Wetlands help maintain wetland and dryland biodiversity in the Sahel, but that role is under threat: an example from 80 years of changes at Lake Tabalak in Niger

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Wetlands help maintain wetland and dryland biodiversity in the Sahel, but that role is under threat: an example from 80 years of changes at Lake Tabalak in Niger

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Wetlands in arid and semi-arid regions are enormously important for the biodiversity of the surrounding drylands, and for the humans living there. Increasing human populations put increasing pressure on the dryland resources as well as on those wetlands. This case study of Lake Tabalak in Niger shows the changes that have taken place there over 80 years. From a tree-covered depression with a traditional well, it changed to a 1.150 ha lake in the 1970s. From this lake, where pastoralists and their livestock had free access to water and fodder all year round, it developed into a depression with almost wall-to-wall market gardens. In April–June, the end of the dry season, herders now have to pay large sums to have their animals feed on what there is of crop residues at the lake, before continuing to the natural grasslands further north once the rains have arrived. What little is left of the teeming wildlife in that region around 1940 is not coming to the lake anymore. The lake’s usefulness for trans-Saharan migratory birds has demonstrably decreased over the past 20 years. This lake, a key component in the dryland system it belongs to, facilitating year-round use of the drylands that surround it and connecting dry season grazing areas in the south to rainy season grasslands in the north, has become, or is becoming, degraded for all uses, not least wetland and dryland biodiversity. Increasing pressures over the coming decades will cause similar dryland systems elsewhere to suffer the same fate and lose important parts of their functionality and their biodiversity, if adequate countermeasures are not taken. Such countermeasures must concern the wetland systems rather than the individual wetlands that the dryland systems contain, and lead to participative integrated natural resource management involving all stakeholders, for instance through multi-stakeholder fora.

Keywords: agriculture; multi-stakeholder management; natural resource management; pastoralism; Sahel

Introduction

One of the key characteristics of much of the biodiversity of dryland regions is its ability to survive under very dry circumstances. All the same, for many birds and large mammals in dryland regions, access to open water for drinking during the dry season is a key factor influencing their distribution. Access to food that is found in wetlands, or that congregates at wetlands, can be very important, too. Access to open water is also key for migratory birds that migrate to or via dryland areas, in particular water birds.

Because wetlands are areas were water and nutrients are concentrated, they are areas of relatively high biological production potential and relatively low production risk. As a result, wetlands are of great value not only to biodiversity, but also to farmers, pastoralists, fishermen and collectors of natural products. That value is even greater in dryland regions, where the production potential of the surrounding uplands is generally relatively low and the production risk high. An overview of how isolated wetlands in Niger are used for different purposes at different times of year, what their economic values are and how the various uses interact amongst themselves and with uses of associated drylands is given by Brouwer (2009, 2010, 2014).

As the population increases the human pressure on wetlands in drylands also increases, to the detriment of local biodiversity. Other factors that can lead to increased pressure on wetlands in dryland areas include climate change and changes in upstream catchments. In this paper, we describe and analyse developments over the past 80 years at Lake Tabalak in Niger, including changes in its hydrology, changes in its use by people and changes in selected components of the wetland and dryland biodiversity dependent on the lake. Based on those historical developments, we make recommendations for the future, both for Lake Tabalak and for other wetlands in dryland regions that have not yet changed so dramatically.

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Lake Tabalak’s hydrological history

Lake Tabalak, a Ramsar Wetland of International Importance since 2004 (Ramsar Bureau 2004), lies in the Republic of Niger, 50 km NE of Tahou, at 15.11° N 5.67° E and 400 m above sea level (Figure 1). Within the Tahoua Region, it falls under the Arrondissements of Abalak, Tahoua and Keita (Oumarou et al. 2009). Average annual rainfall in this sandy and rocky part of Niger is only about 300 mm/yr, falling mostly during the short rainy season of July–September (Mullié and Brouwer 1994; Direction Agricole à Abalak, personal communication 2007).

As recently as 1953, where Lake Tabalak is now, there was only a seasonally flooded depression with stands of Acacia nilotica and Balanites aegyptiaca trees. Land use changes in its catchment apparently gradually caused that depression to receive more run-off. Poor rainfall in the early 1970s (cf. Zwarts et al. 2009, 22) probably led to the protective vegetative cover in the Lake Tabalak watershed becoming much reduced. Subsequent torrential rains created large amounts of run-off, which led to a barrier at Ibaga, SE of Tabalak, being ruptured (Ramsar Bureau 2004). The ensuing flood filled the depression and created Lake Tabalak. Other large lakes in Niger that were formed in the early 1970s in a similar fashion include Lake Dan Doutchi (15.07° N 5.41° E, maximum extent 1500 ha; Brouwer and Mullié 1994a) and Lake Akadané (15.38° N 7.05° E, maximum extent 500 ha).

Once Lake Tabalak had been formed, run-off from its catchment each rainy season was enough to keep the lake in existence (Ramsar Bureau 2004). Local people moved in to exploit the opportunities the new lake provided, as did people from Birni N’Konni and from Nigeria further south. Upgrading of the road to transport uranium from the mines in the north of Niger provided additional work opportunities. Thus the village of Tabalak came into being (Ramsar Bureau 2004). Figure 2 shows a Google Earth image of Lake Tabalak.

The maximum extent of the permanent lake formed around 1970 is about 1150 ha. Its actual extent depends on the time of year, and on the rainfall of the preceding rainy season. During the national water bird counts in 1992–1995, in the middle of the dry season, it varied between 1150 ha (January 1995, following a wet 1994) and 650 ha (January 1994, following poor local rainfall in 1993) (African Waterbird Census data). In February 2006, following poor rainfall in the preceding year, it was also approximately 600 ha, as the Google Earth image in Figure 2 shows. In 1996 the lake dried up completely, due to very poor rainfall in 1995 (Ramsar Bureau 2004). Whether the lake is functionally permanent or not has of course a big effect on its ecology and associated management options.

According to local farmers, the lake held more water during the early 1990s than before then, because degradation of the vegetation in its catchment led to increased run-off to the lake. In January 1993, when its extent was approximately 1000 ha, the average depth in the middle of Lake Tabalak was about 2.6 m (Mullié and Brouwer 1994). Over the past 20 years, Lake Tabalak’s hydrology has changed again. Due to silting up because of a further reduction in vegetative cover and increased erosion in its catchment, and/or due to reduced inflow because of diversion of surface flow upstream, by 2012 depth of the lake in March had been reduced to 0.6–0.7 m (AK, unpublished data).

Utilisation, management and threats pre-1950

While still a wooded depression, Lake Tabalak was used by Bororo and other pastoralists to let their livestock feed on branches, leaves and pods, and perhaps also to water the livestock while there was standing water among the trees. In 1930 the pastoralists established a traditional well for watering (Traoré 2010). As population pressure was low, with less than 1000 people living near the lake, relatively little management was needed and there were few or no threats.

Biodiversity pre-1950

In describing the changes over the past 80 years in the biodiversity at and around Lake Tabalak, we focus on (woody) vegetation, large mammals and water birds. This is because these are the only biodiversity components about which information is available from a number of moments in time. This information comes from both general descriptions (vegetation, large mammals) and detailed counts (water birds).

Vegetation

Vegetation-wise, the stands of Acacia nilotica and Balanites aegyptiaca trees, present at Tabalak until at least the 1950s, stand out. Similar seasonally flooded depressions with Acacia nilotica trees in their lowest parts can still be found in various parts of the Sahel.

Large mammals

No complete survey is known of the large mammals formerly found in the Tabalak area, but observations in different publications give impressions, from which we present a selection here. Lhote (1951) included a map that shows which large game species occurred somewhere during the 1940s in the area where Touaregs lived, from Mopti in Mali and Niamey and Zinder in southern Niger,
north and east to southern Algeria and SW Libya. For the Lake Tabalak region, Lhote’s map showed the occurrence of lion (*Felis leo*), ostrich (*Struthio camelus*), giraffe (*Giraffa camelopardus*) and warthog

Figure 1. Approximate location of Lake Tabalak, 50 km NE of Tahoua, Niger, West Africa. The bar in the Google Earth image equals 25 km. The elongated Lake Tabalak is in the centre, Tahoua at lower left.
(Phacochoerus africanus). Dama gazelle (Gazella dama) he showed to the east (Tanout), north (Tamesna) and west (north of Filingué) of the Tabalak region, but not around Tabalak itself. A map of the occurrence of large fauna in the Tahoua region in the late 1930s, in Nicolas (1950), showed the additional presence around Tabalak of spotted hyena (Crocuta crocuta), striped hyena (Hyaena hyaena), red-fronted gazelle (Gazella rufifrons) and patas monkey (Cercopithecus patas). A bit further east are marked oryx (Oryx dammah), wild dog (Lycaon pictus), dama gazelle, giraffe and topi (Damaliscus korrigum (D. lunatus)). Details for a handful of these species were as follows.

Dama gazelle used to be one of the most widespread and common of gazelles in the Sahara and Sahel, with herds of hundreds of animals occurring (Kingdon 1997). According to Lhote (1946), by the 1940s it had already become very rare in the central Sahara, but was still very common in parts of the Aïr. The greatest number of herds of this species seen in Touareg country by Lhote and

Figure 2. (a) Google Earth image of the northern half of Lake Tabalak: northern basin and part of central basin. The scale bar at lower left equals 1.4 km, the area shown equals 6.5 × 6.3 km². Note the national road N23 along the western shore of the lake and crossing it at its northern end; the fields along virtually the entire shoreline of the northern half of the lake; the mud flats at the northern end of the lake, a good habitat for water birds but limited in size; the scarcity of trees (black dots). (b) Google Earth image of the southern half of Lake Tabalak: the central basin and the small southern basin. The scale bar at lower left equals 1.4 km, the area shown equals 5.0 × 6.4 km². Note the national road N23 coming in from the south-west and running along the western shore of the lake; the fields along most of shoreline of the lake; the mud flats at the southern end of the central basin, a good habitat for water birds but limited in size; the scarcity of trees (black dots). The barrier that broke to form the lake in the early 1970s is upstream, i.e. to the south east, in the dry riverbed just right of bottom centre.
colleagues were between I-n-Gall and Tahoua, the region where Lake Tabalak lies. Herds there sometimes still contained as many as thirty animals (Lhote 1946). Dama gazelles need more water than other desert gazelles, which they could have found in the seasonally flooded depression at Tabalak at least during part of the year.

Scimitar-horned oryx (Oryx dammah) formerly had a range of more than 4 million km²; in 1938 a herd of an estimated 10,000 scimitar-horned oryx was encountered in Chad (Kingdon 1997). In the 1940s it was still common in the entire steppe zone of the Touareg country. In October 1938, near Aderbissinat 200 km NE of Tabalak,
a herd of 400–500 was seen, probably attracted by the availability of water there during the dry season (Lhote 1946).

In historic times the subspecies *peralta* of the giraffe still occurred throughout the Sahel, from Senegal and Mauritania eastwards to the Nile (Kingdon 1997). Around 1909, 90 were killed in the Gao region in just one year by one Touareg, who was guarding the telegraph line from Timbuktu to Niamey, which the giraffes with their long necks used to break about every week.

![Figure 3. Lake Tabalak in 1993: (a) easy access for cattle; (b) emerging land hardly exploited. Copyright Joost Brouwer, Brouwer EAC.](image-url)
Table 1. Results of water bird counts at Lake Tabalak, Tahoua region, Niger, 1992–2007.

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<tbody>
<tr>
<td>Day of count</td>
<td>29 Jan</td>
<td>26 Jan</td>
<td>25 Jan</td>
<td>30 Jan</td>
<td>19 Jan</td>
<td>13 Apr</td>
</tr>
<tr>
<td>Maximum area (ha)</td>
<td>1150</td>
<td>1150</td>
<td>1150</td>
<td>1150</td>
<td>1150</td>
<td>1150</td>
</tr>
<tr>
<td>Area during count (ha)</td>
<td>1150</td>
<td>1000</td>
<td>650</td>
<td>1150</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Percentage of vegetated zone surveyed (%)</td>
<td>70</td>
<td>55</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>?</td>
</tr>
<tr>
<td>Percentage of open zone surveyed (%)</td>
<td>70</td>
<td>55</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>?</td>
</tr>
<tr>
<td>Source of numbers</td>
<td>AfWC</td>
<td>AfWC</td>
<td>AfWC</td>
<td>AfWC</td>
<td>SWGK</td>
<td>LUCOP</td>
</tr>
</tbody>
</table>

| Phalacrocorax africanus | Reed Cormorant | origin AP | 1 | |
| Nycticorax nycticorax | Black-crowned Night Heron | AP | 10 | 6 | |
| Ardeola ralloides | Common Squacco Heron | AP | 6 | 1 | 1 |
| Bubulcus ibis | Cattle Egret | A | 8 | 9 | 15 | 15 |
| Egretta alba | Great White Egret | A | 33 | 9 | 1 | 2 | 6 |
| E. intermedia | Yellow-billed Egret | A | | | | 1 |
| E. garzetta | Little Egret | AP | 162 | 28 | 34 | 50 | 5 | 60 |
| Ardea cinerea | Grey Heron | P | 99 | 107 | 103 | 26 | 77 | 20 |
| A. melanoccephala | Black-headed Heron | A | 7 | 1 | 1 | 2 |
| A. purpurea | Purple Heron | P | 3 | | | |
| Butorides striatus | Green-backed Heron | A | 2 | | | |
| Ciconia ciconia | White Stork | P | 1 | | | |
| Threskiornis aethiopica | Sacred Ibis | A | 160 | 81 | 34 | 50 | 6 | + |
| Plegadis falcinellus | Glossy Ibis | P | 122 | 16 | 3 | 5 | |
| Platalea alba | African Spoonbill | A | 35 | 88 | 25 | 25 | 43 | 95 |
| P. leucorodia | European Spoonbill | P | 2 | 2 | 6 | 23 | |
| | spoonbills unidentified | AP | 21 | | | |
| Dendrocygna bicolor | Fulvous Whistling Duck | A | 15 | | | |
| D. viduata | White-faced Whistling Duck | A | 2045 | 15 | 360 | 500 | |
| Alopochen aegyptiaca | Egyptian Goose | A | 1224 | 1385 | 415 | 725 | 394 | |
| Plectropterus gambensis | Spur-winged Goose | A | 9 | | | |
| Sarkidiornis melanotos | Knob-billed Goose | A | 38 | 28 | 74 | 50 | 6 | + |
| A. acuta | Pintail | P | 552 | 83 | 2015 | 31 | |
| A. querquedula | Garganey | P | 15 | | | |
| A. clypeata | Northern Shoveler | P | 66 | | 7 | |
| A. nyroca | Ferruginous Duck | P | 3 | | | |
| | ducks unidentified | P | 1050 | 3 | | |
| Fulica atra | European Coot | P | 1 | | | |
| Baleaerica pavonina | Northern Crowned Crane | A | 43 | (40) | | 70 | |
| Vanellus spinosus | Spur-winged Plover | A | 7 | 5 | | | |
| C. dubius | Little Ringed Plover | P | 21 | 57 | 78 | 6 | 7 | + |
| C. marginatus | White-fronted Sand Plover | A | | | | 7 | |
| Limosa limosa | Black-tailed Godwit | P | 1 | | 1 | 5 | |
| Tringa nebularia | Greenshank | P | 43 | 6 | 2 | 4 | 4 | + |
| T. stagnatilis | Marsh Sandpiper | P | 52 | | | + | |
| T. glareola | Wood Sandpiper | P | 110 | | | | |
| T. hypoleucos | Common Sandpiper | P | 2 | 4 | 4 | | + |
| T. erythropus | Spotted Redshank | P | 52 | 260 | 7 | 70 | |
| Gallinago gallinago | Common Snipe | P | 2 | 1 | | | |
| C. minuta | Little Stint | P | 276 | 100 | 268 | 35 | 79 | |
| C. temminckii | Temminck’s Stint | P | 4 | | | + | |
| Philomachus pugnax | Ruff | P | 80 | | 5 | 20 | |
| Himantopus himantopus | Black-winged Stilt | AP | 4 | 20 | 9 | + + | |
| Recurvirostra avosetta | Avocet | P | 14 | | | |
| | small waders unidentified | P | 500 | | | |
| Gelochelidon nilotica | Gull-billed Tern | P | 4 | 3 | 41 | ++ | |
| Sterna caspia | Caspian Tern | P | | 1 | 1 | |
| S. albifrons | Little Tern | P | 36 | 6 | 1 | |
| C. leucopterus | White-winged Black Tern | P | 1 | | | |

(Continued)
By the 1940s, a survey of the shoemakers in Tahoua and Agadez showed that together they received seven to ten giraffe skins per year, which were much prized and competed for because shoes made of giraffe leather fetched two or three times the price of shoes made of cattle leather (Lhote 1946). This indicates that there were at that time still giraffes in the Tabalak area, albeit in reduced numbers.

In the late 1930s, lion still occurred throughout the Sahel, up to about 100 km north of Tabalak (Nicolas 1950). They were still common in the Aderbissinat region 200 km to the north-east, where they congregated near the local wetland during the dry season, dispersing again when the rains started, like their prey. Touaregs of the Kel Gossi tribe in nearby eastern Mali hunted lion on horseback and on foot (Lhote 1946).

In the 1940s, spotted hyena were also still present throughout the Sahel zone. Around Menaka in Mali, 200 km NW of Tabalak, hunting after dark from a hide yielded two or three hyenas each night (Lhote 1946).

Warthog used to occur all the way to well north of Tabalak, living in depressions and wooded valleys like Lake Tabalak used to be (Nicolas 1950). During the rainy season, topi used to come north as far as Lake Bagam, north-east of Tabalak; it liked to enter ponds (Nicolas 1950).

African elephant (Loxodonta africana) occurred as far north as the Azawar, several hundred km north of Tahoua, until the 1880s.

**Birds**

Not a lot is known about the historical occurrence of most bird species in the Tabalak area. Nicolas (1950) mentions Touareg names from the Tahoua region for almost 100 bird species, but it is not clear which of these occurred around Tabalak at that time. One exception is the ostrich, which according to Nicolas (1950) was quite numerous NE of Tahoua. It was hunted by Touareg with traps or on foot, with two or three teams in relay. The final kill was executed with a spear or, to avoid damaging the skin, a stick. Ostrich were also hunted with dogs, who at the end of the dry season, when the Ostrich was weak, managed to get hold of it or at least make it stop. In addition to the skin the fat was used, to make ointments against rheumatism, but neither meat nor eggs were eaten by the Touareg, only by the Arabs (Nicolas 1950).

Also according to Nicolas (1950), the head of the secretary bird (Sagittarius serpentarius), or an imitation thereof, was used as a decoy by Touareg hunters. They put it on their own head, with the crest accentuated using the black feathers of a male Ostrich. On their protected knees they slowly approached a single antelope, imitating the stately gait of the secretary bird as they did so, until they were close enough to shoot it with bow and arrow (Nicolas 1950). This indicates that the secretary bird must have been during a period before 1940 a reasonably regular occurrence in the Tahoua region.

**Utilisation, management and threats 1950s–1990s**

After the depression had become a permanent lake in the early 1970s, pastoralists began to settle around the lake instead of only visiting it seasonally. Following the drought of 1983–1984, the government encouraged the settlement of Peulh, Haussa and Touareg at the lake so that they could practice market gardening and recover from their drought-related losses (Oumarou et al. 2009; Traoré 2010). A 50 ha irrigation area, exploited by local farmers, was installed at the south-western end of the lake in 1986–1987 (Ramsar Bureau 2004; Traoré 2010; Abdoul Kader 2012).

Increases in utilisation of Lake Tabalak were not only caused by migration to the lake. Between 1950 and 2010, the population of Niger grew by a factor five, from 3.2 million to almost 16 million. This implies an average annual growth rate of 2.7% and a doubling of

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<tbody>
<tr>
<td>C. hybrida</td>
<td>Whiskered Tern</td>
<td>P</td>
<td>17</td>
<td>5</td>
<td>16</td>
<td>++</td>
</tr>
<tr>
<td>Larus ridibundus</td>
<td>Black-headed Gull</td>
<td>P</td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of species of water bird</td>
<td>33</td>
<td>26</td>
<td>27</td>
<td>16</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Number of afro-tropical water birds</td>
<td>3626</td>
<td>1582</td>
<td>925</td>
<td>825</td>
<td>446</td>
<td>879+</td>
</tr>
<tr>
<td>Number of palaearctic water birds</td>
<td>1450</td>
<td>397</td>
<td>4485</td>
<td>88</td>
<td>309</td>
<td>?</td>
</tr>
<tr>
<td>Total number of water birds</td>
<td>5250</td>
<td>2061</td>
<td>5464</td>
<td>982</td>
<td>766</td>
<td>[700+]</td>
</tr>
</tbody>
</table>

Source of numbers: AfWC = African Water Bird Census (JB, Wim Mullié and other colleagues); SWGK = Netherlands Montagu’s Harrier Foundation (JB and Leen Smits); Origin A = Afro-tropical; P = Palearctic; AP = a combination of the two.
the population every 26 years. At present, the national population growth rate in Niger is estimated at 3.3%, which means a doubling in less than 22 years (Institut National de la Statistique 2012). At Lake Tabalak, the growth from less than 1000 people in the 1930s to 35,000 in 2009 (Abdoul Kader 2012), implies a doubling in population every 15 years. This is equivalent to an average annual population growth rate of 4.7%, due to births and immigration combined.

According to Mullié and Brouwer (1994), by the early 1990s Lake Tabalak was heavily used for watering of livestock from the surrounding drylands. The livestock also browsed on the surrounding vegetation and, after the harvest, on crop residues remaining on the fields along the shores of the lake. Only an estimated 20% of Lake Tabalak’s perimeter of close to 30 km, or roughly 300–600 ha, was taken up by market gardens, used for growing cassava, beans, gourds, melons, etc.; the other 80% was available for access by livestock (Figure 3; Mullié and Brouwer 1994). Note that this strip of market gardens 100–200 m wide would in part have been moving as the dry season progressed and the lake level dropped. Higher-lying land would dry out and be harvested, while lower-lying land would become available for cropping.

According to Ramsar Bureau (2004) and Oumarou et al. (2009), restocking with fish of Lake Tabalak took place in the mid to late 1960s, and then in 1974/1975, 1977, 1982, 1986/1987, 1988 and 1989, organised by various organisations including the local fishermen themselves. By the early 1990s, the estimated yield was 90–100 tonnes of fish per year.

In the early 1990s there did not appear to be any coordinated management of Lake Tabalak and/or its surroundings (Mullié and Brouwer 1994).

Threats to Lake Tabalak in the early 1990s included, according to Mullié and Brouwer (1994), sedimentation and encroachment of sand dunes, possible salinisation/alkalisation, due to evaporation of water and the salts left behind not being removed by leaching or run-off and, for the water birds, serious disturbance by the local population, especially the fishermen.

Biodiversity in the 1990s

Vegetation

Following the formation of the lake, the trees in the centre of the depression all disappeared, due to its being flooded permanently. Only around the edges stands of trees remained. In 1993, the trees the lake used to have at its northern end, *Acacia nilotica*, *A. albida* and *Balanites aegyptiaca*, were mostly cut by local inhabitants. JB was told at the time that they did this out of spite, because they were angry with the local Department of Environment staff for enforcing unwelcome regulations. The 2006 Google Earth image shows that 12 years later there had not yet been any significant regeneration of these tree stands.

Large mammals

By the early 1990s, almost all large mammals had disappeared from the Tabalak area. There were rumours of the odd hyena still being around, and also some red-fronted gazelles and patas monkeys (local information to JB and colleagues during the water bird censuses). That was about it. There may still have been enough unoccupied lake shore at the time for these animals to drink at the lake. Development of Lake Tabalak cannot be the main cause of the disappearance of all the other large mammals from the area, but the increased disturbance from human activity would not have helped. See the discussion section below.

Birds

Water bird counts were carried out at Lake Tabalak at the end of January from 1992–1995, as part of the Niger component of the African Waterbird Census. While there was already significant disturbance due to human activity, the lake was at that time a good place to see water birds. An average of 4000 Palearctic and Afro-tropical water birds of up to 32 species were seen per count. See Table 1, Mullié and Brouwer (1994) and the Niger Bird Database (2013).

Variation between years in numbers of water birds counted can be explained in part by variation in regional rainfall in the year before each count. For instance, rainfall in 1993 was quite poor, which meant that small wetlands in the region dried out quickly. By January 1994 only the larger wetlands like Lake Tabalak still contained a fair amount of water, which led to water birds being concentrated there, especially Palearctic ducks. Almost 5500 water birds were counted that year. The rainy season of 1994, on the other hand, was very plentiful and filled many wetlands to the brim. As a result, a lot of wetlands in southern Niger still contained water in January 1995, water birds remained dispersed and less than 1000 were counted at Tabalak. See Mullié et al. (1999) for a more detailed discussion of rainfall effects on water bird distribution in the Sahel zone of Niger.

This being said, there was a notable steady decline during those four years of counts in afro-tropical water bird numbers at Lake Tabalak, from 3600 to 800. Not too much should be read into the results from a short...
series of counts at one wetland, but for some afro-tropical species the decline in numbers counted at Lake Tabalak during the 1990’s is matched by an apparent national decline. A case in point is the Egyptian

Figure 4. Lake Tabalak in 2012: (a) onions and other crops on the mudflats; (b) a well-developed fishing industry. Copyright HA Abdoul Kader.
Alopochen aegyptiacus, which during 1992–1995 declined from 1200 to 700 at Lake Tabalak, while the national population estimate declined from about 20,000 to about 8000 (background data to Brouwer and Mullié 2001). The decline at Lake Tabalak will have had a large influence on the decline in the national population estimates, but there were declines at other wetlands in Niger as well. It remains unclear whether the apparent decline was due to (a combination of) increased disturbance, increased harvesting, reduced breeding or other causes.

Utilisation, management and threats by 2004

The Ramsar site information sheet (Ramsar Bureau 2004), mentioned that the height of the dam under the main road at the north-east end of the lake had been increased at an unspecified time, which also increased the storage capacity of the lake. As the dam also includes a bridge section, it is not clear to us how its being raised increased the lake’s storage capacity. In addition, vegetation had been planted to fix the dunes surrounding the lake. In 1976 an international consultant had written a proposal for the development of the lake aimed at rational use of its resources, notably by intensification and diversification of its agricultural uses, without mentioning any specific conservation measures. The actions suggested in the report were only beginning to be realised by 2004 and were not harmonised with other development actions, according to Ramsar Bureau (2004).

The Ramsar information sheet gives the impression that pastoralism was not considered very important anymore at Lake Tabalak. It is only mentioned once, in an off-hand way. See however, the importance for pastoralism accorded to the lake in LUCOP (2007), further on in this article.

Agricultural activities on the other hand, directly on the lake, were mentioned to occupy 600 ha, benefitting 5400 people in 12 villages around the lake. All the arable land was deemed to be cultivated, also further away from the lake, and agriculture was extending into marginal land on the surrounding plateaux (Ramsar Bureau 2004).

Water from the lake was used for drinking and cooking. Fish production was estimated by Ramsar Bureau (2004) at 100–300 tonnes per year, worth € 50,000 to € 150,000 locally (and 5–10 times that amount in the capital Niamey 500 km away, Brouwer (2010)).

Management was said to be shared by the state and local organisations (Ramsar Bureau 2004). Local structures (the Fishermen’s Cooperative, the Committee of Farmers and Market Gardeners of the lake, the Fish Merchants’ Association, the Women’s Group) played a very important role in the prevention and management of conflicts between the different users of the lake’s resources and organise access to those resources together with the traditional leaders. Responsible for the management of the Ramsar site was the local district Department of Environment based at Abalak, which came under the Ministry for Water, Environment and Combatting Desertification (Ramsar Bureau 2004). Note that the Ramsar Bureau does not mention herder organisations. Eight years later, Abdoul Kader (2012) saw this lack of organisation among herders as a serious problem.

The following threats to Lake Tabalak were mentioned (Ramsar Bureau 2004):

- climate change;
- unsuitable agricultural practices leading to erosion;
- illegal cutting of trees and shrubs;
- the use of illegal means of fishing leading to depletion of the fish stock, related to a lack of education of the fishermen in spite of the existence of their cooperative;
- overgrazing, particularly on the sand dunes surrounding the lake.

Biodiversity by 2004

By 2004 the remaining trees surrounding the wetland were being used for construction and as firewood. Regarding large mammals, the Ramsar site description sheet only mentions Dorcas gazelle (Gazella dorcas) and warthog, which were very rarely encountered near the lake (Ramsar Bureau 2004). All other large fauna was apparently gone, in line with the findings in the 1990s. The water bird count results for 2002 included as an annex to Ramsar Bureau (2004) are unusually high, e.g. 8327 Egyptian geese, 204 black-crowned cranes, 750 sacred ibis and 510 knob-billed geese. Because the numbers are so high, and the identity and expertise of the counters is not known, these count results are not included in Table 1.

Utilisation, management and threats by 2007

According to a mission for LUCOP (2007), Lake Tabalak was at that time still quite important to livestock. Livestock were watered at the lake, fodder was cut from the surrounding vegetation and there was direct grazing of crop residues remaining in the fields along the shoreline were recession agriculture was practiced. The mission noted strong agricultural and market gardening pressure round the lake. A second market gardening area, of 240 ha, had been established in 2006, including a pumping station, irrigation and drainage canals, and access roads (Traoré 2010; Abdoul Kader 2012). According to Brouwer (2010), by 2007, 80% of the perimeter was
taken up by market gardens, up from 20% in the early 1990s. Livestock access possibilities had diminished accordingly.

Regarding management, the LUCOP (2007) mission noted that neither the local elected officials nor the users of Lake Tabalak appeared to be aware of its status of Ramsar Wetland of International Importance, or of the consequences of that status for management of the lake. Ramsar status demands sustainable management of a wetland, also in respect of its biodiversity. Certainly the off-take of 3 million m$^3$ of water for irrigation would appear to be in conflict with the Ramsar status, as it was considered likely to lead to drying up of the southern-most of the three basins of Lake Tabalak. This is the deepest of the three basins and thus the one that holds water longest. The mission report proposed bringing the different interest groups together to improve their knowledge of the lake and each other, so that they could work in cooperative fashion towards sustainable management of the lake and the surrounding uplands. This could include taking advantage of the Ramsar status of the lake by installing information panels and a bird observation hide, as well as training local eco-guides to show around tourists and school groups (LUCOP 2007).

Threats mentioned by LUCOP (2007) included cutting of what remained of the Acacia nilotica stands, upstream erosion leading to silting up of the lake basin and, most importantly, (developing) off-take of 3 million m$^3$ of water every year for the 240 ha market garden development, which increased the risk of the lake drying up during the dry season. Thousands of pastoralists and their families were negatively affected by this (LUCOP 2007; Abdoul Kader 2012).

**Biodiversity by 2007**

The LUCOP (2007) mission to Lake Tabalak in mid-April 2007 counted more than 700 water birds of 23 species. This is very similar to the 766 water birds of 23 species counted by an expedition of the Dutch Montagu’s Harrier Foundation ten weeks earlier (Table 1). Notable were the continued importance of Lake Tabalak for 70 black-crowned crane (a threatened species), and for African and European spoonbills, though by April the European spoonbills had already gone north to their breeding areas. Lake Tabalak is by far the most important known site for both species of spoonbill in Niger (Niger Bird DataBase 2013).

The LUCOP mission found the most important sites for birds to be an island at the northern end of the lake, which accommodated the black-crowned cranes as well as a duck roost; and the nearby mud flats and grassy lake shores. At the southern end of the southern basin of the lake there were similar mudflats (LUCOP 2007).

**Utilisation, management and threats by 2010–2012**

By 2009, the municipality or ‘commune’ of Tabalak had 35,000 inhabitants, up from less than 1000 in the 1930s, with an average household size of 10.7 people. The total annual budget was 25,000 euros and the investment budget 5335 euros (Abdoul Kader 2012). The municipality covered 666 km$^2$ to the north, east and south-east of the Lake plus almost all of the lake itself. It included 54 villages and hamlets (Oumarou et al. 2009).

Traoré (2010) describes the effects of agricultural development of depressions and wetlands, including Lake Tabalak, on the survival of small pastoralists. He visited the area in May 2010, when there were many transhumant herders at Lake Tabalak because the rains and the new pasture growth in the grasslands up north hadn’t started yet. Only the smaller of the basins of Lake Tabalak still contained water. The entire depression was covered with market gardens (Figure 4(a)). Average market garden size was between 1.5 and 2.5 ha and a very wide range of crops and sometimes fruit trees were grown (Abdoul Kader 2012). Only five access routes to entire lake still existed for livestock, four of them 30 m wide and one 20 m (Oumarou et al. 2009). Livestock were grazing everywhere. Market gardeners were selling access to crop residues, for grazing, in plots of 200–300 m$^2$. This second ‘harvest’ was said to be more lucrative for them than the agricultural produce itself, bringing in 13,000–15,000 FCFA, or 20–23 euros, per 100 m$^2$ (Abdoul Kader 2012). The transhumance pastoralists indicated that they had no choice but to accept having to pay for this grazing of crop residues, and hope for an early start to the rainy season. Their problems were further exacerbated by the reduced availability of dry season grazing further south, forcing them to come back north to the Lake Tabalak area earlier than in the past (Traoré 2010).

Some market garden plots at Lake Tabalak looked more like attempts at raking in money from the pastoralists than like real market gardens. Because of problems in gaining access to fodder resources, pastoralists might have to sell livestock at the time of year when prices are lowest and eventually abandon this livelihood altogether (Traoré 2010).

There were, in 2010, 8300 cattle, 14,500 sheep, 11,500 goats, 12,400 donkey, 11,500 camels (dromedaries) and 200 horses owned by people living in the municipality of Tabalak. Transhumance livestock, owned by people who don’t live in the community of Tabalak, but who do use the lake for watering, is not included in these numbers. The livestock of the municipality of Tabalak in part also goes north to graze for the rainy season (Abdoul Kader 2012).

The government appears to have done little to stop the conversion of this traditional end-of-dry-season
grazing area and fallback zone with relatively good quality forage into market gardens where pastoralists have to pay high prices to graze the crop residues of mediocre quality. Article 2 of Government Decree no. 87/077/PLMS/MI of 1987, which defines areas reserved for pastoralism, can be read as a formalisation in disguise of the previous unofficial appropriation of grazing areas for agricultural purposes (Abdoul Kader 2012).

Similarly, ‘cash for work’ soil conservation projects have helped convert surrounding upland traditional grazing areas into agricultural fields. To give a quantitative perspective on these changes, in the Commune of Tabalak, between 1975 and 2009, upland agriculture increased from 24,000 ha to 46,000 ha; during the same period the area of grazing land decreased from 35,000 ha to 6600 ha, according to Oumarou et al. (2009). Although the numbers don’t quite add up (6000 ha have disappeared), it is clear that there has been an enormous loss of grazing land in the surroundings of Lake Tabalak. With an estimated fivefold increase in population over those 34 years (annual increase of 4.7%), this was only to be expected.

Fishing continues to be a very important source of revenue to the community, bringing in € 87.000 in one year with only very simple equipment (Figure 4(b); Abdoul Kader 2012). By 2012 there were nine fishing cooperatives which formed a single fishermen’s union. Fishing was well regulated by the state, with a fishing permit being required for each fisherman, certain fishing equipment prohibited, and a well-defined closed season of seven months to allow the fish to spawn and grow. Small fish were never put back, the size of fish caught being regulated only by mesh size of the nets. Regulations were enforced by the government and the presidents of the fishing cooperatives. During years of drought and towards the end of the fishing season smaller mesh sizes were allowed. Fish prices per kg of each species were fixed at the start of the fishing season in a meeting of the government, fish merchants, fishermen and consumers. Income was divided between fishermen, merchants and the cooperative, using fixed percentages that differed slightly between species. No chemicals were used to catch fish (Abdoul Kader 2012).

Other uses of Lake Tabalak in 2012 included brick making, carting of water for construction purposes and bird hunting (Abdoul Kader 2012).

In relation to management, Abdoul Kader (2012) mentions the poor organisation of, and frequent conflicts between, the various parties that use the lake, even though there are various management efforts, including by the Commission Foncière Communale (Cofocom, Communal Land Tenure Commission), and the Comité de Gestion Concertée de la mare de Tabalak (CGC, for management of the lake). Agriculture, livestock raising and fisheries are still by far the most important economic activities around Lake Tabalak and are generally practised in some sort of combination: 24% of the population only farms, 11% only raises livestock, 29% combines livestock with market gardening, 11% combines market gardening with fishing and 26% practices all three. There are no pure fishermen, and livestock raising and fishing are not combined as such (Abdoul Kader 2012).

Pastoralists tend to be the most transient and the least organised of the users of Lake Tabalak. They generally consider changes to the lake to be acts of God and not something that people can do anything about. Fishermen-market gardeners see themselves as fishermen first and complain about the negative effects of market gardening on the lake. Even so, during the dry season the agricultural fields are fertilised by having the local livestock, and where possible the transhumance livestock, camp on them at night (Abdoul Kader 2012). Livestock also bring nutrients to the lake through dropping their manure and urine when being watered. This increases the productivity of the lake and benefits farmers and fishermen, as well as water birds (Brouwer and Mullié 1994b; Mullié et al. 1999; Brouwer 2010).

Local inhabitants are of course very much aware of what Lake Tabalak gives to them. Too often, however, they see the lake as a resource for themselves to use, with others making that usage more difficult. Of those interviewed, 45% recognised that there are conflicts between the different users, mostly concerning damage by animals and non-respect of regulations. Local representatives of the various ministries as well as the municipality are responsible for controlling the cutting of trees, for controlling fisheries (together with the fishing cooperatives), for controlling invasive weeds (together with local inhabitants), and for public awareness (Abdoul Kader 2012; TS pers. obs.).

Local inhabitants are also aware that the level of Lake Tabalak is now often much lower than it ever was before, and that there is a serious risk of it disappearing ‘in ten years’ if no corrective action is undertaken. One problem is considered to be the lack of technical education of the users of the lake, whatever their source of income. At the same time all envisage expanding their activities around the lake, which is already over-used, given the continuing degradation of its natural resources (Abdoul Kader 2012).

According to Abdoul Kader (2012), threats to Lake Tabalak included market gardening practices that are not suitable for the environment, such as using motor pumps for irrigation, inappropriate use of chemical fertilisers and pesticides and the construction of field boundaries that trap wind-blown sand and/or are a point of entry for invasive plants. Other threats are abandonment of the practice of fallowing and over-utilisation of the vegetation in the catchment of the lake, leading to increased upstream erosion en thus silting up of the lake basin.
From 1975 to 2009, the area of gullies or ‘koris’ increased from 900 to 3100 ha, according to Oumarou et al. (2009).

In addition, the return of emigrants from Ivory Coast and Libya, because of the upheaval in those countries since the turn of the century, increased the human pressure on, and exploitation of, Lake Tabalak. Poor rainfall was also seen as a threat by the local population, although the general tendency since the early 1980s has been for an increase in rainfall (Abdoul Kader 2012).

A number of the local people also realise that they need to work together to achieve a solution: each village or group or person for it- or him- or herself won’t work. That being said, they also feel that outside finance will be needed and, of course, the cooperation of the government, development organisations and other non-users of the lake. Better access to outside markets, to credit facilities and to means of conserving their produce, including fish and meat, would also help to achieve sustainable participative integrated natural resource management (PINReM), as required by its Ramsar status (Abdoul Kader 2012).

**Biodiversity by 2012**

By 2011, almost all the indigenous trees in and around Lake Tabalak were either gone or heavily used for various purposes, including pruning for livestock feed. The exotic thorny, woody invasive weed *Prosopis juliflora* competed with what was left. Due to the conversion to market gardens, the original fringing and aquatic non-woody vegetation was also either gone or under heavy pressure, replaced in part by introduced species such as neem (*Azadirachta indica*), mango trees (*Mangifera indica*) and eucalypts (*Eucalyptus* sp.; Abdoul Kader 2012; TS, pers. obs.).

For large wild mammals as well as for water birds, the situation at Lake Tabalak has not improved since 2007. That means that large wild mammals are all but gone from the area, and that the numbers of water birds using the lake during the dry season are well down on the numbers of 20 years ago. The recommencement of hunting of birds at the lake, mentioned by Abdoul Kader (2012), legal again since 1996 with a permit and during a specified season, will not have helped. Good numbers of threatened black-crowned cranes and of African and European spoonbills may still make dry season use of the lake.

**SWOT analysis 2012**

A slight modification of a SWOT analysis (strengths, weaknesses, opportunities and threats) of Lake Tabalak and its users, by Abdoul Kader (2012), brings out the following.

**Strengths:**
- the large number of local organisations
- the local presence of government services
- the presence of a Communal Land tenure Commission (Cofocom), e.g. to resolve conflicts and determine property rights
- the motivation of locals to contribute labour
- the status of Lake Tabalak as public land, requiring everyone who uses it to contribute to its management, upkeep and proper functioning.

**Weaknesses:**
- the poor administrative and financial capacity of local organisations
- the lack of interest by the Ministry of Agriculture and Animal Production in the lake
- the inexperience of local organisations, partly caused by personnel changes following each local election
- the lack of power and of recognition of local organisations, such as the Comité de Gestion Concertée de la mare (CGC)
- the divergence of the interests of different stakeholders.

**Opportunities:**
- decentralisation, if the community takes advantage of the openings for participative integrated natural resource management that decentralisation provides
- the interest of development organisations in facilitating sustainable use of the natural resources of the Lake Tabalak area
- the Ramsar status of the wetland, if the national government commits itself to striving for the sustainable management of Lake Tabalak that its Ramsar status requires.

**Threats:**
- little recognition of the needs of local inhabitants in national legislation and in the text of the Ramsar Convention
- poor communication between the national government and the Ramsar Convention and the local inhabitants
- the lack of benefit to local inhabitants of many external initiatives
- the risk of the Ramsar status being withdrawn
- the lack of long-term commitment by technical and financial partners, including the national government.
What the effects will be of climate change, often seen as a threat, remains unclear. Abdoul Kader (2102) ends by proposing an approach for arriving at sustainable PINReM, involving all stakeholders and modern as well as traditional power structures. Additional income could be gained from ecotourism (e.g. to see migratory birds), development organisations, parties to the Ramsar Convention, levies on products from the lake, contributions by user organisations and development of external markets.

Conclusions and recommendations
As we have shown, over the past 80 years Lake Tabalak and surroundings have developed

- from a well-wooded depression, mostly used seasonally by pastoralists, and with probably much less than 1000 inhabitants,
- to, around 1970, a lake of 1150–1200 ha at maximum extent, much favoured by pastoralists and water birds,
- and from there to what is now an area with 35,000 inhabitants, with as most important local economic activities market gardening (from shore to shore by the end of the dry season) and fish production.

The situation for biodiversity at and around Tabalak has changed enormously accordingly. Most of the woody vegetation has been cut; most of the remainder is heavily pruned each year for livestock fodder and fence making. The main reason for disappearance of the thousands of large mammals of many species from the surrounding drylands is no doubt overhunting. Scimitar-horned oryx has been hunted to extinction in the wild (Durant et al. 2013). Hunting has also caused the dama gazelle to become critically endangered, with perhaps only 300 individuals left in 4 isolated populations in Niger (Termit, the Aïr) and Chad (Durant et al. 2013). Lhote (1946) already indicated that the advent of motorised transport and of automatic weapons had led to a great reduction in numbers of addax antelope (Addax nasomaculatus). However, for certain species decreasing access to fodder or prey, and to water, due to land use changes and increased disturbance at wetlands, has no doubt played a role as well. This also goes for water birds: their numbers at Lake Tabalak probably rose after the lake became permanent in the 1970s, but they have been decreasing over the past twenty years.

As agriculture, especially market gardening, increased at Lake Tabalak, pastoralism has lost much access to its resources. It must not be crowded out completely. If that happened there would be no more transhumance pastoralists from the Tabalak area to utilise the production capacity of the dryland grazing areas further north. Nutrient transfer by livestock from surrounding dryland grazing lands to Lake Tabalak would also cease, negatively affecting that same agriculture as well as fish production.

Planned increased off-take of water, to benefit new irrigation projects, will cause further drying out of Lake Tabalak and is likely to lead to serious conflicts with present users of the lake.

The main cause of the present problems at Lake Tabalak appears to be what is known as ‘the tragedy of the commons’. The area where Lake Tabalak was formed belonged to no one, or was considered to belong to no one. So individual people, responsible to their own families and own groups first, took what they needed without considering longer-term sustainability and coordinating with others. Those that settled at the lake to farm or fish had the most to say, those that only passed by seasonally with their livestock were crowded out. In addition, the lake and its direct surroundings were and are part of three communes in three different districts, which makes coordinated management more complicated.

To make the Lake Tabalak resource last as long as possible, benefiting of as many people as possible, PINReM, involving all stakeholders, must be implemented as soon as possible. Fortunately, as Oumarou et al. (2009) and Abdoul Kader (2012) show, there already is local awareness of the need for such coordinated, sustainable management, and of the necessity to contribute if one wants to continue to profit. A case in point is the coordinated management of the fisheries throughout the lake, though coordination with other activities is still poor or lacking. Abdoul Kader’s SWOT analysis is a good starting point for working towards the desired integrated PINReM. The multi-stakeholder forums promoted by the LUCOP Project in the pastoral areas around Tabalak and further north in Niger (Sommerhalter 2008; Rabeil, Newby, and Harouna 2014), can help achieve this.

The situation at Lake Tabalak is already such that even PINReM is unlikely to bring back much of the large mammal biodiversity that once existed there and in the surrounding drylands, even if those surrounding drylands permitted such a return. That the developments at Lake Tabalak are not unique is shown in Table 1 of Brouwer (2010), in which developments over some twelve years at Lake Tabalak and nine other isolated wetlands in Niger are summarised. At all of them there has been much degradation and biodiversity loss, from one of the isolated wetlands waterbirds have disappeared completely. The same thing happened at Lake Madarounfa near Maradi already twenty years earlier (JB, pers. obs.) These developments makes it all the more urgent to avoid, at other wetlands in the Sahel that are not quite as damaged yet, a repeat of the environmental and social problems that
occurred at Lake Tabalak. To achieve this, at all these wetlands in drylands:

- PINReM should be worked towards as soon as possible, before outside interests become much larger; outside interests being the interests of people that are not traditional users of the lake or do not live locally.
- In developing PINReM, account must also be taken of the interests of those who are present at the wetland only part of the year, such as transhumant pastoralists.
- The interests of biodiversity must be taken into account as well.
- Proper valuation of all the services provided by the wetland ecosystems concerned is essential in this process, and should be carried out sooner rather than later.
- Recognition and valuation of the interactions between the wetlands and the associated drylands should be an important part of this.
- It should also be taken into account that in dryland areas, wetlands function as wetland systems, not individual wetlands. Depending on spatial and temporal distribution of rainfall, one wetland may be important for pastoralists and waterbirds one year, another wetland the next year.
- Any proposed change to a wetland should be accompanied by an all-encompassing environmental impact assessment.

In addition to mutual benefits, such as transfer of nutrients to wetlands by livestock that use a wetland, there can also be conflicts of interest between, e.g. pastoralists, farmers, fishermen, collectors of natural products and those who want to conserve biodiversity and/or use it wisely. This is especially so when the interests of one or more groups become large in relation to the size of the wetland. This is another reason why these wetlands should not be managed individually, but rather as a system of wetlands, with perhaps certain interests prevailing at one wetland and other interests at other, nearby wetlands. Management of all wetlands in a region as one system also allows reserving some of the wetlands as fall-back resources during the inevitable times of drought.

Good management of the wetlands in dryland areas is not sufficient for conservation of the associated wetland and dryland biodiversity, but it is definitely an essential component.

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