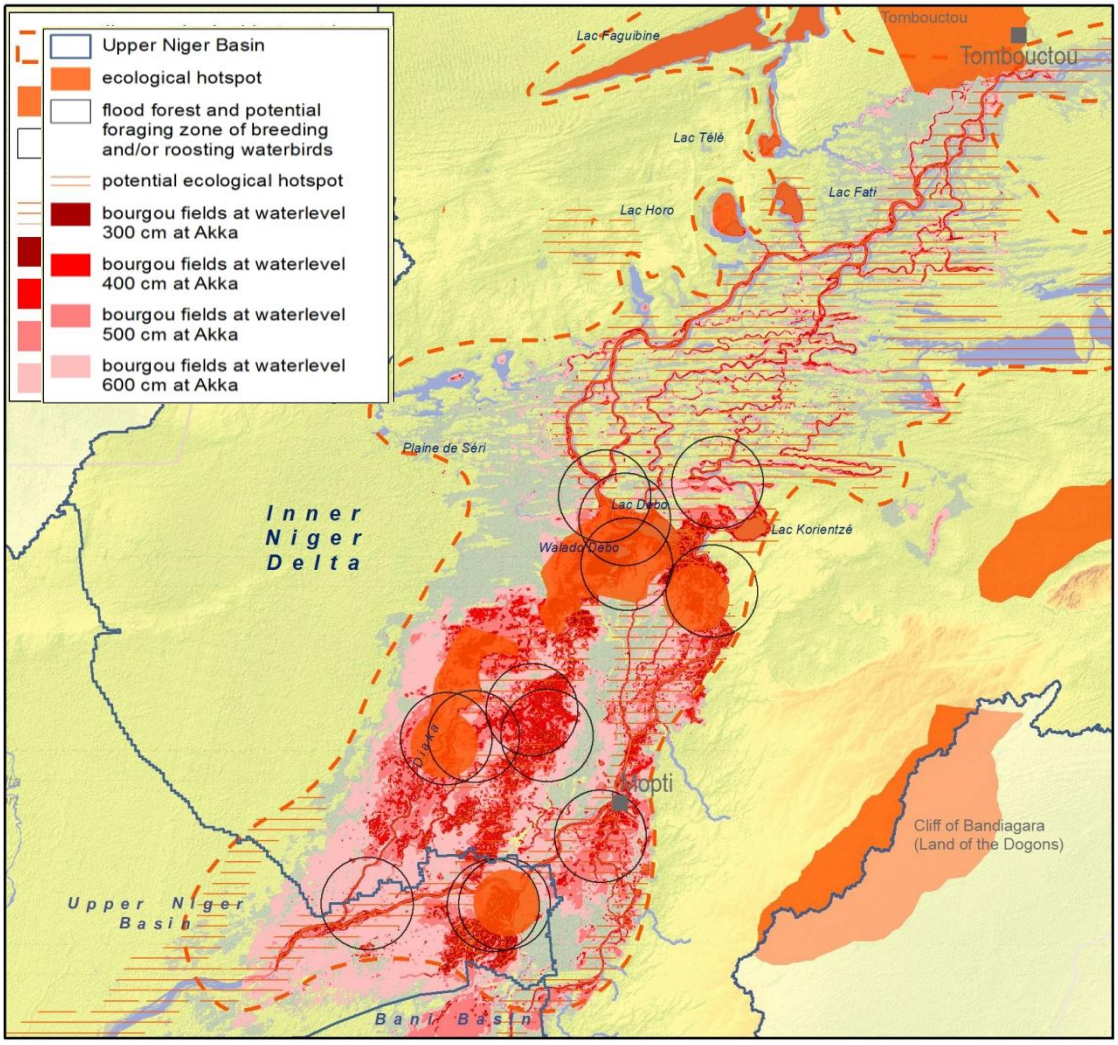

Fig. 5.2. Key structures in the Delta proper. See text for explanation.

common species, other large mammal species are extinct in the IND and surroundings. The exception is the occurrence of a small population of elephants roaming the savannas' between the Reserve du Sahel in Burkina and the region of Gourma and Douentza, sometimes coming near the delta region (see hotspot report II). The area north of Tombouctou is added as it is identified as IBA by Birdlife International (see Appendix 1 in hotspot report II).

Final preliminary map of ecological hotspots

The resulting map of preliminary key structures in the IND as ecological hotspot is shown in Fig 5.1 and Fig 5.2. The maps present the flood forests, foraging zones and bourgou fields at four different flood levels (300, 400, 500 and 600 cm at Akka), expressing the strong relationship with the flood extent and maximum flood level. As we added also ecological hotspots already identified on the higher abstraction level of IBAs (KBAs, see Appendix 1), there is overlap with the key structures.

The dry forests are not included in this stage. Next to these habitats, the northern lakes are included and east of the delta the Reserve des Élephants. For now the plain de Seri is lacking but needs to be added in a later stage for its significance as breeding area for Black-crowned Crane. The map needs to be completed by dry forests / wooded savannas in the delta (*centre vide, levees*) and the surrounding plains.

5.3 Knowledge gaps and data needs in 2017-2018

Based on the previous chapters, as well as the preliminary maps with key ecological structures, we can identify priorities in the need for filling knowledge gaps and collect additional data.

- Spatial analysis and additional field data on key habitats in the IND, including dry forests (see for more information in hotspot report II).
- Flooding map with separation in connected and unconnected areas to the river system.
- Monitoring of water bird concentrations (aerial census) and colonially breeding water birds including the northern lakes (see for more information in hotspot report II).
- Information on fish species on the market in Mopti, with information on size in relation to the flood season, in completion to the data collected by Opération Peche Mopti;
- Field missions to map the presence and prime areas for Hippos and other fauna in the Delta, including updated information on the occurrence of Manatees.

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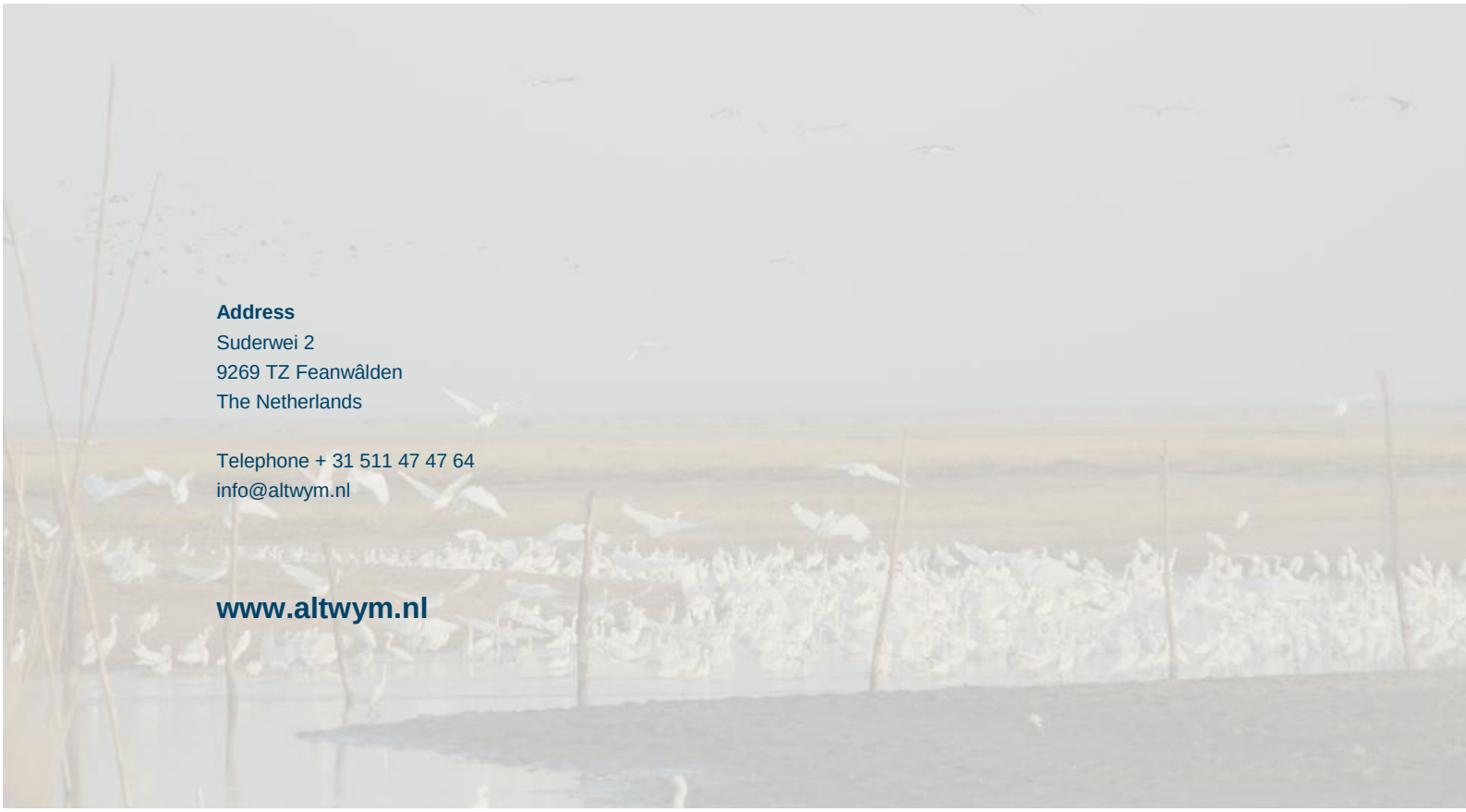

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