Chapter 4

Approaching Human Dimensions in Lemur Conservation at Lake Alaotra, Madagascar

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Additional information is available at the end of the chapter

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Abstract

'Human dimensions of wildlife management' is a concept that emerged some 50 years ago and has gained global application. A majority of cases report on human-wildlife conflicts (HWCs), where wildlife is causing problems to an expanding human population or vice versa. In Madagascar, lemurs represent a flagship for conservation. Many lemur taxa are threatened, and conservation is facing increasing challenges due to habitat loss and degradation. The Alaotran gentle lemur (*Hapalemur alaotrensis*) is the only marshland living lemur. Its conservation is particularly challenging due to various conflicting interests of different stakeholder groups. The Alaotra region is the bread basket of Madagascar, producing a majority of inland fish and rice. Here we present a new venue taken by conservation, which is based on a transdisciplinary research approach, participatory modeling, and gaming through role-playing games (RPGs). This holds promise to engage stakeholders from the onset of conservation planning and management, and it is hoped that increased participation will spur ownership and thus reduce conflicts among stakeholders to increase conservation effectiveness to safe *Hapalemur alaotrensis* from extinction.

Keywords: *Hapalemur alaotrensis*, human dimensions of wildlife management, human-wildlife conflict, transdisciplinary research, participatory modeling, role-playing games, stakeholders

1. Introduction

Human dimensions of wildlife conservation evolved in the 1960s and gained increasing attention in the past 30 years, both in research and among practitioners. While biological and ecological paradigms dominated natural resource and wildlife management for long, increasing human-wildlife conflicts spurred the awareness that people aspects need to be included in management

decisions as they are critical to conservation success [1, 2]. 'Human dimensions' is a broad field today, which concerns the question how to best manage wildlife, that is, how to ensure species' survival without compromising people's needs. It occurs in as diverse settings as agriculture, hunting, tourism, and leisure realms and entails efforts to understand and affect human behavior by incorporating insights about people's attitudes, perceptions, and norms into policy and management programs [2, 3]. Increasing overlap and interference in landuse caused increasing incidents of human-wildlife conflicts in the past few centuries. Such conflicts may occur when elephants raid farmers' fields, when wolves predate on domestic sheep, or when humans shoot a lion that is thought to have killed cattle. Newer definitions also incorporate human-human conflicts evolving from human-wildlife conflict, for example, individuals being negatively affected by wildlife versus conservation organizations or state authorities [4, 5].

Per definition, human-wildlife conflict (HWC) occurs when "the needs and behavior of wildlife impact negatively on the goals of humans or when the goals of humans negatively impact the needs of wildlife" (World Park Congress Recommendation as cited in [4]). Human population growth coming along with land reclamation and cultivation in formerly uninhabited areas is one of the main reasons for increasing human-wildlife conflicts [6]. HWC occurs globally and concerns a variety of species and sociocultural and socioeconomic contexts, including mammals, fish, insects, and reptiles globally. The range of human-wildlife conflict includes lions, monkeys, and elephants in Africa, leopards and tigers in India, or wolves in Canada, USA, and Europe, to name but the most prominent ones [7].

Regardless of the HWC context, some main characteristics do apply. For example, communities are not homogeneous entities, but incorporate different stakeholder groups with different needs and value systems [8]. Incorporating these different views and finding acceptable 'solutions' for all parties involved and affected is a complex and complicated task for conservation management and planning. With increasing recognition about the importance of the human dimension, stakeholder participation became more important; moreover, research collected evidence that conservation projects are more likely to be successful if locals are involved in management decisions and conservation planning [9]. Decker and Chase [3] identified five main approaches how wildlife managers can seek public participation. They differ in the degree of influence of wildlife managers and stakeholders on policy and management decisions, beginning with highest influence of the managers and lowest of stakeholders with the (top-down) authoritative approach. With decreasing own influence, wildlife managers can increasingly let stakeholders contribute to decision-making with the passive-receptive, inquisitive, transactional, and co-managerial or delegation approach (cf. Figure 1 in [3]). Current literature suggests that management decisions and rules tend to be better accepted when stakeholders were involved in the decision-making process. One reason for this is that attitudes, aspirations, and norms are better understood and can be incorporated in decision-making. In order to resolve or alleviate human-wildlife conflict, human dimensions thus encompass people's beliefs, values, attitudes, behaviors, and socioeconomic and demographic characteristics of individual stakeholders or stakeholder groups; it deals with the proximate level of interaction among and between management decisions, processes, and staff (cf. [10]).

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Primates represent a particular case in the HWC realms. While they are similar to humans and venerated in some settings, people perceive them as pests in other instances, while the contexts are ranging from agricultural fields to reserves and tourist camps to towns [11]. Major threats to primate populations are conversions of natural habitat into areas of human use such as forestry, plantations, and agricultural fields; trapping for biomedical trade, bushmeat trade, and transmission of diseases represent further threats [11, 12]. While HWC concerning primates such as baboons, vervets, and macaques is well covered in the scientific literature (e.g., [11, 13–16]), Madagascar's lemurs are hardly considered even if the majority are endangered and efficient management measures are needed to halt further population declines.

1.1. Lemur conservation in Madagascar

Madagascar hosts a unique assembly of endemic primates. The lemurs are a monophyletic group of strepsirhine primates occurring only on Madagascar [17] consisting of five families: Daubentoniidae (1 species), Indriidae (19 species), Lemuridae (21), Lepilemuridae (26), and Cheirogalidae (36) [18]. In the last 10–15 years, advances in molecular biology have resulted in an increase from some 50 to 107 known lemur taxa [19, 20]. Lemurs exist in nearly all of Madagascar's forest ecosystems, from the very dry spiny forests of Madagascar's southwest, along the dry forests of the west, and along the entire east coast in the subhumid and humid forests [20, 21]. All lemurs are nationally and internationally protected species. Ordinance No. 60-126 of October 3, 1960, represents the first official national text on the protection and hunting regulations of wild species, including lemurs (cf. [22]). Madagascar signed the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, also known as the Washington Convention) in 1975 and added all lemurs shortly thereafter to CITES Appendix I (Decree 77–276 of August 26, 1980). To protect its unique wildlife, Madagascar was among the first countries to establish a protected area network of National Parks with the first created in 1927. In the Durban Vision proclaimed in 2003 during the Fifth World Parks Congress in South Africa, then President Marc Ravalomanana declared to triple the terrestrial surface in Madagascar up to some 10% of Madagascar's land under some sort of formal protection [23, 24]. Despite all these formal agreements and laws, many lemur species are threatened by habitat loss and hunting (for both bushmeat and pet trade; [25–28]). The 2012 IUCN Red List evaluation of the threat status of Madagascar's lemurs shows that 94% of species are either classified as Vulnerable, Endangered, or Critically Endangered [29]. The biggest challenge to lemur conservation is the fast pace of deforestation with agricultural production and infrastructure being two of the main proximate drivers [30], thus leaving many lemurs in isolated forest fragments [31]. Forest fragments are highly susceptible to anthropogenic change and thus some lemur populations and species, even some of the newly discovered species risk disappearing due to their lowered resilience in fragmented or degraded habitats (e.g., decreasing numbers, loss of genetic diversity, increased disturbance [32]). Degraded forests are furthering the exposure of primates to humans [33], and their close phylogenetic relationship puts them more at risk of disease transmissions from humans to primates [34]. In Madagascar, it has been shown that *Avahi laniger*, *Eulemur rubriventer*,

Hapalemur aureus, *Microcebus rufus*, *Propithecus edwardsi*, and *Prolemur simus* have increased diarrhea cases due to exposure with human enterobacterium [35]. While bushmeat represents a major threat for Madagascar's lemurs, a traditional form of taboos, called *fady*, protects some lemur species from hunting and consumption. The *fady* largely are ancestral rules which are still respected by a majority of the Malagasy people; however, these taboos differ from region to region, and with increasing mobility, an increasing number of taboos are weakened by immigrants from other tribes and regions (for more details, see [36–38] and references therein). In this context, the abandonment of an old attitude or tradition can cause significant conservation issues when exploitation suddenly is no longer seen as socially inacceptable. For example, the *fady* formerly protecting *Indri indri* and *Propithecus verreauxi* from consumption are less respected today [36]. However, *fady* can also cause increased hunting pressure. The aye-aye (*Daubentonia madagascariensis*), for example, is oftentimes killed when encountered because the nocturnal lemur is believed being an evil omen bringing disease or death to family members or even whole villages if encountered and not killed [39].

Opposed to the situation in many other contexts, crop-raiding evidence in Madagascar is scarce. Still, some species have been reported to raid, for example, *Propithecus verreauxi coquereli*, *Lemur fulvus*, *Avahi laniger occidentalis*, and *Leplilemur mustelinus edwardsi* targeting cashew fruit, mango, and tamarinds [11, 40], but also *Daubentonia madagascariensis* [41]. In general, HWC in Madagascar is mainly represented by habitat loss of lemurs, while lemurs themselves do not directly affect farmers' subsistence. A key issue to conservation in Madagascar is the increasing competition between humans and wildlife. Human population growth results in spreading of human activity such as agriculture, precious wood, and stones into areas which were wildlife habitats before. With the protection of wildlife habitat (e.g., the establishment of protected areas), local people may be restricted in extending their fields or activities, or are even forced to relocate, thus encountering opportunity costs due to land-use restrictions or hunting bans [42–44]. A widely used approach to engage conservation with local resource users is community-based conservation (CBC). It has been designated to be the most practical approach to fight biodiversity loss in developing countries [45]. However, it has also been considered as time-consuming and complicated, and criticized that it does not necessarily provide win-win situations, but that losers may be generated through the transfer of rights, power, and resources as well [46–47]. The approach is oftentimes implemented for the promotion of development or livelihood security while reaching conservation goals as well [48]. The biggest challenge lies in the intrinsic complexity of the conservation and development issue(s), combined with the multitude of different contexts that makes simple upscaling or transfer to other sites literally impossible. Each case involves a multitude of different stakeholders and resources, different power relationships, and management priorities. These complex socioecological issues require the consideration of multiple perspectives, worldviews, and priorities.

A community-based conservation approach is also being implemented in the Lake Alaotra region (**Figure 1**) to preserve the Alaotran gentle lemur (*Hapalemur alaotrensis*; **Figure 2**) [49]. In the remaining of this chapter, we will present the case study of the Alaotra, Madagascar's rice granary. We will describe the Alaotran gentle lemur, its conservation challenges and analyze

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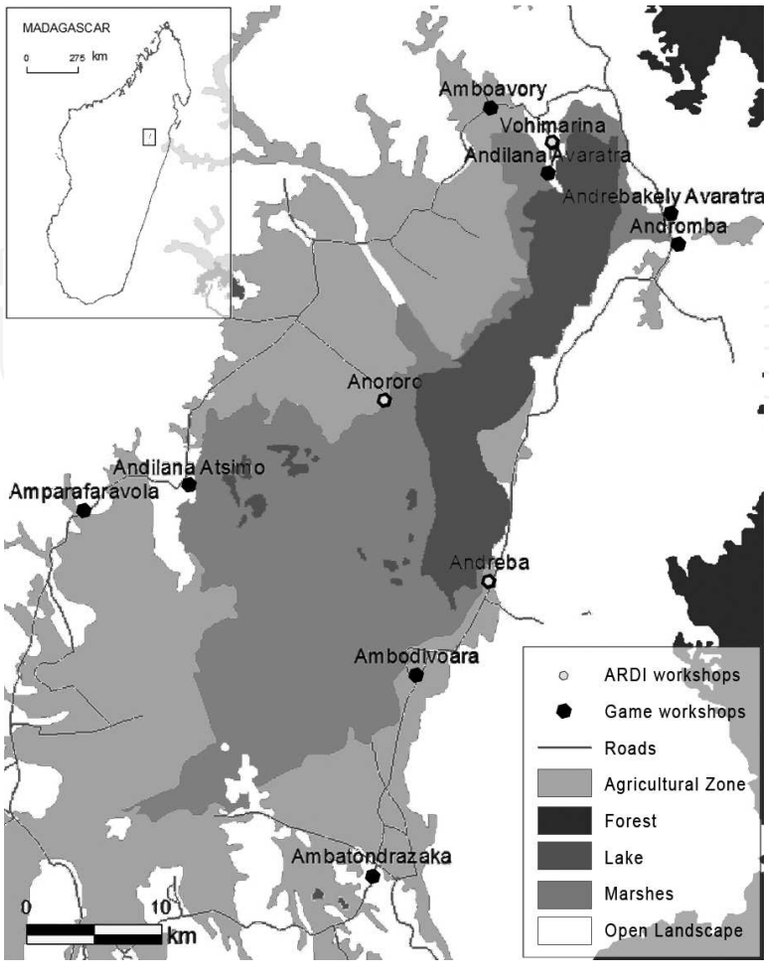

Figure 1. Lake Alaotra region. The map shows the lake, with surrounding marshes, rice fields, open landscapes (dominated by grasslands), and forests. Intervention villages are situated around the Alaotra wetland. This map has been modified from Reibelt et al.'s Figure 1 published in the Journal Madagascar Conservation & Development under a Creative Commons Attribution 3.0 Unported License.

the human dimensions of the conservation endeavors in the marshes and communities around Lake Alaotra.

1.2. The Alaotran gentle lemur and its conservation

The Alaotran gentle lemur (*Hapalemur alaotrensis*) is globally unique, living in and restricted to the marshlands of Lake Alaotra. It represents one of the five extant species in the genus *Hapalemur*. The other four species, namely the southern bamboo lemur (*H. meridionalis*), northern bamboo lemur (*H. occidentalis*), lesser bamboo lemur (*H. griseus*), and golden bamboo lemur (*H. aureus*), all are forest dwellers, occupying a variety of forest types across Madagascar. Genetically and phenotypically, *H. alaotrensis* is closely related to *H. griseus*, and it is hypothesized that the marshland living one must have originated from the forests before humans settled in the Alaotra some few hundred years ago [50–52]. *H. alaotrensis* is a crepuscular primate and performs cathemeral activity behavior [53], shows female dominance, a

Figure 2. A juvenile *Hapalemur alaotrensis*, with permission from photographer Arnaud De Grave, Le Pictorium Agency.

social behavioral trait common in many lemurs [54], and has a specialized diet based on marshland vegetation only [53] and it is well adapted to wetland conditions [51]. *Hapalemur alaotrensis* is the only primate species in the world that lives exclusively in a wetland habitat. The species is classified as Critically Endangered [55] due to its very restricted geographic range. *Hapalemur alaotrensis* is at high risk of extinction due to rapid and ongoing habitat destruction for conversion of the marsh to rice fields [56]. The marshland coverage was around 19,000 hectares in the early 2000s and it has decreased to below 14,000 in the mid-2000s; in 2012, there was an extreme fire year affecting more than 50% of the remaining marshes [57]. There are two factors leading to increased marshland burning: lack of law enforcement and prolonged drought seasons. For example, a single rice field was found within the Park Bandro at Andreba in 2013, but this increased to five rice fields in 2014. People in Andreba stated that they will transform the marsh into rice fields if the current delinquents are not punished. A census of Madagascar Wildlife Conservation (MWC), a Malagasy NGO, revealed that in 2016, a fourth of the park was covered with illegal rice plantations [58].

Lemur conservation in the Alaotra is intricately complicated and complex constituting a typical wicked problem[1] (sensu [59]) as many conservation problems (see also [60]). As is typical for wicked problems, there are a multitude of stakeholders involved in the Alaotra region who are directly or indirectly linked with the wetlands (cf. [61]), each with their own worldviews, values and knowledge systems, ending up having divergent and sometimes opposing or even conflicting interests or agendas. There are several different governing institutions that sometimes share overlapping responsibilities and tasks; there are, for example, the Ministry of Environment that is responsible for the wetlands and forests and the Madagascar National Parks that are responsible for protected areas which sometimes fall on forests or as here on wetlands; there is the Ministry of Fisheries responsible for the overseeing of lake-wide activities or the Ministry of Agriculture governing all land-based activities that fall within the agricultural domain and the open landscapes and wetlands. There is a strong position for lemur and biodiversity conservation in general, since there are endemic species found in the Alaotra (e.g., *Hapalemur alaotrensis* and *Salanoia durrelli*). In addition, intact marshes have an important role for functioning ecosystem services such as water retention, filtering, and water quality [62]. On the opposing side, there is a strong lobby promoting the conversion of marshlands for rice production, since rice is a quality of life [63] and an important staple food in Madagascar, especially in the Alaotra [64]. Rich people from outside the Alaotra are interested in buying land for turning it into rice fields [65].

1.3. The human dimension in the Alaotra region

A startling issue among conservation biologists is the fact that conflict management oftentimes is tackled by making assumptions about human attitudes and behaviors which are seldom congruent with reality [5]. Research has shown, however, that conservation projects benefit by taking into account the needs, attitudes, and aspirations of locals in order to increase the efficacy of conservation efforts [5]. In the Alaotra, there is an immense anthropogenic pressure on biodiversity and the natural ecosystems. In order to strike a possible balance of biodiversity values with the growing need for agricultural products and other ecosystem services, the understanding of livelihood needs, the main resource users' attitudes toward and perception of life, livelihood, and lemurs become essential to inform conservation planning. Resource users who work in the marshes would prefer land sparing to land sharing, that is, having clear demarcation zones for work (e.g., fishing and farming) and zones for biodiversity conservation such as is the case for the special conservation zone Park Bandro [66]. People also seem to have a neutral or even positive attitude toward the lemurs and their conservation as long as they can pursue their livelihood activities [56]. Community members in general view the environment as a social construct or related to

[1]Wicked problems are characterized by the following attributes: (1) formalizing the problem is not possible, that is, the construction of a solution space is the core challenge since every problem is a symptom of yet another problem; (2) no evident stopping rule exists (when is it solved?); (3) there is no true or false solution to it, and rather, there is only a better or worse one; (4) every decision "will generate waves of consequences over an extended (…) period of time" ([59]: 163)—tracing all the consequences is impossible, especially when the half-lives of such are long; (5) every solution constitutes a "one-shot" operation where every implementation is consequential [59].

human benefits; for example, the introduction of the invasive snakehead fish (*Channa maculate)* is seen as positive by local teachers since it delivers additional proteins to people [67]. Stoudmann and colleagues [63] identified five main livelihood attitudes in the Alaotra region: (1) 'Responsibility makes a man' refers to people who take their situation into their own hand, and which are involved in improving the state of things. (2) 'Let us be realistic' is a rather fatalistic view of things by people who think that one cannot do much about life; (3) 'Children are the future,' an attitude shared by mainly women, who are concerned about changes affecting the next generation, who acknowledge the importance of education, and who are worried about teenage pregnancies. (4) 'Good things come to those who work hard' is the attitude shared by people who pursue various agricultural strategies (e.g., fertilizer, crop diversification), and who believe that working hard will improve their standard of living. (5) 'Be prepared for the unexpected' is a group of resource users who, similar to the previous group, invest heavily into diversification and who have an entrepreneurial spirit [63].

A majority of Alaotra's rural population are engaged in some sort of agricultural or fishing activities [68]. Livelihood conditions are becoming harder. For example, annual fish catches amounted to 4000 t in the 1960s, making the Alaotra the most important inland fishery region of the country. Recent numbers have been dropping to below 800 t per annum [69]. The steady decline of the fish stock is most likely a result of overfishing, acidification of the lake, introduced fish species, and siltation [70–73]. A majority of the marshlands fringing the lake have already been converted for rice production, with some 100,000 ha outputting ca. 300,000 t per year [57, 74]. However, changing environmental conditions (e.g., deforestation and clearing of surrounding hill slopes through slash-and-burn agriculture known as *tavy*, leading to increased siltation of affluent rivers) have diminished the lake size to 20% of its former size in 2000. Continued dry spells could soon let wither Lake Alaotra and make it another 'case of Lake Baikal'; according to Bakoariniaina et al. [75], some 5 km^2 of lake surface have disappeared within a period of 30 years. Consequently, rice crop productivity in the Alaotra basin has dropped to about 40% of its former level [75, 76]. The stakeholders' livelihood strategies for meeting their needs and to cope with changing socioeconomic and environmental conditions are currently resulting in a lose-lose scenario (sensu [77]) in the Alaotra socioecological system. The area is home to almost one million people, thus being the highest population density in a wetland area in Madagascar [78]. Arable land is becoming increasingly scarce, forcing many people into the marshes to establish rice fields [57, 66]. Extensification is still widely common compared to intensification [79]. Recent years experienced extended drought periods in the region, with some years receiving almost no rain at all. This showed two main consequences in the socioecological system of the Alaotra. (1) People have been pushing into the marshes and lake for establishing rice fields or claiming the territory for future rice production by staking and building so-called *hamatra* or reed fences. These have started to even crisscross the entire lake from east to west, thus casting a grim picture of the future Alaotra as being one big rice field. (2) The reduced water availability in marshes and lake has negatively affected the lake-wide fish stock. There is less and smaller fish available [73, 80, 81]. More people than ever are pushing into the marshes and lake to fall back on fishing as a last resort, sometimes even using mosquito nets in despair.

2. A transdisciplinary approach for lemur conservation

Current environmental destruction trends do not cast an optimistic future for the survival of *Hapalemur alaotrensis*. The unique wetland primate may disappear from the Alaotra and Madagascar within the coming years if habitat destruction cannot be halted. Concerted conservation efforts are underway engaging various NGOs working together with the riverine communities and the authorities. It is hoped that increased collaboration and the adoption of a transdisciplinary approach will allow pushing back the threats that *Hapalemur alaotrensis* and its habitat encounter. Activities and programs include habitat restoration, marsh patrols, various research projects [49], environmental education [67, 82], and awareness-raising campaigns including the World Lemur Festival (called Bandro Festival; based on the vernacular name of *Hapalemur alaotrensis*). However, these are not enough. Thus, a new conservation approach for the Alaotra is been unfold in order to slow down the main threat to the existence of the unique marsh lemur, the habitat destruction for agricultural production. Habitat restoration is a classic conservation activity and urgently needed in the Alaotra to link isolated subpopulations [49, 56]. Complex conservation problems require creative approaches [60]. What is creative about habitat restoration? MWC accompanies all its conservation efforts with games. The serious gaming approach, which requires intense exchange and communication with stakeholders, is based on Companion Modeling (ComMod, cf. [83]). It builds on an inductive process of creating conceptual models from field evidence and judgments with restitution to knowledge providers in the form of interactive games. The central tool is a model or game which can, depending on the conservation issue and needs at stake, be a research means to elicit different potential future scenarios and stakeholder responses to this, or a communication tool to bring different stakeholder groups together to exchange and discuss on possible management options. In such game settings, the resulting outcomes are shaped by the cumulative and sometimes interacting decisions made by individual players, coupled with all the interacting decisions by the other players, as well as the rules of the game. The games are strategic situations [84], thus representing effective tools for exchange and solution seeking in decision-making and scenario planning contexts (cf. [85]). There is a strong relationship between game behavior and players' real life (e.g., [86]) and this tool thus represents a valid alternative to more classic social science approaches.

This inter- and transdisciplinary research (sensu [87]) aims at understanding farmers' perceptions and attitudes and allows farmers to explore the ecological, economic, and sometimes social outcomes of their individual and cumulative decisions. At the onset of the ComMod approach are participatory workshops (field work), where stakeholders share their mental models or mind maps with each other and the researchers, that is, where group discussions describe and develop a common representation of the socioecological system which all involved parties can agree upon. The methodology is based on ARDI [88] and represents a dedicated participatory modeling method. Researchers and stakeholders identify the main Actors, Resources, Dynamics, and Interaction (ARDI) being relevant to the socio-ecological system at stake and the agreed-upon issue(s). Then, the identified components are translated into players, game components, and rules for a role-playing game.

2.1. The games

2.1.1. A wetland game for research

The wetland game [81] has been developed for research purposes to understand land-cover-type changes and livelihood strategies of the main resource users living around Lake Alaotra. The research processes and results are aimed to include the human dimensions into conservation planning. The developed wetland game is a role-playing game (RPG) consisting of a market, a landscape, and a bank. Players are farmers and fishers as in real life and can do fishing and different farming activities (rice, onion, and vegetables) and invest into technology (compost). They further have the choice to do opportunity activities (logging, mining, and hunting), invest into housing (three quality levels) or different quality of life parameters, namely protein, electricity, health, and education (**Figure 3**). Players track individual decisions on their personal player sheet and subsequently place their activity tokens on the game board, the common landscape (**Figure 4**), which represents the different land types in the Alaotra region (lake, agricultural zone, hilly grasslands, and forest (see [81] for details on the game development process)). Consequently, the common landscape shows the cumulative decisions and impacts of all players. These changes are mostly represented by changes in the original land cover type, which are induced by land-based activities (e.g., farming in the marshes transforms them into agricultural zone, which is indicated via color change of the respective cell(s) [81]. The bank (represented by a ComMod team member with a computer) tracks all the players' decisions and calculates and pays the cash output. The agricultural or fishery production depends on factors such as how many other resource users are sharing the same space, how much of the original land type is still intact, or how is the weather (i.e., is there a climatic event such as drought or cyclone). The researchers are accompanying the gaming phase by quantifying the activities, thus decisions taken by the players and the impacts on the common landscape. Moreover, a qualitative phase follows the gaming where experiences during the game are shared, discussed, and explored. It is during the debriefing [89] where there is room

Figure 3. Wetland research game: players buy activities at the market.

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Figure 4. Wetland research game: players track how their individual decisions accumulate on the common landscape.

for freeing emotions and understanding what happened during the game, in order to then bridge the virtual game reality with the real world. Important to note here is that game behavior does not necessarily reflect reality; the game behavior serves as entry point to compare game activities and real life. It also frees people of the social constraints that are often accompanying people during an interview or open discussions on topics of potential conflict. A follow-up monitoring 1 week after the workshop allows researchers and players to exchange one by one on further details and thoughts concerning the issue at stake. Participants acknowledged the opportunity to openly discuss land-use strategies and decisions and appreciated the fact that they could also exchange controversial ideas in the workshop setting without entering in disputes. Several gamers perceived that the game offered them a new, broader perspective on their surroundings and the ongoing processes in reality. They further described in the debriefing sessions that game behavior matched real-life behavior from about 50 to 100% and thought that the gaming experience would help them to make better decisions in the future.

2.1.2. A wetland game for discussion and outreach

"There is no right way to do conservation. There are only choices" [90]. Scales [91] adds that "To help make these choices, research and policy in Madagascar desperately need more conversations-between biologists, anthropologists, archeologists, economists, environmental historians, and geographers; between researchers and practitioners; and between 'experts' and the individuals, households and communities directly dependent on the island's natural resources for their livelihoods." Exchange is crucial for effective learning and to avoid repeating the same mistakes over and over again [48]. In order to have a game which can be used for exchange, negotiation, and outreach, the research game was simplified accordingly.

The discussion game is a follow-up of the wetland research game and was designed to develop, discuss and explore rules and regulations in the context of marshland conservation and management. The discussion and communication tool is a simple representation of the Alaotra socioecological system, representing the lake with fish, the marshes with biodiversity and the

agricultural zone with rice fields (**Figure 5**). The basic rule is that all eight players need one fish token and two rice tokens at the end of each round to feed their family. Players are free to plant rice, use compost, and go fishing as they wish. As soon as a resource is depleted, or players do not have enough production to survive, the game is interrupted to discuss game behavior and consequences and, foremost, to elaborate on how the situation could be improved when replaying the game. Players are thus invited to establish game rules (e.g., restrictions on fish catch or prohibition to transform marsh) and to test the success of their established rules and whether these are suitable to reaching a sustainable system where everybody can survive (**Figure 6**).

The game calibration shows the most crucial linkages and interdependences in the Alaotra system. The marshes are breeding ground for some fish species; thus, reproduction reduces with shrinking marsh area (i.e., when players burn the marshes to establish rice fields). Moreover, the marshes play a role in water availability in the system. With each transformed marsh patch, there is less water available, which has a negative impact on rice output. Finally, there are less marsh patches than players available; this is a proxy for increasing population and the fact that there is not enough (marsh-) land available for everyone. The game thus addresses a common pool resource situation with the fish (and the marshes) and helps exploring the question of what future management scenarios are possible and which could be embraced by the communities? The game serves as a simple window to the future, helping the local stakeholders to become aware and understand current trends in the system and potential consequences of their decisions.

First results suggest that people tend to intensively (over)exploit the system if they have the opportunity to do so. The players quickly establish new effective game rules, which show high similarity to already existing conservation rules. The strength of the game is that the participants can discuss prerequisites, advantages, and disadvantages of different potential rules and then decide themselves which one to try out. During the testing workshop debriefings, participants emphasized the interdisciplinary nature of the game, its suitability for rural resource

Figure 5. Wetland discussion game: prototype representing lake, marsh, and agricultural zone.

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Figure 6. Wetland discussion game: regional authorities implementing a self-developed rule during testing phase.

users but also school children, and judged the game to be realistic, instructional, enjoyable, and suitable to enter into fruitful discussions. It still remains to be tested whether this game approach can increase the acceptance of already existing conservation rules in the real Alaotra socioecological system.

2.2. Concluding remarks and outlook

Over the course of the past 5 years, the conservation community was able to substantially enhance its understanding of the human dimensions of *Hapalemur alaotrensis* conservation around Lake Alaotra. What are conservation management preferences for the subsistence farmers and fishers? What are their attitudes toward the endemic lemur or the core conservation zone Park Bandro at Andreba [56, 66]? What are the rural stakeholders' strategies to cope with change [63], and how do they take decisions in the agricultural domain [64, 81]? The next step is now to implement all the gained knowledge and understanding to enhance conservation actions and continue the dialog of trust with the different stakeholders. It is assumed that the intense exchanges and workshops enhanced understanding and respect on both sides, and this will be fundamental in the implementation phase. The deployment of role-playing games helps conservationists to engage with various stakeholder groups to spur discussions to increase knowledge and understanding of problems at hand. It helps the stakeholders to elicit their mental models and to strengthen their adaptive capacity and critical thinking, and foremost, it holds promise to strengthen their ownership in resource management and planning.

The recent research efforts highlight that local resource users are not basically against conservation of the marshes and its biodiversity; nevertheless, protected lemur habitat is shrinking constantly and at faster pace in recent times. Lemur habitat restoration measures are urgently needed, but these will likely interfere with peoples' newly established rice fields. Even if the fields are formally illegal since placed within the New Protected Area, law enforcement is weak, and people depend on their rice harvest. Restoration actions thus bear a high risk to

increasing HWC in the sense of human-human conflict, that is, farmers versus conservationists. Here, it is critical to intensely exchange and communicate with the communities involved and to further integrate the various stakeholder groups in the decision-making process. Current plans by Durrell Wildlife Conservation Trust and Madagascar Wildlife Conservation (both have been active in the region for over 20 and 14 years, respectively) and other collaborating NGOs are to reconnect the isolated Park Bandro with marsh habitat and further lemur subpopulations in the south. It is critical where to reforest marshes in order to increase chances that the newly planted cyperus shoots will not be destroyed immediately by fishers or farmers who were not part of the decision process. Conservation bodies and researchers will thus organize planning workshops with the adjacent communities and involve all crucial stakeholders such as official and traditional village leaders, VOI (responsible entity for natural resource management), affected fishers and farmers. Based on ecological data, different scenarios will be developed and then discussed and assessed with the stakeholders to include the human dimensions, that is, their attitudes and preferences. The aim is to reconcile both human needs and biodiversity values.

The understanding obtained in the various meetings, workshops, and gaming sessions will help with this difficult task. There is seldom one 'solution' or 'answer' to conservation issues or human-wildlife conflict, but different choices, which are more or less acceptable to different stakeholders or interest groups [3, 8]. Stakeholder involvement and negotiation processes are crucial to determine acceptance of proposed management in advance [92]. In Madagascar, a disconnection of policy decisions and community needs has reduced the effectiveness in the conservation and development sector in the past 30 years [79]. Especially in poor countries, people sometimes feel as victims of top-down decisions in conservation, which impact their lives and livelihoods without giving them the opportunity to take part in the decision-making process. This can create resistance or opposition toward conservation projects and conservation organizations. Including local resource users in the conservation planning process creates feelings of ownership and increases chances of long-term success of conservation projects. This link may explain why the special conservation zone Park Bandro is still existent and well-respected by the majority of the adjacent community of Andreba because it was created together with the community (but see [49] for details).

As in the global conservation movement, initiatives for the protection of *Hapalemur alaotrensis* initially focused on habitat protection and ecological insights. However, with growing human pressures, the human dimension increasingly became more prominent in management decisions and conservation strategies. In the past century, conservation advocates realized a broad range of conservation and development projects, reaching from basic reforestation and exploitation regulations, over education and outreach initiatives, to agriculture support and improvement. However, with ever-increasing human population numbers (both local increase and immigration) and changing climatic conditions, it is becoming increasingly challenging to convince people of conservation importance. Weak law enforcement corrodes conservation success in many developing countries, especially when rural people can increase their little income through illegal activities [93]. Law enforcement is thus critical in protected area management to ensure long-term conservation success [94–96]. Though the integration of mutual benefits for human wellbeing and biodiversity has gained increasingly attention in Madagascar following global

trends, the challenges of realizing this by community involvement and co-governance in Madagascar remain the same: the management and monitoring of these areas is proving to be difficult due to a combination of a lack of financial and human resources, as well as weak technical capacity [97]. This makes the human dimensions even more important; considering local resource users' needs and aspirations and including them in the decision-making process has been proven in many other contexts to increase ownership, support, and long-term conservation success. The fact that people in the Alaotra region are willing to negotiate conservation zones in the marshes raises hope that *Hapalemur alaotrensis*, currently being listed as 1 of the 25 most endangered primates in the world [98], still has chances of survival.

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