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Reflooding the coupled human and natural system of the Waza-Logone Floodplain, Cameroon

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The rewilding framework is used to guide the restoration of ecological processes in natural systems, but the framework can also be used in the restoration of social and ecological processes in coupled human and natural systems. We use the case of the large-scale reflooding of the Waza-Logone Floodplain in Cameroon three decades ago as an example of rewilding a coupled human and natural system. Drawing on studies that have been conducted of the Logone Floodplain and Waza National Park over the last five decades, we discuss the reflooding efforts, review the long-term impact of the reflooding, and reflect on the assumptions of the reflooding effort. Our review shows that restoring the hydrological and ecological processes benefitted human populations but was not sufficient for supporting wildlife; and, political dynamics impact ecological processes and must be considered for rewilding to succeed.

KEYWORDS

rewilding, reflooding, social-ecological processes, coupled human and natural systems, vegetation, wildlife, pastoralists, insecurity

Introduction

The reflooding of the Logone Floodplain in the Far North Region of Cameroon three decades ago can be conceptualized as a large-scale abiotic rewilding of a social-ecological system in which humans are an integral part. In our review of this case study, we explore how the frameworks of rewilding and coupled human and natural systems can be integrated to support the restoration of social and ecological processes in floodplains and other social-ecological systems. The case shows how rewilding and restoring ecosystem processes was beneficial for human systems, but that it was not sufficient for protecting wildlife in the floodplain. The lack of involvement and investment of the government in supporting Waza National Park to protect its wildlife may have been one of the main reasons why the reflooding did not benefit wildlife.

The goal of rewilding, according to Carver et al. (2021), is "the restoration of functioning native ecosystems containing the full range of species at all trophic levels while reducing human control and pressures" (1888). The authors outline ten principles for rewilding, which include landscape-scale planning focusing on restoring ecological

processes that are always changing, particularly within the context of global climate change (Carver et al., 2021). The rewilding approach makes an analytical distinction between human and natural systems with the goal of separating the two. While it may be possible to reduce human control in some systems (and to reduce natural controls of human systems), that is not necessarily a desirable goal, and it may be counterproductive.

The framework of coupled human and natural systems also makes an analytical distinction between human and natural systems (Liu et al., 2007), but unlike the rewilding approaches it does not seek to separate humans and nature (Figure 1). Rather it views the world as consisting of dynamically coupled human and natural systems, or, better, coupled human and natural *processes*. For example, there are currently no areas that are not affected by humans (e.g., plastic particles at the north pole) and there are no areas in which nature does not shape humans (e.g., antibiotic-resistant bacteria in hospitals). Moreover, these systems are tightly integrated through the couplings between human and natural processes, that can be beneficial (e.g., trees providing ecosystem services in cities, pastoralists creating grazing lawns in savannas) or detrimental (e.g., ticks from deer spreading Lyme's disease in cities, concentrated animal feeding operations polluting streams and rivers). In the framework of coupled human and natural systems, rewilding involves restoring ecological processes that can contribute to equitable and sustainable outcomes for both humans and wildlife.

The main difference between the two frameworks is that the coupled systems framework is relatively agnostic about what the state of these systems should be, as it is foremost an analytical framework, whereas the rewilding framework has a normative component or purpose, which is to restore natural systems by reducing human impacts.

The Waza Logone Project that led the reflooding efforts to restore the coupled human and natural system of the Logone Floodplain aimed to restore ecological processes to contribute to equitable and sustainable outcomes for both humans and wildlife. Rather than reducing human impacts, reflooding the Logone Floodplain was about serving both humans in the Logone Floodplain and wildlife in Waza National Park. In this paper, we discuss these reflooding efforts and their long-term impacts. One of the themes in our discussion is that while the reflooding was a short-term success, the benefits of reflooding were uneven for humans and wildlife in the long-term, mainly because of security problems in the region and lack of government investment in the park.

We have written about the reflooding efforts and its impacts previously (e.g., Moritz et al., 2016; Scholte, 2005), but in this paper, we take a long-term perspective considering the impacts of reflooding on human and natural systems in the floodplain. We realize ours is an unusual example of an abiotic rewilding of a large-scale landscape that was beneficial to floodplain inhabitants, but ultimately less so for wildlife populations. The case study demonstrates that rewilding and restoring ecological processes is not only beneficial to natural systems, but also to human systems. In addition, for rewilding to succeed in benefitting both human and wildlife populations, one has to not only restore ecological

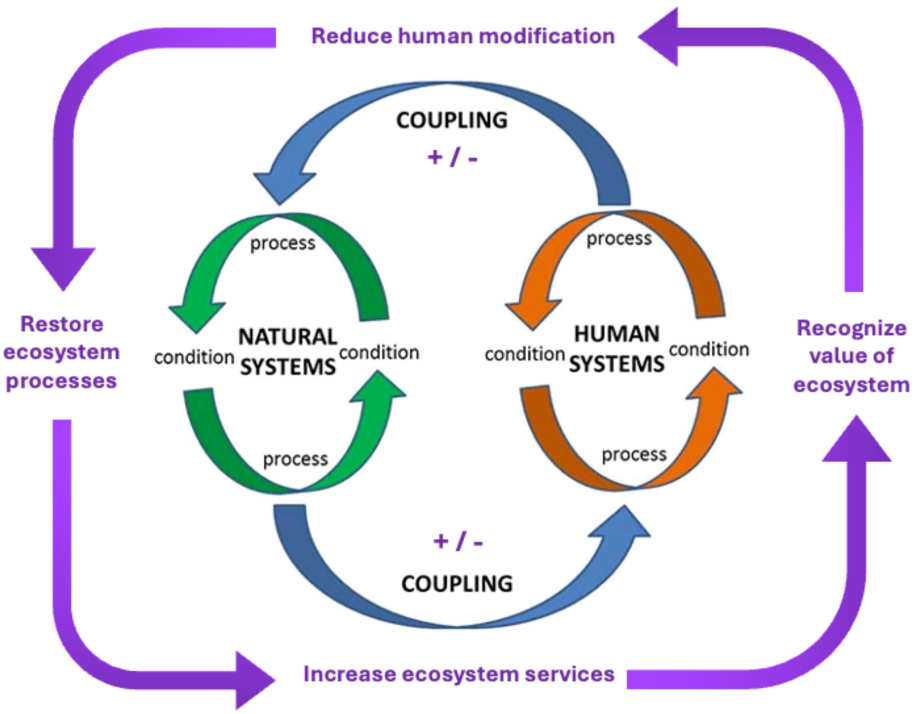

FIGURE 1
Conceptual frameworks of coupled human and natural systems and rewilding. Adaptation of the graphic from the solicitation from the Dynamics of Coupled Natural and Human Systems (CNH) Program at the U.S. National Science Foundation (NSF) (Baerwald et al., 2016). The arrows and text in purple represent the rewilding conceptual framework.

processes, but also consider the social, economic, and political processes that are critical for sustainable development. In some instances, rewilding may benefit from an adaptive co-management approach, which seeks to integrate the social dynamics and priorities of local communities.

Historical context

The Logone Floodplain is located in the Far North Region of Cameroon, and it is one of a number of seasonally flooded flatlands that are an integral part of the watershed of the Chad Basin. It is a key resource area for wildlife, migratory birds, and provides livelihoods for tens of thousands of fishers, farmers, and pastoralists (See Figure 2). The plain is flooded from September through December when the Logone River exceeds 1,500 m^3 s^{-1} (Delclaux et al., 2010), and the area flooded depends directly on the flow rate of the Logone River (Jung et al., 2011). The floodplain is an anthropogenic landscape that has been shaped by human populations for centuries through fishing, herding, and farming (Scholte, 2005). In the last five decades there have been major changes in the flooding regime of the Logone floodplain, with direct and indirect consequences for the coupled human and natural systems of the floodplain. These changes were due to climate change and variability, but mostly due to the engineered modifications of the hydraulic landscape.

A particularly dramatic modification occurred in 1979 when the Cameroonian government embarked on a large-scale infrastructural project to increase domestic rice production in Cameroon. The project involved a 30 km-long dam that created a reservoir – Lake Maga – that was fed by seasonal rivers in the west and by the Logone River upstream of the floodplain. The water in the reservoir is used for irrigated rice fields located north of the dam. To protect the reservoir and rice fields from seasonal flooding, an approximately 50 km-long embankment was built along the west bank of the Logone River (Figure 3). The consequences of these infrastructural projects on the flooding regime were dramatic: large areas in the western part of the floodplain, including Waza National Park, were no longer flooded. As a result of decreased habitat, fish populations declined and many fishermen emigrated or changed their fishing strategies to cope with the decline (Laborde et al., 2016). The reduced flooding also reduced resources and habitats for wildlife and migratory birds in the floodplain (Loth, 2004; Scholte, 2005).

The dam also had major consequences for pastoralists. The reduction in flooding directly affected forage production, in part via a change in plant species composition in areas most affected by the reduced flooding (Scholte, 2005). Perennial species like V*etiveria nigritana*, *Echinochloa pyramidalis* and *Oryza longistaminata* slowly disappeared, while less palatable annual grasses like *Sorghum arundinaceum* increased in areas where flooding was reduced. Moreover, on the western edge of the floodplain, which no longer flooded, the grass savannah gradually changed into a dense *Acacia seyal* shrubland. Both the shift from perennial to annual species and from grass to woody savannah reduced the grazing resources for pastoralists, many of whom left the floodplain in response (Scholte et al., 2006).

The Waza-Logone Project was an international effort to undo part of the damage of the upstream dam and embankment that severely reduced flooding in an area of 1,500 km^2, including Waza National Park. The project started in 1993 and was based on a decade-long collaboration between the Garoua Wildlife College (Cameroon) and Leiden University (The Netherlands). Earlier unpublished studies of the Logone Floodplain on vegetation, wildlife, fisheries, and pastoralism, showed the impact of the floodplain desiccation, and drew the attention of authorities in Cameroon and the Netherlands. Dutch researchers successfully

FIGURE 2
Livelihoods and wildlife in the Waza-Logone Floodplain. Clockwise from top-left: Korrigum drinking in Waza National Park, fisher navigating the floodplain during the flooding season, herder watering cattle in the dry season (pictures from Paul Scholte and CARPA).

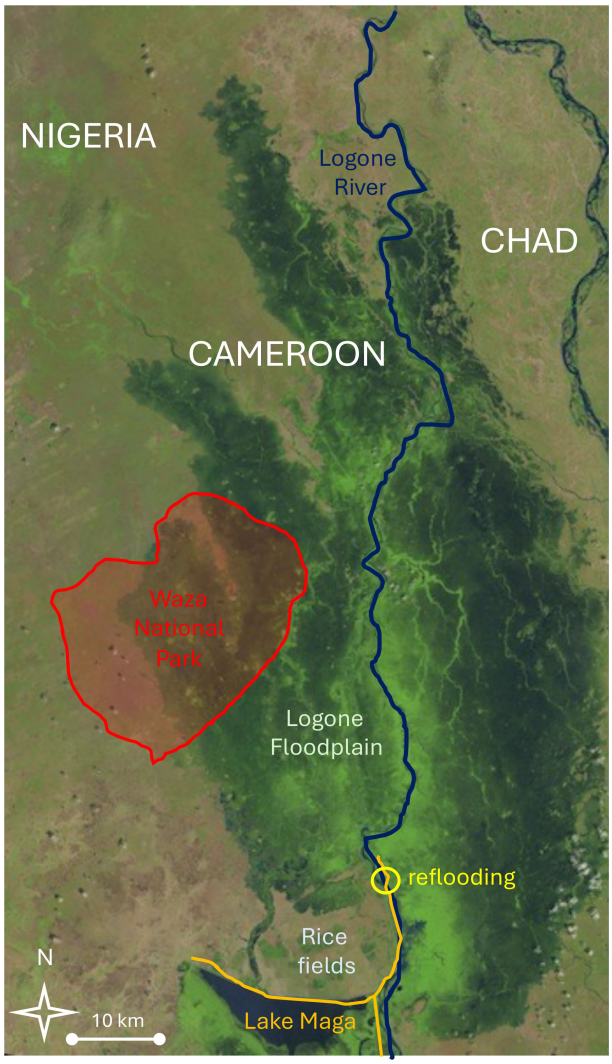

FIGURE 3
Map of the Logone Floodplain. The flooded area is colored green. The yellow circle indicates where the Waza Logone project opened two waterways in the embankment for the reflooding of the floodplain.

lobbied the Netherlands Ministry of Development Cooperation to make funds available for a specifically designed project on floodplain rehabilitation. The International Union for Conservation of Nature and Natural Resources (IUCN) was invited to lead the project, in collaboration with Cameroonian authorities, Leiden University, and the Netherlands Development Organisation (SNV).

The Waza-Logone Project aimed to serve both wildlife in Waza National Park and the human inhabitants of the Logone Floodplain. The researchers appealed to donors through their integrated approach, which focused on rehabilitating both the human and natural systems of the floodplain. They were concerned that reflooding efforts that focused only on the human systems, may generate less interest and funding from donors for the project. For inhabitants of the floodplain, the park and plain are two distinct entities, pastoralists, for example, refer to the floodplain as *yaayre* (floodplain) and the park as *surande* (forbidden area). It is generally conservationists who refer to the area as the Waza-Logone Floodplain to stress the ecological connectivity.

The Waza-Logone reflooding project started off with hydrological studies, showing limited risks to rice fields north of the dam, resulting in recommendations to initiate controlled pilot releases of water with monitoring (Wesseling et al., 1994). The options for reflooding were discussed with local communities and authorities. Their overwhelming positive feedback led to the opening of two watercourses blocked by the embankment. The first was opened in 1994 and the second in 1997, resulting in an additional water flow into the floodplain with a maximum debit of about 20 and 10 m^3/s respectively. Some 600 km^2 of desiccated floodplain have since been reflooded. Over the following three decades, different research teams have monitored how the coupled human and natural systems of the floodplain responded to the reflooding.

Studies of the Logone Floodplain

The human and natural systems of the Logone Floodplain have been studied for six decades, from before dam construction through to the reflooding. These anthropological, ecological, hydrological, and interdisciplinary studies have provided us with a long-term perspective on the dynamics and resilience of this coupled system and its components.

Before the construction of the dam, a range of studies were conducted in the floodplain, including the hydraulics of the floodplain (Billon et al., 1966), fish and fisheries (Bénech and Quensière, 1983; Blache et al., 1962), the vegetation in the Logone Floodplain with a rangeland productivity perspective (Gaston and Dulieu, 1976), a vegetation study of Waza National Park (Wit, 1975), a sociological study of pastoralists and livestock in the Logone Floodplain (Beauvilain, 1979, 1981), and a study of large herbivores in Waza National Park (Esser and Van Lavieren, 1979). These studies give a sense of what the floodplain was like prior to dam construction at the end of the 1970s.

After the construction of the dam, PhD and MA students from the Ecole de Faune (Cameroon), Dschang University (Cameroon), and Leiden University (Netherlands), conducted studies of the social and ecological systems in the floodplain and how they changed after the dam construction. Many of these students were supported by the Centre d'Étude de l'Environnement et du Développement au Cameroun (CEDC). Their research included studies of pastoralism (Schrader, 1986; de Bruijn, 1987; Moritz, 1994), fisheries (Van der Zee, 1987; Groeneveld, 1993; Harkes, 1993; van Est and Noorduyn, 1997), wildlife (Tchamba, 1996; Njiforti, 1997), vegetation (Oijen and Kemdo, 1986), and hydrology (Naah, 1990). Research on vegetation, wildlife, and pastoralism in the Waza-Logone floodplain has been synthesized in later papers (Scholte, 2007; Scholte et al., 2006; Moritz et al., 2019) and gives a good sense of both the short-term and long-term impacts of the dam on the social-ecological system of the floodplain.

A few months prior to opening the embankment, the Waza-Logone Project started a program to monitor the impact of the

reflooding efforts, including hydrology studies of flood depth and duration (Sighomnou et al., 2002), wildlife populations (Scholte, 2013), migratory birds (Scholte, 2005), socio-economic studies of fisheries, and pastoralists (Scholte et al., 2006). A vegetation study was also conducted which examined changes in species composition along a transect that was monitored prior to the reflooding efforts (Scholte, 2007). These studies give a sense of the short-term impacts of the reflooding on the social-ecological system.

After the Waza-Logone Project ended in 2003, researchers continued to study the social-ecological systems in the floodplain, including the hydrology (Jung et al., 2011; Shastry et al., 2020; Murumkar et al., 2020; Vassolo et al., 2016; Westra and de Wulf, 2009; Delclaux et al., 2010), fisheries (Laborde et al., 2018, 2019; Laborde et al., 2016), and pastoralism (Moritz et al., 2019b, 2013). More recently, colleagues and students from the University of Maroua and the University of Ngaoundéré (both in Cameroon) as well as local non-profit organizations in Cameroon founded by former Waza-Logone project staff, have conducted studies of pastoral production systems (Mey et al., 2019), hydro-politics (Armel, 2016), fisheries (Ziébé, 2015; Mahamat and Diaouré, 2008; Labara et al., 2020), and resource conflicts (Khari, 2011). These studies give a sense of the long-term impacts of the reflooding on the social-ecological system.

Impacts of reflooding efforts

The short-term impacts of reflooding exceeded expectations: within five years perennial grasslands largely recovered, the numbers of waterbirds increased two-fold, the population of floodplain antelopes quickly increased, and livestock numbers doubled (Scholte, 2005). At the time, the Waza-Logone Project was considered a major success and showcased as an exemplary development project that restored both the ecosystem and supported the livelihoods of those living in the floodplain. Below we discuss the long-term impacts of the reflooding drawing from studies conducted in the last twenty years. We focus our analysis on the nexus of flooding, vegetation, wildlife, and pastoralism in the floodplain.

Flooding

The main driver of the coupled human and natural system of the Logone Floodplain is flooding. Floods are driven by rainfall in the larger basin of the Logone River, where rainfall has been decreasing since the 1960s (Murumkar et al., 2020). The seasonal patterns of flooding and flood recession drive vegetation and fish productivity, on which pastoralists, small-scale rice farmers, and fishers depend (Laborde et al., 2016). In the last four decades the changes in flooding patterns have resulted in two regime shifts (Moritz et al., 2016). First, the Maga Dam limited flooding and negatively impacted vegetation and fish biomass in the downstream floodplain (Scholte, 2005). The dam construction coincided with a period of below-average rainfall in the 1970s and 1980s, and a drought that further reduced seasonal flooding. The second regime shift happened when the Waza Logone project opened two waterways into the floodplain to partially mitigate the effects of the dam (Loth, 2004), which restored flooding to a much larger area. Around the same period, regional rainfall also recovered to average values (Delclaux et al., 2010), which further contributed to the restoration of the flooding regime. Finally, while climate change has led to a decrease in rainfall within the Logone watershed (Murumkar et al., 2020) and the growth in the number of fish canals has sped up the recession of the floodwaters (Laborde et al., 2016; Shastry et al., 2020), this has not yet resulted in another regime shift of flooding patterns.

Vegetation

To monitor how the floodplain vegetation would respond to the reflooding, researchers from the Waza-Logone Project focused on the three dominant perennial grasses: *Oryza longistaminata*, *Echinochloa pyramidalis* and *Hyparrhenia rufa*. The first year of reflooding the species showed a decline, which was followed by a relatively slow increase in the next four years (Scholte, 2005), but from the fifth year onwards, all three species showed a rapid and steady increase that seem to continue up to today, more than 30 years after the reflooding (Figure 4). Data from a grid in the park at the edge of the post-dam flood zone indicated that some perennial species (*Oryza longistaminata*, *Echinochloa pyramidalis*, *Vetiveria nigritana*) only re-appeared two decades after the reflooding, suggesting that some of the ecological processes are happening much slower, requiring long-term observations. The vegetation studies indicate that the reflooding impacts on vegetation are enduring, that flooding is the main driver of this coupled system, and that long-term monitoring is critical for assessing the impact of reflooding.

Wildlife

Wildlife surveys conducted in the last five decades show that the populations of kob (*Kobus kob*) and korrigum (*Damaliscus lunatus korrigum*) decreased significantly after the construction of the dam and showed only a marginal increase after the reflooding efforts (Scholte et al., 2007, 2013) (see Figure 5). In the last fifteen years, the numbers of these herbivores have decreased considerably. Other wildlife species, like lions (*Panthera leo*) have also diminished in numbers (Tumenta et al., 2010). A combination of interrelated reasons may explain the reduction in wildlife numbers in Waza National Park, including shrinking operating budgets of the park, fewer guards, and increasing insecurity in the region. This insecurity included the kidnapping of a family of tourists, leading to tourism collapse and decreasing tourism revenues (Scholte, 2020). Thus, despite the reflooding efforts, which improved habitat for herbivores, wildlife populations have continued to decline.

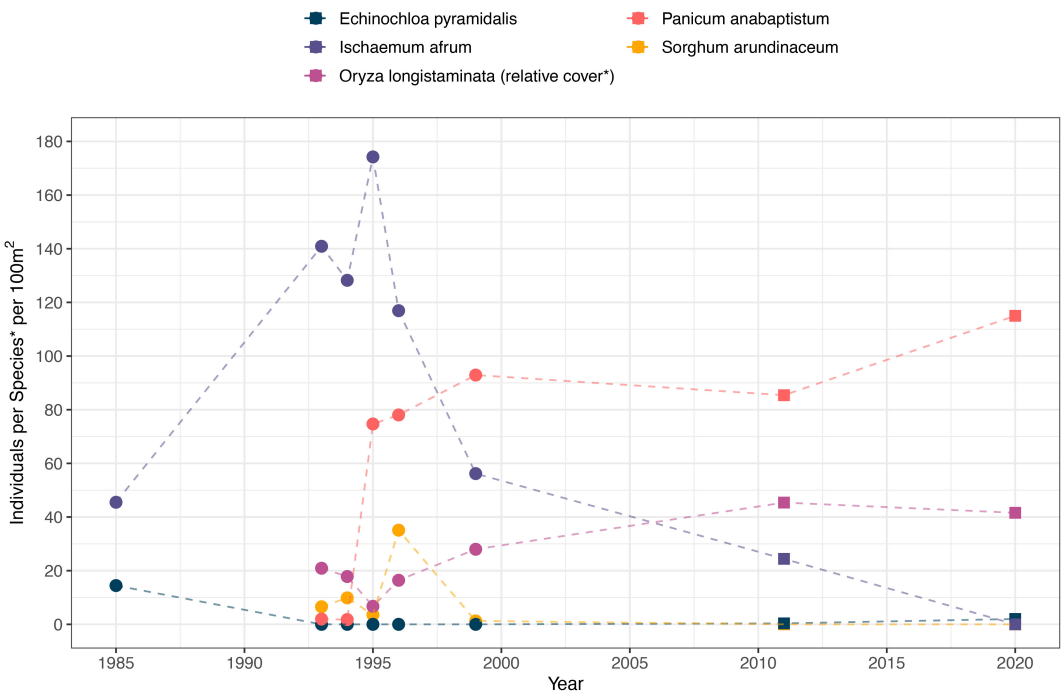

FIGURE 4
Changes in vegetation in Waza National Park, 1985 – 2020. Data from longitudinal study of 23 10-by-10-meter plots within a 1 x 0.5 km area in Waza National Park at the edge of the floodplain (Scholte, 2005:95) with preliminary results from 2011 and 2020 (Scholte, in preparation).

Pastoralism

The Logone Floodplain has long been a very important dry season grazing area for pastoralists in the Chad Basin, including pastoralists from neighboring Niger and Nigeria (Beauvilain, 1981). Access to the grazing areas is open for all pastoralists regardless of nationality, ethnicity, or seniority (Moritz et al., 2013) and studies show that pastoralists in the floodplain have always adapted to changing ecological and political conditions that affect grazing and safety (Moritz et al., 2019; Schrader, 1986; Scholte et al., 2006). A census of pastoralists in the floodplain that started just before the reflooding and continued for five years after reflooding showed that pastoralists quickly adapted to the improved grazing lands by either staying longer in them or returning to the floodplain after having moved elsewhere because of the desiccation of the floodplain (Scholte et al., 2006). This resulted in a three-fold increase in grazing intensity that stabilized from 1997 onwards with no signs of overgrazing. A long-term study of pastoral mobility and grazing pressure showed evidence that mobile pastoralists distribute themselves in an ideal free distribution in which the distribution of grazing pressure matched that of the grazing resources (Moritz et al., 2014a, 2014), even after the arrival of thousands of pastoralist refugees from Northeast Nigeria following the rise of Boko Haram (Moritz et al., 2019). This evidences that pastoralists use of common-pool grazing resources functions as a self-organizing complex adaptive system that is resilient, equitable, and sustainable (Moritz et al., 2018).

One of the goals of the reflooding efforts was to reduce competition between livestock and wildlife in Waza National Park (Scholte et al., 2006). The assumption was that the reflooded areas outside the park would offer enough grazing for their livestock and would stop pastoralists from grazing their animals in the park. While these efforts were initially successful (Scholte et al., 1996), pastoralists later used the park not in search of forage but to seek refuge from insecurity in the floodplain (Scholte et al., 2022a) (Figure 6).

Insecurity

The greater Chad Basin has a long history of insecurity, and this has affected the inhabitants of the floodplain directly and indirectly for centuries (Beauvilain, 1989; Mohammadou, 1983). In the decades that we have worked in the floodplain, insecurity was a major concern for floodplain inhabitants as it threatened their lives and livelihoods. This insecurity took different forms, including clashes between Arab pastoralists and Kotoko fishers, amplified by national party politics; low-level insecurity in the form of cattle thefts and raids that frequently resulted in loss of life; armed banditry that involved hold ups, car jackings, and kidnappings; terrorist attacks by Boko Haram; and the violence committed by agents of the state. These insecurity problems were also present when the Waza Logone Project was active in the region. Because the insecurity affected populations in the floodplain alongside project personnel, the project leadership advocated for greater engagement of the government in the security problems (Scholte et al., 1996). While greater government engagement improved security in the floodplain, it came with excessive force, torture, and extra-judicial killings by security forces (Moritz and Scholte, 2011). In the decades since reflooding, insecurity

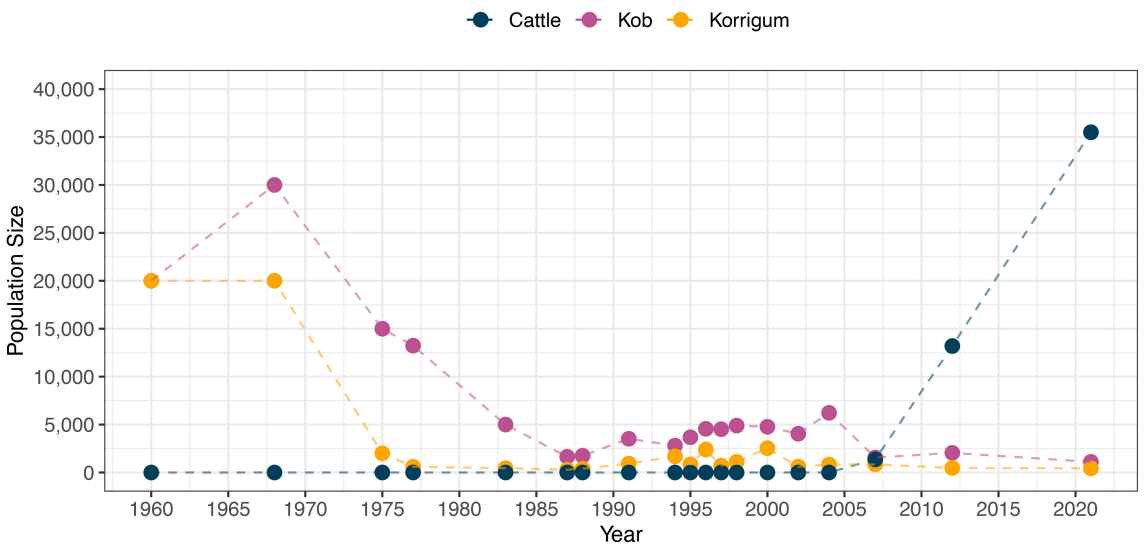

FIGURE 5
Numbers of kob, korrigum, and cattle in Waza National Park, 1960-2021. Dam construction in 1979 resulted in a decline of kob and korrigum numbers, reflooding in 1994 and 1997 resulted in a short-term increases in antelope numbers, and insecurity in the floodplain resulted in a major increase in the number of cattle seeking refuge in the park in 2019 (updated from Scholte (2013) and Scholte et al. (2022a).

continues to be a major concern in the Logone Floodplain and neighboring Waza National Park. In particular, the terrorist attacks and threat of Boko Haram (Kelly Pennaz et al., 2018; Moritz et al., 2019) alongside the more recent widespread communal violence between Arab pastoralists and Musgum fishers (Scholte et al., 2022a) continue to pose major security challenges. Insecurity increased pressure on the park and its wildlife as pastoralists sought safety near or in the park (Scholte et al., 2022a, 2022b).

Discussion

In many ways, the reflooding efforts of the Waza-Logone Project were a success. It led to a steady recovery of vegetation, fish populations, and livestock numbers that continues through today. Long-term monitoring of different systems shows different outcomes: vegetation and pastoralists continue to benefit from reflooding, but wildlife in and outside Waza National Park have not.

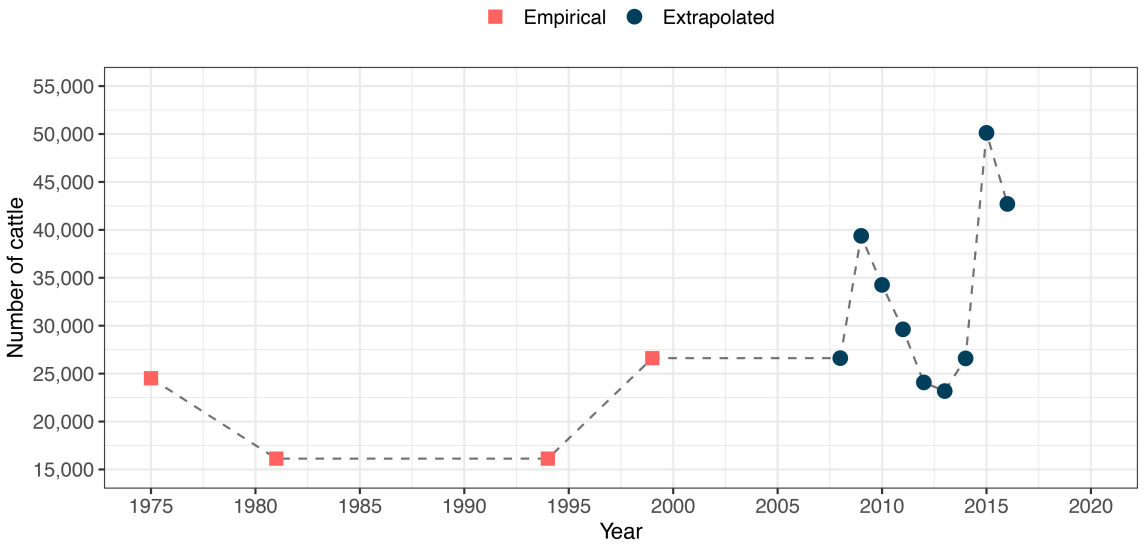

FIGURE 6
Number of cattle in the central floodplain, 1975-2016. The figure shows the trends in the number of cattle in the central floodplain, directly east from Waza National Park. The data marked in red are from empirical studies of cattle numbers and the data marked in black have been extrapolated from several studies of pastoralism in Logone Floodplain reviewed in Moritz et al. (2019:40). The high number of cattle in 2015 and 2016 is due to the arrival of pastoralists fleeing the terror of Boko Haram in neighboring Northeast Nigeria.

Assessing the impacts of reflooding and the state of the coupled human and natural systems of the floodplain yields different results depending on the time period. Five to ten years after reflooding, it was considered a great success, but now, 25 years later, not so much. Wildlife suffered from insecurity and lack of investment in the park. The Waza-Logone Project was working on the assumption that the government would continue to invest in Waza National Park and support the protection of wildlife. While flooding is the main driver of the social-ecological system, a long-term perspective shows how important the larger economic and political context is. Rewilding or reflooding does not happen in a vacuum; insecurity had a major impact on human and wildlife populations.

The Waza-Logone Project had a vision of the floodplain as a social-ecological system, but that vision also had its blind spots. In particular, farming was not part of that vision, most likely because it was less compatible with wildlife conservation and other forms of land use like pastoralism and fisheries. No monitoring studies focused on farming in the floodplain – the focus was on fisheries and pastoralism – even though Musgum fishers in the floodplain were also engaged in rice farming. After the reflooding, there has been a steady expansion of dry season sorghum cultivation at the periphery of the floodplain and later large-scale rice cultivation right in the middle of the floodplain. The goal of the Waza-Logone Project was that the social-ecological system would be restored with the reflooding. The implicit assumption was that communities would continue to make a living as they were doing at that time with fishing, herding, and some farming. A co-management approach to the Waza-Logone project and following the reflooding, to the park, could be beneficial in rewilding as it better accounts for the livelihood concerns of communities who use the area, while engaging them in conservation goals and processes.

The Waza-Logone Project was active for less than ten years in the floodplain. The project was informed by studies conducted in the past. Expatriate and national experts worked on the project for only a few years. They could not imagine how the floodplain would change and how communities would continue to shape the anthropogenic landscape. However, communities in the floodplain have always changed and adapted and continued to do so in response to the construction of the dam and the reflooding efforts. In the last two decades, communities innovated and adapted in response to flood restoration, e.g., by digging more and longer fish canals, digging artificial ponds to capture more fish, practicing aquaculture in the rivers, and clearing larger rice fields and more sorghum fields – all different ways to make the floodplain more productive for humans and which demonstrate their already vested interests in ecosystem management. In hindsight, it would have been better to develop alternative scenarios for how the floodplain could develop, including how political, economic, and demographic changes may affect the social-ecological system of the floodplain.

Conclusion

All natural systems are affected by human systems and vice versa, which means that the framework of coupled human and natural systems is useful to study and manage systems that are considered "more natural" like parks and wilderness, as well as systems that are "more human" like cities and agricultural areas. The Waza-Logone Floodplain has both – Waza National Park and the Logone Floodplain. Conserving wildlife in the park was one of the motivations for the reflooding effort, but not the only one. The reflooding effort of the Waza Logone Project was a landscape-level intervention that considered how Waza National Park is embedded in the larger Logone Floodplain.

The reflooding effort did not restore the social-ecological system as before the dam, but key hydrological and ecological processes were restored. However, our review shows that while human populations in the floodplain have benefitted from the reflooding, wildlife populations in Waza National Park and the floodplain have declined, despite the reflooding and the recovery of floodplain vegetation. Restoring the hydrological and ecological processes was necessary but not sufficient for supporting wildlife; political dynamics impact the ecological processes and have to be considered for rewilding to succeed.

African floodplains, like the Logone Floodplain, are tightly coupled human and natural systems that are of great importance for humans and wildlife. These floodplains have always been anthropogenic landscapes, shaped by humans in one way or another, to make it more productive for them. Supporting or restoring the natural flooding patterns is critical for maintaining the productivity of floodplains for humans and wildlife, but in the Logone Floodplain humans have been able to more successfully adapt to the reflooding than wildlife in Waza National Park.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Ethics statement

The paper is based on a review of published and unpublished studies of the Waza Logone Floodplain.

Author contributions

MM: Conceptualization, Writing – original draft, Writing – review & editing, Visualization. CH: Conceptualization, Writing – original draft, Writing – review & editing, Visualization. PS: Conceptualization, Writing – original draft, Writing – review & editing

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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References

Armel, S. (2016). Aménagements hydrauliques sur le fleuve Logone: le TChad et le Cameroun entre coopération et confrontation, (1970- 2012). *Ann. Faculty Arts Lett. Soc. Sci.* XV, 247–266.

Baerwald, T. J., Firth, P. L., and Ruth, S. L. (2016). The Dynamics of Coupled Natural and Human Systems Program at the U.S. National Science Foundation: lessons learned in interdisciplinary funding program development and management. *Curr. Opin. Environ. Sustainability* 19, 123–133. doi: 10.1016/j.cosust.2016.02.001

Beauvilain, A. (1979). [amp]]Eacute;leveurs et élevage le long du fleuve Niger dans le département de Dosso (Niger). *Cahiers d'Outre-Mer* 126, 66-102. doi: 10.3406/caoum.1979.2889

Beauvilain, A. (1981). [amp]]Eacute;levage et éleveurs du grand yaéré (Nord Cameroun). *Rev. géographie du Cameroun* 2, 163–176.

Beauvilain, A. (1989). *Nord-Cameroun: crises et peuplement.*21(Manches, France: Imprimerie Claude Bellee).

Bénech, V., and Quensière, J. (1983). Migrations de poissons vers le lac TChad à la decrue de la plaine inondée du Nord Cameroun II: Comportement et rythmes d'activité des principales espèces. *Rev. d'Hydrobiologie Tropicale* 16, 79–101.

Billon, B., Bouchardeau, A., Callede, J., Roche, M., and Rodier, J. (1966). *Monographe Hydrologique du Logone. 6eme partie: Reueil de données numériques* (Paris: ORSTOM).

Blache, J., Miton, F., and Stauch, A. (1962). *Première contribution à la connaissance de la pêche dans le bassin hydrographique Logone-Chari-lac TChad* (Paris: ORSTOM).

Carver, S., Convery, I., Hawkins, S., Beyers, R., Eagle, A., Kun, Z., et al. (2021). Guiding principles for rewilding. *Conserv. Biol.* 35, 1882–1893. doi: 10.1111/cobi.13730

de Bruijn, M. (1987). "Alles komt uit de rivier: Fulbe veehouders in de overstromingsvlakte van de rivier de Logone in Noord-Kameroen," in *Mileu en ontwikkeling Leiden (Netherlands): centre for environmental studies* (Leiden University).

Delclaux, F., Haas, E., and Rouche, N. (2010). *Satellite monitoring of Yaéré floodplain dynamics (North Cameroon).* Vol. 340 (Wallingford (UK: International Association of Hydrological Sciences).

Delclaux, F., Seignobos, C., Liénou, G., and Genthon, P. (2010). "Water and people in the Yaéré floodplain (North Cameroon)," in *Floodplains: physical geography, ecology and societal interactions*. Ed. M. A. Álvarez (Nova publishers, Hauppauge (NY).

Esser, J. D., and Van Lavieren, L. P. (1979). Importance, répartition et tendance évolutive des populations de grands herbivores et de l'autruche dans le parc national de Waza, Cameroun. *La Terre La Vie Rev. d'Histoire naturelle* 33, 3–26. doi: 10.3406/revec.1979.5034

Gaston, A., and Dulieu, D. (1976). *Etude agrostologique pour l'aménagement hydraulique pastorale des Yaérès: rapport final* (Ndjamena (Chad: CBLT).

Groeneveld, P. (1993). *An ecological study to the dry season fishery in two pools on the Logone floodplain* (Leiden: Centre of Environmental Studies, Leiden University, the Netherlands).

Harkes, I. (1993). *Abana - Fishery and Frictions: The organisation of the fishery in the depressions of the Waza-Logone floodplain, North-Cameroon* (Leiden: Centre of Environmental Studies, Leiden University, the Netherlands).

Jung, H. C., Alsdorf, D., Moritz, M., Lee, H., and Vassolo, S. (2011). Analysis of the relationship between flooding area and water height in the Logone floodplain. *Phys. Chem. Earth* 36, 232–240. doi: 10.1016/j.pce.2011.01.010

Kelly Pennaz, A., Ahmadou, M., Moritz, M., and Scholte, P. (2018). Not seeing the cattle for the elephants: the implications of discursive linkages between boko haram and wildlife poaching in waza national park, Cameroon. *Conserv. Soc.* 16, 125–135. doi: 10.4103/cs.cs_16_153

Khari, B. (2011). Impact socio économique des conflits liés aux ressources halieutiques dans la plaine d'inondation de Waza Logone, (Extrême-Nord, Cameroun). *Mémoire fin formation FASA Université Dschang Dschang (Cameroon).*

Labara, B. K., Djaowe, A., Tajo, D., Chouto, S., Chendjou, F. X., Tagne, R., et al. (2020). La pêche artisanale par canaux dans la plaine du Logone : une rentabilité source de conflits entre pêcheurs. *Bulletin de la Société Géographique de Liège* 75, 83–100. doi: 10.25518/0770-7576.6109

Laborde, S., Fernández, A., Phang, S. C., Hamilton, I. M., Henry, N., Jung, H. C., et al. (2016). Social-ecological feedbacks lead to unsustainable lock-in in an inland fishery. *Global Environ. Change* 41, 13–25. doi: 10.1016/j.gloenvcha.2016.08.004

Laborde, S., Mahamat, A., and Moritz, M. (2018). The interplay of top-down planning and adaptive self-organization in an African floodplain. *Hum. Ecol.* 46, 171–182. doi: 10.1007/s10745-018-9977-y

Laborde, S., Mahamat, A., and Moritz, M. (2019). "Entre auto-organisation et planification dans la plaine d'inondation du Logone (Cameroun)," in *Le TChad des lacs: Les zones humides sahéliennes au défi du changement global*. Eds. C. Raimond, F. Sylvestre, D. Zakinet and A. Moussa (IRD, Paris).

Liu, J., Dietz, T., Carpenter, S. R., Folke, C., Alberti, M., Redman, C. L., et al. (2007). Coupled human and natural systems. *AMBIO - A J. Hum. Environ.* 36, 639–649. doi: 10.1579/0044-7447(2007)36[639:CHANS]2.0.CO;2

P. Loth (Ed.) (2004). *The return of the water* (Gland (Switzerland: IUCN).

Mahamat, A., and Diaouré, A. A. (2008). *Practique des canaux de pêche dans la plaine d'inondation du fleuve Logone: un coup fatal aux écosystèmes des zones humides sahéliennes.* (Maroua (Cameroon): ACEEN).

Mey, G. A., Doua, S. A., Chouto, S., and Tessoubo, A. (2019). Dynamique Spatio-Temporelle des Prairies et Pastoralisme dans la Plaine d'inondation du Logone (Extrême Nord-Cameroun). *Eur. Sci. J. ESJ* 15, 158-180. doi: 10.19044/esj

Mohammadou, E. (1983). "Peuples et royaumes de Foumbina," in *African languages and ethnography*. Ed. S. Y. Hino (Institute for the study of Languages and Cultures of Asia and Africa (ILCAA, Tokyo).

Moritz, M. (1994). *Yaake, yaayre wi'ete no yaayre: pastoralists' perceptions of and adaptation to rangeland degradation of the Logone floodplain, Far North Cameroon. (report written for the Waza Logone Project, IUCN)* (Maroua (Cameroon).

Moritz, M., Behnke, R., Beitl, C. M., Bird, R. B., Chiaravalloti, R. M., Clark, J. K., et al. (2018). Emergent sustainability in open property regimes. *Proc. Natl. Acad. Sci. (PNAS)* 115, 12859–12867. doi: 10.1073/pnas.1812028115

Moritz, M., Garcia, V., Buffington, A., and Ahmadou, M. (2019). *Pastoralist refugee crisis tests the resilience of open property regime in the logone floodplain* Vol. 86 (Cameroon: Land Use Policy), 31–42.

Moritz, M., Hamilton, I. M., Chen, Y.-J., and Scholte, P. (2014a). Mobile pastoralists in the Logone Floodplain distribute themselves in an Ideal Free Distribution. *Curr. Anthropology* 55, 115–122. doi: 10.1086/674717

Moritz, M., Hamilton, I. M., Scholte, P., and Chen, Y.-J. (2014b). Ideal free distributions of mobile pastoralists within multiple seasonal grazing areas. *Rangeland Ecol. Manage.* 67, 641–649. doi: 10.2111/REM-D-14-00051.1

Moritz, M., Laborde, S., Phang, S. C., Ahmadou, M., Durand, M., Fernandez, A., et al. (2016). Studying the logone floodplain, Cameroon as a coupled human and natural system. *Afr. J. Aquat. Sci.* 41, 99–108. doi: 10.2989/16085914.2016.1143799

Moritz, M., and Scholte, P. (2011). Ethical predicaments: Advocating security for mobile pastoralists in weak states. *Anthropology Today* 27, 12–17. doi: 10.1111/j.1467-8322.2011.00807.x

Moritz, M., Scholte, P., Hamilton, I. M., and Kari, Saïdou (2013). Open access, open systems: pastoral management of common-pool resources in the Chad basin. *Hum. Ecol.* 41, 351–365. doi: 10.1007/s10745-012-9550-z

Murumkar, A., Durand, M., Fernández, A., Moritz, M., Mark, B., Phang, S. C., et al. (2020). Trends and spatial patterns of 20th century temperature, rainfall and PET in the semi-arid Logone River basin, Sub-Saharan Africa. *J. Arid Environments* 178, 104168. doi: 10.1016/j.jaridenv.2020.104168

Naah, E. (1990). *Hydrologie du Grand Yaère du Nord Cameroun. Dissertation* (Yaoundé (Cameroon: l'Université de Yaoundé).

Njiforti, H. (1997). *The biology and management of wild helmeted Guineafowl (Numida meleagris galeata Pallas) in the Waza region of North Cameroon* (Wageningen (Netherlands: Wageningen University).

Oijen, C.H.J.v., and Kemdo, (1986). "Les yaérés dégradés: une description systématique et écologique de la végétation de la plaine d'inondation du Logone, Nord-Cameroun.," in *Garoua (Cameroon): École pour la formation de spécialistes de la faune (Garoua)* (Centre de l'étude de l'environnement (Leyde, Mesres, Institut de recherches zootechniques).

Scholte, P. (2005). *Floodplain rehabilitation and the future of conservation and development: Adaptive management of success in Waza-Logone, Cameroon, Centre for Environmental Studies* (Leiden (Netherlands: Leiden University).

Scholte, P. (2007). Maximum flood depth characterizes above-ground biomass in African seasonally shallowly flooded grasslands. *J. Trop. Ecol.* 23, 63–72. doi: 10.1017/S026646740600366X

Scholte, P. (2013). Population trends of antelopes in Waza National Park (Cameroon) show escalating effects of poaching and livestock intrusion. *Afr. J. Ecol.* 52, 370–374. doi: 10.1111/aje.12106

Scholte, P. (2020). "Waza National Park: the impact of insecurity on tourism and conservation," in *Aires protégées d'Afrique centrale- État 2020*. Eds. C. A. G. Yaoundé and S. Yaoundé (OFAC-COMIFAC & IUCN, Cameroun and Gland, Suisse).

Scholte, P., Adam, S., and Serge, B. K. (2007). Population trends of antelopes in Waza National Park (Cameroon) from 1960 to 2001: the interacting effects of rainfall, flooding and human interventions. *Afr. J. Ecol.* 45, 431–439. doi: 10.1111/j.1365-2028.2007.00774.x

Scholte, P., Kari, S., and Moritz, M. (1996). The involvement of nomadic and transhumance pastoralists in the rehabilitation and management of the Logone flood plain, North Cameroon. *IIED Drylands Programme Issues Paper* 66), 1–21.

Scholte, P., Kari, S., and Moritz, M. (2022a). Thousands of pastoralists seek refuge in Waza National Park, Cameroon. *Oryx* 56, 330. doi: 10.1017/S0030605322000217

Scholte, P., Kari, S., Moritz, M., and Prins, H. (2006). Pastoralist responses to floodplain rehabilitation in northern Cameroon. *Hum. Ecol.* 34, 27–51. doi: 10.1007/s10745-005-9001-1

Scholte, P., Pays, O., Adam, S., Chardonnet, B., Fritz, H., Mamang, J. B., et al. (2022b). Conservation overstretch and long-term decline of wildlife and tourism in the Central African savannas. *Conserv. Biol.* 36, e13860. doi: 10.1111/cobi.13860

Schrader, T. (1986). *Les yaérés au Nord du Cameroun: pâturages de saison sèche ()? Aspects socio-écologiques du développement pastoral dans la plaine inondable du Logone* (Leiden (Netherlands: Centre des etudes de l'environnement (CML), Leiden University).

Shastry, A., Durand, M., Neal, J., Fernández, A., Phang, S. C., Mohr, B., et al. (2020). Small-scale anthropogenic changes impact floodplain hydraulics: Simulating the effects of fish canals on the Logone floodplain. *J. Hydrology* 588, 125035. doi: 10.1016/j.jhydrol.2020.125035

Sighomnou, D., Nkamdjou, L. S., and Liénou, G. (2002). "La plaine du Yaéré dans le Nord-Cameroun; Une expérience de restauration des inondations," in *Gestion intégrée des zones inondables tropicales*. Ed. D. Orange (IRD, Paris).

Tchamba, M. (1996). *Elephants and their interactions with people and vegetation in the waza-logone region* (Utrecht (Netherlands: Utrecht University).

Tumenta, P. N., Kok, J. S., Van Rijssel, J. C., Buij, R., Croes, B. M., Funston, P. J., et al. (2010). Threat of rapid extermination of the lion (Panthera leo leo) in Waza National Park, Northern Cameroon. *Afr. J. Ecol.* 48, 888–894. doi: 10.1111/j.1365-2028.2009.01181.x

Van der Zee, E. (1987). "Kotoko vissers in de logone vloedvlakte," in *CML report* (CML, Leiden, Netherlands).

van Est, D. M. E., and Noorduyn, R. E. (1997). *Management of natural resource conflicts: a case from the Logone Floodplain in North-Cameroon. Seminar: managing the dry African savannah; options for conservation and sustainable use* (Leiden University).

Vassolo, S., Wilczok, C., Daïra, D., and Bala, A. (2016). *Groundwater - surface water interaction in the lower logone floodplain* (Hanover, Germany: Federal Ministry for Economic Cooperation and Development).

Wesseling, J. W., Drijver, C., Naah, E., Namba, A., and Zuiderwijk, A. (1994). *Waza Logone flood restoration study: Identification of options for re-flooding* (Leiden (Netherlands: Centre for Environmental Science Leiden).

Westra, „T., and Wulf, R. de (2009). Modelling yearly flooding extent of the Waza-Logone floodplain in northern Cameroon based on MODIS and rainfall data. *Int. J. Remote Sens.* 30, 5527–5548. doi: 10.1080/01431160802672872

Wit, P. (1975). "Preliminary notes on the vegetation of Waza National Park," in *FAO report* (Food and Agriculture Organization, Rome).

Ziébé, R. (2015). *Fisheries in the Waza Logone Floodplain: An analysis of the status of the fisheries sector and mitigation of conflicts with the sector in North Cameroon* (Leiden (Netherlands: Leiden University).