

Transitions by Methodology in Human-Wildlife Conflict - Reflections on Tech-based Reorganization of Social Practices

Margarita Grinko*^{†‡}
Tanja Ertl*^{†§}
margarita.grinko@uni-siegen.de
tanja.ertl@uni-siegen.de
University of Siegen
Siegen, Germany

Konstantin Aal^{†§}
konstantin.aal@uni-siegen.de
University of Siegen
Siegen, Germany

Volker Wulf^{†§}
volker.wulf@uni-siegen.de
University of Siegen
Siegen, Germany

ABSTRACT

Can cattle farmers live peacefully alongside lions, and what role can technology play in this sensitive setting? Since 2017, we have been investigating this question in the Okavango Delta, Botswana, using a Grounded Design (GD) approach. Based on community involvement we have been building and evaluating a system together with local and foreign experts which warns the locals when a lion comes near their village or their cattle and which has significantly reduced livestock predation by giving time for action. However, as our research shows, technology alone is not the solution for locals' problems: education, knowledge transfer, economic self-determination, as well as the revival of herding traditions and lost connection to nature need to evolve further to foster a true coexistence between humans and predators in Botswana - and perhaps all over the world. To address these problems and solutions by design and ensure sustainability of its outcome, it is important to take into account the oral culture and collective history of the inhabitants with predators, especially lions. Consideration must also be given to their social environment and individual experiences and goals, as well as their digital infrastructure, accessibility, and digital ecologies. We therefore argue that the successful development of a design solution requires a holistic understanding of design that is built on inclusion, participation, collaboration, understanding, respect, sacredness and the always-recurrent cyclic renovation of life.

KEYWORDS

Human-Wildlife Conflict, Grounded Design, Botswana, Lions, Transitional Systems

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*Both authors contributed equally to this research.

[†]Information Systems and New Media, University of Siegen, Siegen, Germany

[‡]KontiKat – Zivilgesellschaftliche und betriebliche Kontinuität durch sozio-technische Vernetzung in Katastrophenlagen (funding code 13N14351)

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1 INTRODUCTION

Throughout the history of humanity, the relationship between humans and wildlife has been characterized by neighborly coexistence, cooperation and mystery, but also mutual threat, exploitation and fear. In research, the latter aspect is called Human-Wildlife Conflict (HWC) [39], which extends across lakes and oceans [42] and even into the skies [53]. This conflict encompasses innumerable situations and species, ranging from the most diminutive of insects to big mammals [6, 63, 75, 94]. While humans expand their habitat and attempt to control nature to their benefit, these encounters often lead to fatal consequences for the wildlife. The risk posed by the conflict has recently come forcibly to the public's attention through documents such as the WWF's 2018 Living Planet Report [7] and nature documentaries such as Netflix's 2019 *Our Planet*¹. Previous research in the field of human-computer interaction (HCI) has tried to counteract these developments with various approaches. Egan et al. (2019) established an urban and interactive permaculture project on-campus in Edinburgh. Their approach is characterized by the combination of permaculture, university campuses and digital media and focuses on shifting "our thinking and doing" [29]. In a different study, Ziegler (2019) tried to adapt environmental governance structures from indigenous, rural communities for natural resource management. Here, he concludes that "technologists need to adapt participant-led research methods that leverage local communities' expertise about their own environments, social institutions and cultural norms" [103].

The African continent is possessed of an enormous variety of unique wildlife and specific ecological habitats, a large proportion of which are tremendously fragile. At last count, 133 species of animal in Africa were on the critically endangered or endangered list and 104 species of plant [49]. All of this amounts to a pressing and complex challenge of not only local but global significance [68]. It forms the backdrop to this paper, which focuses upon one instance of HWC: the conflict between cattle farmers and lions in northern Botswana. African lions (*Panthera leo*) have particularly fascinated humans and played an important role in Western and African folklore. The bushmen of South Africa considered lions "to be among the most humanlike of all animal-people" [84]. However, despite their special place in human culture, the relationship between these big carnivores and people is often problematic: for Botswana², destruction of fields by elephants, loss of livestock by lions or the accidental but rare death of humans when meeting a predator are the most challenging moments [51]. As a result, the Botswana who live close to the Okavango on the edge of the Delta, suffer from the lack of food and personal security. The

¹<http://www.ourplanet.com/>, available on Netflix

²Inhabitants of Botswana (singular: Motswana)

outskirts of national parks, the areas where wild animals are protected, have become hot spots for conflicts with larger animals, especially predators [23].

A number of efforts have been made to reverse some of the more serious outcomes of HWC or to prevent issues from arising in the first place (see section 2). Increasingly, HWC has also been recognized as an arena within which technology might have a role to play [44, 66]. At the same time, community-based resource management has rarely been linked to ICT [103]. Implementing such strategies on the ground can be enormously challenging, both logistically and relationally, with solutions sometimes depending upon the complicity of local populations with wildly divergent interests [59, 89]. However, Information and Communication Technology (ICT) may offer new views on conflict mitigation and develop new solutions that can address the concerns of all stakeholders, including the predators themselves. At the intersection of HWC and also Animal-Computer Interaction (ACI), we are following an on-the-ground approach. By implementing an approach following a design case study [102] (see section 3), we sustain an ongoing cooperation with local stakeholders and researchers. To try to mitigate some aspects of the conflict between human settlers and the population of wild lions in the northern Okavango Delta in Botswana, a GPS-based lion alert system was designed and deployed so that lions could be tracked and livestock owners warned on their mobile phones whenever a lion was close to their pastures or village (see section 4). Alongside of this, a variety of conflict reduction strategies were implemented from educational meetings to a herding program. Also, understanding user practices and how these evolved alongside the technology is instructive for the system iteration and for identifying how future approaches to mitigating HWC might be developed.

Our results suggest that solutions need to be built upon a proper understanding of a range of considerations, including human orientations and practices, animal behaviors, and environmental factors, and they have to protect the interests of humans, livestock and predators in equal measure. In relation to this, the warning system clearly has a role to play, but its effectivity is limited, due to technical infrastructure, digital illiteracy, the poor economic situation on the ground, and the loss or lack of knowledge about herding and building and using kraals as well as lions and their importance for the ecosystem. Further limitations are resulting from an ongoing conflict of interests between farmers and tourism employees as well as farmers and the government due to the declaration of the Okavango Delta as a national park, and later World Heritage Site, which caused loss of identity as hunters and fishers. Moreover, the growing tourism sector and its side effects of urbanization, wage labor, educational aspirations, loss of connection to wildlife and limited prosperity impact not only culture, but also identities embedded in it. Additional compensation payment challenges complicate the relationship with the government. Therefore, the LionAlert system will need to be supported by on-the-ground-activities that fill the gaps, such as education, livestock caring support and economic empowerment. In addition, new roles need to be established within existing communities to ensure that these online and offline interventions are sustained, addressing new identity building. Against this backdrop we argue that the integration of multiple stakeholders and methods as well as a focus on sustainability, conservation and co-existence makes our system transitional. This holistic perspective, with reference to Arturo Escobar (2018), will be the basis for the introduction of 'Matristic Design' that follows values which are associated with historical matristic cultures (see sub-section

5.4) [33], a new and more holistic design approach. By providing these insights and perspectives, we also highlight the role of computing in a rural setting which is affected by real-world limits and how to incorporate these limits into the design process and intervention.

2 RELATED RESEARCH ON HUMAN-WILDLIFE CONFLICT AND MITIGATION

As mentioned above, HWC is an old and broad topic, which has been covered from many perspectives. Focusing especially on the Okavango Delta, we will look at causes and effects of HWC, as well as mitigation approaches and their success before identifying the research gap.

2.1 Causes and consequences of HWC

The growth of human population and its livestock and their invasion into natural habitats, which results in habitat loss, hunting, introduction of alien species, and pollution, is considered to be one of the most critical threats for many wildlife species today [22, 23, 73]. When sharing room so closely, human needs and those of wild animals overlap [23] and it comes to conflict situations where both sides experience suffering. This has led to the endangered status and extinction of thousands of species especially since the globalized spread of human settlements since the 1970s [36].

In Africa, HWC has been exacerbated by a range of factors: the African population is expected to double during the next 30 years [37, 91]. At the same time, climate change appears to be rendering larger and larger swathes of the continent difficult to live in, especially in terms of farming and food production [92]. Many African nations are plagued by political and economic insecurity (Adepoju 2019).

To relieve the situation and retaliate their losses, livestock farmers have resolved to hunting or poisoning lions [73, 95]. Studies show that this conflict has led to a considerable decrease in the numbers of predators in places all over Africa [9, 46, 48, 57, 77]. However, large predators such as the lion fulfil an important function in the specific ecosystem with regard to the equilibrium of individual populations. Their disappearance could change "*the structure and function of the entire ecosystem*" [23] unpredictably [36]. Additionally, large predators form a major tourist attraction [3, 12, 23, 46, 57].

2.2 Mitigation

Mitigation of HWC itself has two distinct kinds of focus. One of these relates to addressing and trying to resolve the consequences of conflict, the other is concerned with minimizing the scope for conflict arising in the first place.

2.2.1 Efforts to mitigate the consequences. A wide variety of strategies have been adopted for dealing with the outcomes of HWC by non-governmental organizations (NGOs) and governmental bodies. In gross terms, these can take three forms, which also have their own limitations: one concentrates on dealing with the outcomes of past conflicts, the other upon conflicts that are ongoing. The former includes recent moves towards the 'rewilding' of a variety of habitats where populations of wild animals have long since been displaced. The second relates to attempts to actively protect existing populations of wild animals before they become displaced, often using regulatory instruments. The latter is of relevance to the case studied in this paper. As a third approach, there is monetary sanctions for poaching and compensation for farmers who have lost their cattle to predators.

Rewilding: Historically, the prime resort was to wildlife protection and the setting up of nature reserves [17, 47]. A number of projects

of recent times have focused on a fairly radical approach to conservation called ‘rewilding’ [36, 82, 83]. This involves attempts to restore or build entire ecosystems from the ground. Initially the focus was upon building wildlife corridors in the US, but it has extended globally to the development of entire sites, often involving extensive initial investment, both in financial and labor terms.

Conservation, animal protection and associated regulation: New economic strategies in Botswana build on prior decisions of the government about the proclamation of the Okavango Delta as a National Park, with a hunting ban within the area and an increase in the lion population being linked to that [59]. The efforts for conservation often tend to give an impression of a preference for the protection of the species over and against the well-being of affected local populations. Retrospective attempts to reduce such conflicts involve a variety of approaches, including artificial and natural barriers, e.g. (electric) fences, hedges, rivers or mountains, which so far are only functional in specific regions and for certain species. Local natural resources (e.g., trees and stones) may also be involved. The respective combination of all these factors is obligatory for a successful intervention [23, 43, 59], but success, here, is only focused on the shorter term, as risks of damaging population diversity could be a final consequence of these so called ‘ecological islands’ [36].

Policy: Important, here, is the official sanctioning of illegal kills of wild animals on the one hand and granting compensation in the case of loss on the other hand [43, 51]. Often, the goal here is to promote tolerance towards the affected animals [35].

2.2.2 Efforts to mitigate the conflict. When it comes to trying to minimize the scope for conflicts to arise in the first place, a number of different strategies need to be discussed, including: adoption of policies that might offset the impact of wildlife activity, e.g. predation; education of local populations regarding the wider issues and the attempt to encourage them to adopt a more ‘holistic’ view of the place they share with animals in the natural world; attempts to provide alternative incentives to local populations that might actively encourage them to take a more positive view of local wildlife e.g. ecotourism; use of traditional methods that have previously enabled human populations and animals to live together more harmoniously, e.g. the use of kraals (cattle enclosures), fires, guard-dogs, etc.; and, of particular interest here, the use of technological interventions to try and prevent conflict arising.

Education: Very often studies focus only on the technical aspects of conflict reduction, lacking a wider consideration of “*peoples’ attitudes towards wildlife, which are complex*”, involving “*social factors as diverse as religious affiliation, ethnicity and cultural beliefs*” [22]. People affected by HWC tend to show a negative attitude and little affection towards the protected animals, as conservation efforts are rarely geared towards helping them, and this political and interpersonal conflict nourishes HWC [22, 54, 59, 71]. Misconceptions regarding particular species abound, as illustrated in the image of lions being ‘dangerous’, when it has been found that lions typically avoid people [31, 79]. As a result, proposed solutions are often limited in their effectiveness because they do not reach the core of why such conflicts might arise at all. The case we are examining here explicitly moves towards this broader consideration of local attitudes.

Re-incentivization: This builds in some ways upon the interpersonal conflict that first nourished the conflict [59], with certain animals being considered to be an important attraction that can contribute to an income from tourism, because this adds a ‘mystical atmosphere’ resulting from people’s perceptions of predators [3, 12, 86]. Here we

find a huge clash of divergent interests between the government and the target group of farmers living near the Delta in the northern part of Botswana, who suffer directly from the decrease in their livestock [59]. However, Stander et al. (1997) state that “*the income from ‘leopard tours’ in Namibia, where guests view leopards at a kill-site, exceeds the economic cost of carnivore depredation on livestock in the surrounding villages by 2.6 times*” [83].

Traditional methods: A more effective way to avoid the killing of cattle can be guarding the livestock by shepherded grazing, including guard dogs and the use of high-quality kraals at night. According to Gusset et al. (2009), with reference to other studies 2003, 2005, 2006, the combination of these two variants could prevent 85% of all kills, if supported by further habits like lighting fires next to the kraals at night. Weise et al. (2018) also consider kraals to be significant tools to protect livestock from predators, but they need to be properly maintained, adapted to individual users’ needs and combined with herding [96].

ICT-based approaches: Beyond all this, there is an increasing array of technical applications being brought to bear, such as electrical collars for wildlife or devices which emit sounds, light or scents whenever a wild animal is detected. However, these kinds of solutions come with a high deployment and maintenance cost and effort and do not always conform to legal and ethical standards regarding animal welfare [81]. Building a consensus among all relevant stakeholders from all of the concerned communities and disciplines – in our case, farmers, government officials, biologists, and tourist lodge owners – and using ICT specifically tailored to local requirements, can ensure more sustainable participation and support [11, 19, 38, 99].

At present, there is little evidence of effective technology-based prevention or mitigation approaches in HWC. A positive exception is a study by Sheppard et al. (2015) where the authors built an autonomous GPS geofence alert system to warn wind farm managers if a condor was approaching their wind farm, so that they had a chance to stop the turbines. This actively seeks to reduce bird mortality [80].

In conclusion, HWC management is nothing other than human management. Although systems like that by Sheppard et al. is promising, there is little evidence of user involvement in its development, which is crucial to ensure the system is properly used, adapted and evaluated, especially when thinking about the real-world limits of these systems [80]. The most effective efforts to prevent HWC focus on local human behavior [8, 21, 77, 88]. A change in livestock owners’ attitude and practice is necessary which requires a holistic and sustainable approach to HWC mitigation. Our LionAlert system, which will be introduced in section 4, is aimed at supporting this approach by using technology and particularly Grounded Design to co-develop the technology together with the stakeholders 2017.

3 METHODOLOGICAL APPROACH

3.1 Grounded Design

The basic problem of human-animal conflict refers to a complex clash between actors in an ecosystem, where at least one of the players has no voice. Therefore, the lion’s needs can only be addressed by a proxy representative. In this project loosely structured like a design case study [102], the enabling of this was first ensured by a biologist on site, and furthermore supported via the use of technology. Lions as ‘participants’ in the design process could be quite challenging, but observations of lions in their natural habitat, i.e. ethnography from the HCI perspective could provide further insights for possible designs

[55] (e.g., what kind of tracking device could be used without interfering with the typical behavior of lions and which doesn't restrict their movements or expose their position when hunting); here, the research area of Animal-Computer-Interaction (ACI) tries to address this topic [62, 74, 97]. In addition, captive lions or animals living in anthropogenic environments could be included as participants in design activities instead of the lions (e.g., domestic cats or smaller wild cats). HCI has so far mainly dealt with domesticated animals (such as cats and dogs) and studies with more dangerous animals as design participants are missing [97]. Here, Haraway (2013) argues for real encounters with animals in practical located contexts, face to face with the animal, as the only way to become with and respect and establish a relationship with nonhuman beings [45]. But, while this works quite well for pets, wild animals like lions or elephants are a threat for humans when trying to engage with them.

Locals within the conflict zone also needed support to raise their voices and make them heard. The socio-technical solution concept (here: the LionAlert system) was designed from the ground up in a participatory manner with the end users, i.e., other participants from different hierarchical levels. In principle, socio-technical solution concepts serve to reorganize social practices, which should help to minimize real-world irritations, at best to cancel them [78]). But we must be aware of the risks that any change in social practice not only resolves the original prevailing underlying problem, but also generates changes within the community and ecosystem, which are not always anticipated and can sometimes lead to undesirable late effects. Escobar (2018) describes this as follows: *"We design tools, and these tools design us back"* [33]. Here it is especially important to engage with locals, to understand their needs, to express requirements, which then can be translated together with the inhabitants into a design [10]. Against this background, changed social practices by failed design become irritations themselves in the long run e.g., forming social practices from outside, threatening cultural traditions, or excluding individuals from the community and/or transformation [25, 27]. Nevertheless, to prevent such negative side-effect in the future and for irritated social practices to change retrospectively, the problem-solving process must be participatory and community-based in nature, a premise we meet by means of the Grounded Design (GD) approach [78, 102]. GD promotes situational understanding by using ethnography [40], participatory design (PD) [41] and action research [50] in collaboration with all relevant stakeholders relevant for solution generation to experience the respective lifeworld of the end user target group [1, 30, 32, 90]. The latter are the most relevant within the design case study, as they can be considered as experts of their own everyday life. Nevertheless, the view has to be extended to their respective social environment [78]. The process of knowledge generation is therefore holistic and interactive. After all, decolonialization also means acknowledging alternative means of knowledge storage and sharing [25]. Furthermore, it is an iterative design process, which allows for a stepwise build-up of understanding, whereby the ostensible problem is enriched by context and causes are uncovered [78]. Holistic data collection in this context includes not only demographic, socio-economic and/or technical data, but also insights into how people think, feel and act, as well as the interactions between people and lions, but also between human actors themselves. With this in mind, opportunities and challenges of technical solutions were explored within the existing context and addressed in the co-design process of the different stakeholders to arrive at a solution that enables alternative action strategies which are more suitable in and beneficial for the Global South. The results of the

use case at hand [78], HWC in the Okavango Delta, Botswana, show that a purely technology-based solution would not generate sufficient behavioral change to sustainably minimize human-animal conflict on the ground. Rather, the LionAlert system must be as holistic, or multimedia, as the design process within which it was developed. This thus supports the aspect of Santos' 2015 aporia cited by Escobar (2018), which describes the gap between modern problems and traditional solutions that need to be addressed by radical design thinking [33].

3.2 Local Co-design

Our research visits to the Okavango Delta conflict area are divided into three different study phases, comparable to the design case study construct which consists of an exploratory, a design/prototyping and an evaluation/appropriation phase [102]. The differences to a classical design case study were that a prototype of the ICT tool at hand was already built before we carried out our study, and that we do not focus on one tool in particular, but are also concerned with other means to address the HWC issue.

During the first 6-week research visit between January and March 2017, a semi-structured survey of basic data was conducted using an initial exploratory interview study with a total of 36 participants (farmers, tourism employees, dikgosi (plural for kgosi, a traditional village leader), children and youth) from four villages and adjacent cattle posts. These interviews were conducted with the help of a local team, who reached out to contact possible interviewees and were also aware about the research program and agenda, without this support, recruiting wouldn't be possible (Bidwell 2016). In the survey we focused on the following parameters: demographic data, daily routine, digital technologies, cultural aspects, the manual LionAlert system, social life and tourism. The participants were half female, half male. Age groups were divided into three cohorts: 18-39 years (n=13), 40-64 years (n=12); 65+ (n=11). 15 people had no schooling, 13 had junior level (primary and middle school), 7 had Cambridge level and 1 had a university degree. 20 persons lived in the village, 16 in the cattle post. All 36 persons were farmers, 2 were also employed in tourism and 4 held public office additionally. In total, 25 people were affected by lion kills.

In the second visit in 2018, focus groups with 35 participants (8 women and 27 men; 21-39 years: n= 12; 40-59 years: n=16; 60+ years: n=7) from three villages and different adjacent cattle posts were conducted. Their demographic characteristics were similar to those from the first study, however, less women were participating because of the personal network from which participants were recruited, and because cattle are traditionally taken care of by men. We wanted to learn more about farmers' daily practices and their rural knowledge, their perception of the system and improvement potentials, with a focus on possible conflicts between the existing practices, their knowledge and the technologies, therefore also the limits of the system. Based on the findings, a pre-designed mockup for an interactive LionAlert interface was iterated which allowed users to register for the system, learn more about wildlife and contribute their own observations and knowledge on lions. In addition, we held expert meetings with biologists and tourist guides. In a second round of workshops, this system was evaluated using walkthrough and thinking aloud [69], and subsequently adapted.

Following this second phase, the LionAlert system was automated, individualized warnings were added and a herding program was additionally established (see section 4). We conducted an appropriation study in 2020, where we interviewed 24 participants (4 women and

20 men; 21-39 years: n= 7; 40-59 years: n=13; 60+ years: n=4) on their attitude towards and usage of the warning system. This time, our interviews specifically included tourist lodge managers and employees, government employees, policemen, and teachers. Nine participants have not been registered to receive lion alerts at this point. Similar to the second field stay, field notes and observations completed our data and served for further improvements of the project. Findings from the third field phase particularly emphasized the limitations of technology, which had already been improved, and the importance of additional measures (see also section 5.3). Throughout all phases, we have been in constant exchange with local and international project partners.

4 RESEARCH SETTING AND THE LIONALERT SYSTEM

Botswana is a landlocked country in Southern Africa with a strictly hierarchical social and governmental structure that carries right through to rural areas: villages, traditionally governed by a kgosi, are a key part of the country's make-up and accommodate about 50% of the population [15, 28, 34, 65, 70]. After mining for diamonds and niccolite, tourism is one of the major sources of income. This hinges upon the fact that Botswana largely consists of desert and national parks, with an abundance of wildlife [2, 61, 65]. A large chunk of northern Botswana is occupied by the Okavango Delta. This unique inland river delta covers an area of about 28,000 km² and is home to a wide diversity of wildlife [76]. In 2014, the Okavango Delta became the 1000th site to be added to UNESCO's World Heritage list. But even before this, governmental nature conservation efforts obliged the local communities within the Delta itself to move and resettle at its borders. Since 2014, hunting is no longer allowed in the Delta [5], which disrupted the indigenous, especially San lifestyle and resources and decreased perceived ownership and acceptance of wildlife of which the human inhabitants were no longer considered part (Bolaane 2004). With human settlements expanding, HWC has increased: wild animals regularly intrude upon human settlements at the borders [76].

Our study area encompasses one specific part of the Northern Delta, namely the villages of Seronga, Gunotsoga, Eretsha, Beetsha and Gudigwa. The total population of the area is about 5,000 people and 16,500 cattle [95]. Most of the inhabitants rely upon subsistence farming, and their social standing traditionally depends very heavily upon how many cattle they own [31, 95]. The common practice in rural Botswana is to let livestock roam the veld (uncultivated grassland) during the day. In the late afternoon, they are traditionally brought to a kraal (fence enclosure) [96]. However, very few local livestock owners are able or willing to invest the time and effort involved in gathering their cattle every day. As a result, a lot of the cattle are just left to roam the veld without any enclosures or protection at all [96]. At the time of writing, at least 12 different prides of lions were occasionally encroaching upon the study area as part of their routine movement. The prides were made up of a minimum of 28 known adults and 15 cubs, giving a total of 43. Most of the attacks on the local livestock were attributed to lions, who attack livestock not only because they are close to their habitat, but also because they are slower, easier to hunt, and more nutritious than wild prey. The majority of attacks occur in the veld at night, upon livestock that have not been moved to the kraals and that are left unguarded. This seems to make kraaling by far the most expedient countermeasure [96].

The relatively infrequent inspection of cattle by their owners arising

from these various issues means that the disappearance of animals is often noticed only after a long delay, varying from a day to several weeks. This also inhibits the application of appropriate countermeasures. Instead, livestock owners sometimes pursue an alternative strategy of retaliation or eradication by illegally hunting the lions throughout the delta, thus, further endangering an already fragile population [73, 95].

From an infrastructural point of view, there is only one dirt road connecting all of the villages and most of the cattle posts. The local power supply is variable and not available to everyone. Day-long power outages as well as interruptions of telephone and internet connections are common [31]. While most farmers have a mobile phone, many feature phones are used. Usually, only the younger locals possess smartphones and use them for other purposes than calling. Computers are a rare sight.

We are realizing the LionAlert system in an interdisciplinary team of biologists, designers (the authors) and programmers together with the project Pride in our Prides (PioP) by the NGO Communities Living among Wildlife Sustainably Conservancy (CLAWS)³. When our study began, PioP had already implemented a prototype of a warning system called LionAlert in the study area to prevent human-wildlife conflicts involving livestock predation by alerting livestock owners of lions approaching the grazing areas. The first version was still manually operated. LionAlert is based on the lions wearing collars equipped with a GPS sensor and there being pre-programmed digital geofences, or warning lines, to trigger an alert when a tagged lion trespasses over either of two fixed geofences.

In the first version, once the virtual boundaries had been specified, they remained static and could not be re-programmed remotely, until the collar detached from the lion because its battery was depleted. Every two hours, the sensor pinged the respective lion's coordinates to a server hosted in Germany. When a tracked lion overstepped the digital geofence, a local biologist had initially received an alert on their mobile phone and also via email. The biologist then had to find the lion's location on Google Maps by entering the received GPS coordinates. He subsequently notified an interpreter who in turn notified the dikgosi and farmers in the concerned villages via text message or phone call. Since 2018, the system has been automated and sends customized alerts to its users once the lion breaches the geofence. Furthermore, the geofences can be flexibly adapted, the number of collars and the number of system users has increased.

Upon receiving the alert, livestock owners could secure their cattle in the kraal and take measures to scare away the predators, should they appear. Lions can be scared away with fires and torches or by groups of people generating noise, shouting and releasing their dogs.

Before the alerts were implemented, 63.7% of livestock owners experienced some form of lion attack between May 2015 and April 2016 [96]. In the initial pilot study phase by CLAWS between 2016 and 2018, the warning system has prevented 50% of the attacks. The local communities' attitudes towards the project and lions in general were divided [31, 67]. Our first interviews revealed that there were basically two different points of view, depending on people's profession (farmer vs. tourism employee) and life experience. Some people wanted to see the lions removed and their local culture left undisturbed. Others supported the idea of peaceful coexistence and understood the long-term effect that killing or displacing the lions would have on the economic situation in the Okavango Delta. The increased acceptance of lions,

³<http://www.clawsconservancy.org/>

especially the understanding of their importance for the tourism industry and economic future of the delta, not least thanks to LionAlert and the additional measures described below, has become evident in our field visits in 2018 and 2020.

CLAWS has been involving the community from the project's beginning by introducing the system and giving updates on it in kgotla (central court and community center in each village, plural: dikgotla) meetings. In these meetings, the ownership of and attitude towards lions has been addressed by offering the community the chance to give names to the collared lions. These names are often chosen to reflect the lions' characters in Setswana terms (e.g., Maleherehere ('the sneaky one') or Shishatiya ('the approaching one')). Local herder workshops have also been offered. Furthermore, starting in 2019, a communal herding program has been established in Eretsha: all farmers who want to participate can add their cattle to the herd that is guarded by five herders day and night, kraaled in the afternoon, and medically supervised and treated. The herders are equipped with the LionAlert system to be able to prevent potential attacks. However, livestock owners are updated about their animals' state and still have full control over them.

In the future, we plan to further increase the system effectivity by incorporating and enhancing locals' understanding of lions, their behavior and role in the ecosystem, while supporting their traditional practices of livestock husbandry. We will outline these approaches in more detail in the next section.

5 REFLECTIONS AND DISCUSSION

In this section, we will present and simultaneously reflect on some specific findings of our study. Thus, we will not elaborate on all results, but focus on three distinct themes: conflict of interests, knowledge of the indigenous people of Botswana and its relation to technology, as well as limits of technology. Citation by our study participants are indicated with "P" and the according number given to them. Based on these reflections, we propose a 'Matristic Design' approach.

5.1 Conflict of Interests

Conflicts of interest within the area at the Okavango Delta are besides the human-animal conflict also those between farmers and tourism employees as well as between farmers and the government. Botswana is a multi-ethnic and tribally divided patriarchy in so-called *merafe* (tribal units), which has been independent since 1966. It is democratic and has the status of a newly industrialized country. Its official language is Setswana (Chilisa 2000). After the proclamation of independence, the image of work changed due to the expansion of cities and the emergence of tourism. Education became the determining factor for success. The connection to wage labor in the urban centers, especially Gaborone (capital), Maun, and Francistown, as well as in the national parks (Chobe National Park, Moremi Game Reserve, Central Kalahari Game Reserve, Nxai Pan National Park, and Okavango Delta), offer a modern form of work and financial income. The younger generations in particular benefit from this, as they can participate in the new educational opportunities of the emerging country and thus better position themselves economically, socially and politically, while others - predominantly older generations as well as target groups in rural areas - remain dependent on subsistence farming due to (previous) lack of schooling, possible illiteracy as well as a lack of infrastructure [13, 16]. Most Hambukushu, Wayeyi (Bantu), and Bushmen (San) living within the conflict area between Seronga and

Gudigwa on the northern edge of the Okavango Delta are therefore traditional farmers. Accordingly, the reality falls short of the principles of democracy proclaimed by the government: "*The principle of democracy called for the need to consider education for all people and the need to remove sharp differences in geographical or financial accessibility of education in different sections of the population*" [16]. Further changes arose from the government's ban on hunting within the delta, which was declared a World Heritage Site, to support the tourism industry. This severely curtailed the rural population's traditional and culturally embedded practices and rights to provide for themselves, and greatly affected their identity as hunters and fishers. The ban on hunting allowed the population of lions in the core of the delta to increase freely. On the periphery of the delta, for farmers cattle became the main livelihood [13]. For the few local residents who work in the tourism sector, cattle remain a steady resource to fall back on in times of financial need. As mentioned above, ownership of cattle is also accompanied by claims to prestige, assuming the amount of cattle becomes profitable. However, most Batswana do not enjoy prestige in this regard, living well below the poverty line, having just one up to a few cattle or none at all. Cattle therefore represent a high good for both one reason (prestige) and the other (wealth). Its loss through lion attacks is therefore accompanied by fear and pain. Other challenges to the self-sufficiency of local farmers include periods of drought [52]. This example shows how systemic change interferes with existing traditional culture-based social practices, upsetting functioning systems and thus leading to real irritations like the HWC. Previously legal practices such as lion hunting are now inherently irritated by their illegality and create even more irritation in the new system, which results in conflict of interest between human parties. The described social system and its changes are complex as the system includes multiple fields (politics, economy, education, nature and culture), many actors, their individual and collective identities and aspirations as well as old and new framework conditions. Its transformation over time has been both influenced by and influencing existing power dynamics. These have positive and negative effects, e.g., more education and prosperity, but also fewer rights and freedoms [13, 52]. The developmental effects of urbanization, wage labor, and educational aspirations continue to have an impact on culture, despite the tradition of farming, which has so far been strongly advanced, with knowledge and competence being critical variables for culture and cultural perceptions, as well as identity tied to them [13]. The government tries to compensate for the killings caused by lions and to mitigate the HWC to reimburse farmers and increase their acceptance of wildlife. However, this has proven ineffective in the past because of limited budgets: "*I am aware of the compensation but it is not enough to buy a new cow*" (P6, f, farmer). Also, farmers need to present the head of the killed animal for the compensation to be paid, and they usually need to wait very long, sometimes even up to ten years. This has created disappointment among farmers and the impression that wildlife conservation is more important than they are. On the other hand, the compensation, when it does come, is objectively relatively high as compared to the market value, so from observation, we suspect farmers may prefer the compensation over the additional effort of protecting their livestock. This is but one of many causes why cattle are not properly herded, and does not contribute to a proper human-lion coexistence. The problem is not only found in Botswana [60].

To address this problem, the reasons for delayed compensation payments must be investigated and, at best, resolved. This requires close

networking with the government. Other approaches have based the compensation on prior efforts to protect livestock [58, 72], however, as many farmers do not have sufficient resources to do so, this would further increase the gap between livestock owners and the government. Prerequisites for payment should therefore give way to trust in the farmers on the part of the government, which needs to be built up. Possibilities to better protect livestock, more independence and economic power for the farmers (see section 5.3) would make it unnecessary to abuse newly created trust in the form of compensation fraud.

Our on-site interviews revealed perceived differences among individual residents in light of the systemic changes described above: *“There is a difference between someone living in the village and someone in the cattle post. Because the one living in the settlement needs his livestock for living. The one in the village is just looking for a job. If someone from the village goes to the cattle post he will get something to drink and to eat (...). But if someone comes to the village (...) they just look at them (...).”* (P1, m, farmer). Here, the first changes in culture and mentality become visible, which can be traced back to changed social practices. The increased emergence of technology in the villages and the better infrastructure on site also differentiate the possibilities of the respective inhabitants: *“We cooperate but lifestyle in the villages and cattle posts is different regarding to technology”* (P2, f, employee in tourism; farmer). Further, it is also the respective knowledge of the lions and other wildlife that distinguishes villagers from those in the cattle post: *“They [lions] are moving around through our cattle post every day. We know what is moving close to us, what has happened, what is passed. (...) But if you stay in the village you know nothing”* (P3, m, farmer). Finally, the degree of being affected by lion attacks or their potential occurrence also shows a serious difference: *“The difference (...) is that in the village it’s safer than in the cattle post because (...) today this is the third week for us to be checked by lions”* (P4, m, farmer). The protection of cattle represents at the same time a higher potential danger for its owner, in case he lives in the cattle post to guard his domestic animals. Also, there is a clear gap between the generations. P5 looks with concern at the socially changing bonds among people, who, like work itself, are becoming increasingly mobile, flexible, and therefore more volatile, forgetting their traditional habits and traditions (field note, Feb. 03, 2017/4th). P3 presciently sums up the fragility of human peace: *“What I’ve realized first of all is that before people can have conflict with animals, they start conflicts by themselves. This is like when I know [name] (...) is a wildlife officer. As he is a wildlife officer, obviously he safes wildlife. And then me as a farmer (...) obviously I save my family and my livestock (...). And then the conflict it will start first between me and [name]. (...) Automatically if I hate [name] it will continue to [name] children and I will tell my kids not to play with [name] because [name] is not a good man. Just because [of] his position and his play”* (P3, m, farmer). What farmers recognize is the change coming with independence and development – be it political, economical, educational or technological – it comes with long-term loss of traditional culture, norms and values, further with new thoughts, feelings and practices. It also prepares the ground for conflicts with each other. For all those who are both farmers and tourism employees, there can even occur an inner conflict as there is a difference of perspective with regard to the lion, which is more than worthy of protection: 1) in the sense of species preservation for an intact ecosystem, which they significantly control through their *“interspecific competition and regulation of prey populations density”* [23] and 2) in the sense of tourism, which flourishes in but especially

outside our conflict zone of the delta. The lion, in addition to the threat it poses to cattle ranching, represents an important existential resource in this context and one that is geared towards the future of younger generations [56]. For the farmers within our conflict area, this entails a learning process, which we considered as part of our grounded design [102].

5.2 Indigenous Knowledge and Technology

Most indigenous people of Botswana on the northern edge of the Okavango Delta are primarily self-sufficient, i.e., farmers and herders, although few of them have other secondary occupations. Lack of employment is also a valid reason for living as a farmer: *“Starvation is why I choose to become a farmer and a herder”* (P1, m, farmer). Against this background it becomes clear why cattle are existential in nature, which was repeatedly emphasized by the interview participants: *“A cattle here is [a] source of life. (...) Even not for me only but to assisting the family in the tribe. (...) It covers almost each and everything”* (P8, m, farmer).

However, there is no real strategy for herding the cattle. Rather, it is limited to releasing the animals from the kraals in the morning into the vast, green, water-rich delta and to gathering them in the afternoon (around 3 p.m.), i.e., before the sun sets and the predators awaken. Hardly anyone still accompanies their cattle into the delta themselves, but there are also a few exceptions *“Sometimes I take care of my cattle and go with them”* (P1, m, farmer). One cause of insufficient herding can be traced back to the introduction of mandatory schooling. With the introduction of school attendance, children and adolescents no longer had time to herd the animals, so there was a decrease in the number of herders, which nowadays only happens rarely or when one can afford to hire a herder, and the strenuous herding profession has become unpopular. At night, those who keep their cattle in kraals, which is the vast majority today, take various protective measures, with the men devoting themselves to looking after the animals, in accordance with the Batswana culture: *“During the night we make a fire near the kraal, so predators know that here are people”* (P7, m, kgosi and farmer) – a frequently used means of intimidation, as the lion fears humans and what their immediate presence suggests. Kraals were built for a long time as simple enclosures, but they offered little protection against predators. After efforts were made again by various local initiatives to make kraals lion-proof, many older Batswana remembered that the new construction method is almost identical to the old method that was used decades ago. Therefore, new knowledge was not created, but old knowledge was revived.

The lion has an extremely bad reputation among villagers in the Okavango Delta, because it causes some of the greatest damage to them: *“(…) next to lions, hyenas and wild dogs cause most destruction on us. Most of the other animals don’t do destruction (...)”* (P4, m, farmer). This fear is mostly due to the narratives of third parties, as the following quote reflects well: *“No one taught us about lions. We just heard it from the adults”* (P6, f, farmer). The expert knowledge about lions, which could alleviate those fears about the present life, for example knowledge about preferred food, was unfortunately just as little given among most participants as knowledge about social behavior, as the following statement makes clear: *“I don’t know anything about the social behavior of the lions”* (P6, f, farmer). Some people, especially San who had lived in the Delta before the forced resettlement, remember their close relationship to wildlife and how it changed throughout the years. They lament that this understanding is lost in younger people have less connection to the wild and do not know how to

distinguish tracks and sounds or how to behave if they encounter a lion. In contrast, those who have found work in the tourism sector or who are self-motivated and have access to resources (books, etc.) can sometimes close their knowledge gaps, which can otherwise easily lead to misunderstandings about the lions. Helplessness is also evident in the case of a direct encounter between man and lion, in which by far not everyone reacts so knowingly. Here, most of the participants refer to third party narratives: *“I learned from my father how to react to a lion; that you have to stand still. If you are many you have to scream”* (P1, m, farmer). However, the lion is seen less and less nowadays and there are also fewer and fewer stories about encounters between humans and lions. The tourism industry has further improved the lion’s reputation, and more and more locals understand their value: *“[the lion] brings for these young ones income and employment”* (P55, m, farmer). People like former inhabitants of the Delta, herders and field guides possess a vast amount of knowledge, experience and skills which they can transfer to others along with their appreciation and passion for the rich nature of the Okavango. Here, it is also important to look closer at how knowledge is traditionally stored and passed on, as these may differ from our own perspective and be used to effectively enhance it [25]. A first step would be to acknowledge that indigenous information, learning and science are no less important or valuable than the Western ones, and a Motswana understanding of native nature can foster acceptance of and coexistence with predators better than information imposed from outside [11, 20, 85, 99]. We have seen a display of this in the form of a community theatre play on the history of elephants and their relationship to farmers. In other areas, indigenous traditions and skills are equally practiced and passed on alongside modern developments. For example, some people visit traditional healers if they feel ill. In elaborate and lengthy ceremonies, the healers and other volunteers “treat” the person by dancing, singing and playing drums.

With the introduction of technology and its evaluation, a first step can be taken to mitigate the human-animal conflict, but as the insights here show, there are other challenges (lost knowledge about lions and their behavior; forgotten designs of kraals that protect against lions; less herding). Bidwell (2011) pointed out that the design process needs *“to acknowledge some of the political, social and cultural dimensions that influence the design and use of devices and production of media artifacts”* [11]. While Bidwell was referring to Critical Design [26], this is also true for the LionAlert design process. Subsequently, along with the introduction of technology, several other initiatives have been established to address these issues: in order to better understand the lion and to get a closer look at the animal, video screenings were conducted with close-up footage showing the lion in its natural environment. This was very positively received by the participants, as it showed the predator from another side, as a loving mother who cares for her cubs; thus a pride animal with a strong social behavior, but also as a hunter. At the same time, the villagers were invited to be part of the project and to assign names to the lions living in the area. In this way, the animal became something personal and the villagers also asked how the lion was doing. Especially older indigenous Batswana may be involved in this process by telling their own as well as traditional stories on wildlife, which can then become part of the educational aspect of the system.

Another initiative was the creation of a construction group that helped villagers build kraals based on the lion-safe model. As a result, the safe model spread faster in the region and everyone was also motivated to copy it. However, the responsibility for how the users of the system

react to the alert messages rests solely with the recipient (e.g., make fire or noise; get to safety).

5.3 Limits of Technology

As our research in the Okavango Delta has shown, ICT alone is not enough to solve the problem HWC is presenting both to locals’ livelihoods as well as wildlife conservation, as pointed out by Toyama 2015. When it comes to technology, several aspects limit local usage of it: two of them are the technical infrastructure and economic situation. Even though mobile connection and the possession of mobile phones is widespread, power outages and connectivity breaches frequently discontinue their function. Even when power is available, many locals do not have access to electricity outlets in their homes and therefore no opportunity to charge their devices. In addition, to be able to communicate, mobile users need to acquire ‘airtime’, which can be done in local tuck shops by purchasing small strips with activation codes on them. If the users do not have the money or if the tuck shop’s supply of airtime strips has temporarily run out, the connection to the outside world is interrupted. This led to many users reporting they have not got the alerts in time because they had no reception, their battery died, or they had no funds on their SIM card anymore. For a lion alert system to be fully functioning and reliable, it would need to have its own stable power supply and network, as well as enable its users to benefit from it for free. However, even when all the prerequisites are given, technology can only function to amplify already existing changes. Toyama (2015) equally warns that technology is never the main driver of social progress but rather depends on human changes, which then can be supported by ICT.

Furthermore, using an ICT interface properly required digital literacy. Van Joolingen (2014) defines it as *“interest, attitude and ability of individuals to appropriately use digital technology and communication tools to access, manage, integrate and evaluate information, construct new knowledge, and communicate with others in order to participate effectively in society”* [93]. As we have observed in our workshops, many locals have never used a computer; most of them, mainly the elder farmers, have feature phones. Even reading analogue maps was difficult for some of them, as orientation is based on a different understanding of the environment. Therefore, technology widely used in the Global North cannot simply be transferred to the Okavango Delta as is. Given the hesitant and skeptical attitude many Batswana in the rural area have towards ICT, it may take quite some time to integrate it into their daily life. However, digital literacy is also dynamic and the gap is often overestimated [103]: younger Batswana are very eager to learn about new technologies and already use many apps on their smartphones. They may be multipliers of ICT literacy for their villages, comparable to young people in the West explaining computers and mobile phones to their grandparents.

This also limits the design of new applications together with the end users, which is the principle of Grounded Design. We tested pre-designed mockups with them and could identify obstacles and potentials, but we could not gain proper suggestions from end users, let alone encourage them to design with us, as we were not on the same page about ICT in the first place. This raises the question to what extent Grounded or Participatory Design is possible in contexts with low digital literacy.

To overcome the barrier of digital illiteracy we have been resorting to technology that is already there and being used for the time being, meaning feature phones and smartphones, and sending personalized alerts to their owners whenever a lion crossed a geofence near them.

However, even this simple function comes with another issue: what to do when an alert comes? Here the loss of connection and knowledge to one's environment and its non-human actors becomes apparent. Therefore, to address this question, we introduced the inhabitants to the lions and their behavior in regular kgotla meetings, as well as taught how to react when they receive an alert or even meet the predator face-to-face. But knowledge alone does not help in this case. There have been numerous reasons not to react to the warnings. In the following we outline the main reasons.

Reason 1: One is that many of the alerts are sent at night, so farmers wisely do not leave their safe houses. Cattle are left to fend for themselves and are checked upon and sometimes kraaled in the morning to prevent further possible lion encounters.

Reason 2: When the warnings do come during the day instead, in many cases, farmers are busy with other duties and have no one to send looking for their cattle.

Reason 3: When the water is low in the Delta and the cattle are deep in the veld to find drinking opportunities, the journey is too far and strenuous for many – especially if elephants are known to be roaming around, an encounter with whom can end fatally for the person. This is one of the most popular reasons for not kraaling cattle.

Reason 4: Some locals seem to have missed the importance of kraaling their cattle altogether and prefer to turn to local project partners or the Department of Wildlife and National Parks (DWNP) with the request to catch and relocate the lions that have been known to roam the grazing lands looking for easy prey.

If the users have no opportunity to act, what is the use of a warning system after all?

Ideas to support the current warning system included:

- (a) Automatic lion repellents, i.e., lights and sirens attached to the kraals or kgotlas which are activated should the lion reach a certain distance. However, these would need to be used wisely.
- (b) Careful use could be associated with an intelligent algorithm calculating the probability of lions attacking cattle, because otherwise they would keep the village awake and lose their deterrent effect quickly as the lions would get used to them.
- (c) Equipping users with a smartphone app with similar functions would allow them to scare away lions on their own accord, with low material cost and less threat for the predators (as compared to, e.g., rifles).
- (d) Residents should learn more, either from others' stories and experiences or reflect on their own perceptions about their environment, wildlife, especially lions and their role within it, and in particular their own role, since most of the reasons given for non-action if alerts occur can be traced back to a lack or loss of traditionally existing knowledge that was once traditionally available. Regarding their own role within the conflict and how to mitigate it knowledge on herding, building and using kraals, and how and where to light fires accurately during the nights are just as important as building trust with each other when you have to rely on external shepherds because of other activities.

The Grounded Design approach and its participatory components helped us to get this far and uncover existing shortcomings and challenges on the ground. The question now arises here whether this technology-based design approach can also be used for knowledge transfer when there is a lack of digital literacy.

Knowledge has been a powerful tool to build a connection to the surrounding environment and to one's own identity as a farmer, but as long as fears and misunderstandings dominate the locals' image of

lions, they can never be truly a part of our undertaking to actively minimize the HWC. Mutual understanding of the wildlife and ecosystem to be conserved is key to effective community conservation. While kgotla meetings over the years have influenced the public opinion on predators towards a more positive, accepting attitude, we believe that exposure to more vivid information – stories, images and videos – can support this development without digital illiteracy standing in the way of these ventures. By installing a device, for example a tablet, with related content in the kgotlas, we can give locals the opportunity to learn more about their wild neighbors. On the other hand, they could contribute their own knowledge and experience to build up a resource of communal knowledge which is backed up with scientific facts. Of course, the maintenance and usage should be in the hands of local employees or volunteers. Because the handling of ICT and associated hardware needs certain skills, we can contribute by listening to and teaching the locals and make them multipliers of both technical and biological/conservation knowledge. This maintains the participatory character of the Grounded Design and perpetuates it within the technology-based intervention, thus sustaining the active role of the residents in the long run.

For now, the most effective solution to keep cattle safe from lion attacks has been a communal herding program combined with the LionAlert system which the herders have on their phones. This approach requires well-educated herders who are strongly committed to the cause, as well as trust and support by the cattle owners. While the herding program has experienced difficulties with regard to this at the beginning, it is now heading in the right direction and promises good results. So far, no cattle were killed by lions when being part of it. In addition to daily care, protection from predators and regular medical treatment the cattle receive, controlled herding also ensures a sustainable land usage and helps avoid overgrazing. Future plans include introducing a mobile abattoir to be able to slaughter healthy cattle on-site, increase beef market value and sell it, for example, to local tourist lodges. By further developing communal herding with access to the market, we could strengthen the farmers' economic self-dependency and make cattle a valuable economic factor which needs to be treated with care and protected from predators. Nevertheless, known mistakes such as the overproduction of meat should be prevented.

In summary, it is not the question of either human or technology: ICT can only be a solution if it supports on-the-ground activities by informing, warning, enabling, and is continuously adapted.

5.4 Matrisc Design

Successful (technical) interventions must take into account all relevant stakeholders in order to achieve a sustainable impact [64] and consider and acknowledge the different dimensions (political, social and cultural) which influence the design itself but also the locals [11, 33]. Local stakeholders must not be mere users of technology, but decision-makers for the whole project, and no groups should be left out due to their social status or digital literacy [98, 99, 103] and in addition, the integration of the communities' participatory practices could help, that locals are able to appropriate the design process (Winschiers-Theophilus et al. 2012). But to achieve this, a mutual learning process needs to be established, where specific values (see matrisc design values) guide the collaborative design process. Meurer et al. (2018) argue to consider the specific embedded artifacts which will be created but also the existing practices; the researchers

need to understand “*how to design with a view onto users’ needs and ‘real use’ and how to ‘infrastructure’ in the sense of embedding the design result in the practices of the members of an organization or community and keeping it embedded.*” In addition, they state that one should go beyond the focus on the local use of technology and pay attention to the technological, organizational and political context and also limits, from a longer time perspective [64]. In a context of human-wildlife coexistence, they need to become part of a permaculture as outlined by Egan, Thompson and O’Dowd (2019), where the digital and physical space are intertwined, sustainably designed and the human role in nature is redefined or found again [29].

Against this background, a socio-technical solution concept, which is tailored to collective and individual needs and other aspects, reorganizes an irritated social practice out of daily practice. Based on our own findings, we go even a step further and argue that researchers should also consider and reflect upon their own role in the research environment and the entire design process, and think about the impact of the intervention on second-hand stakeholders (such as nature or, in our case, lions and cattle). Adopting the local perspective also includes long-term thinking about to what extent an intervention is necessary, beneficial and desirable. For example, taking farmers’ control over their cattle could mean a weaker bond to their animals or another identity loss; a stronger tourism and economy in the Okavango Delta could mean more nature exploitation.

The role structure revealed in patriarchal Botswana is based on traditional values and norms that clearly distinguish the identities of men and women and the associated power potentials, which is reflected in the respective social practices and thus also has an impact on the corresponding knowledge and handling of livestock. As foreigners, we researchers tried to adapt to the Botswana system and its customs as best we could. Especially, as three of our researchers were female, they were bound by the hierarchies in the patriarchal field, which made fulfilling their role as researchers challenging at times.

Escobar (2018) emphasizes that “*conversely, historical matristic cultures were characterized by conversations highlighting inclusion, participation, collaboration, understanding, respect, sacredness, and the always-recurrent cyclic renovation of life.*” Following this definition, a holistic design approach should also include these values in its core. We tend to call this Matristic Design. This, as we define it, seeks to increase the quality of life for all agents in nature, and attempts to address, understand and then resolve conflicts that arise in all their facets. In doing so, it relies on the core values already presented:

Respect: This is something that should not be underestimated, here it is particularly relevant to meet stakeholders as equals, to take them and their decisions seriously and to discuss with them on this basis. Respect is the basis for building trust. Both are requirements for each of the steps in the design process.

Inclusion: All relevant stakeholders, their knowledge and their perspectives need to be included in the overall design process instead of imposing it from outside. Here it is also especially important to listen to voices which are very quiet or have no voice at all (e.g., wildlife and nature).

Understanding: This is especially important to not only include stakeholders in the process, but also try to understand their reasoning for their perspective. Here, the researcher can learn something about their own perspective on the context and reflect on it.

Participation: While inclusion guarantees that different perspectives are heard and understood, participation goes one step further and seeks to provide an active role in the process [4, 30]. Participation

conveys self-responsibility for the outcome and, if well guided by the joint process, promotes self-confidence instead of overburdening through a sense of ownership.

Collaboration: As already mentioned by Meurer et al. (2018), different stakeholders have different perspectives, but the main goal would be to let them collaborate with the researchers throughout the whole project and more importantly with each other to create consensus and overcome conflicts [64].

Sacredness: Life is precious and needs to be in the core of each design. While sacredness is often perceived as somehow abstract and belonging to the spiritual part of the world [14], it can be seen as something which goes beyond design and its goals, and question the decisions made in during the process.

The always-recurrent cyclic renovation of life: With a focus on design, an iterative design approach best resembles the recurrent cyclical renovation of life, where it does not end after the completion of a prototype or intervention, but appropriation and integration in daily life continue to play a role [24].

6 CONCLUSION AND FUTURE WORK

Our project on the participatory lion warning system has shown that technological systems can help address issues of human-wildlife coexistence and conservation but also has several limits. It is only effective if it takes into account all stakeholders’ perspectives, - something to thrive for but is often impossible to include in all projects - , is properly embedded in users’ lives and is used to support their practices as well as to create new ones. Our holistic Grounded Design approach is focused on incorporating the local knowledge, attitudes and socio-economic situation into the development. Infrastructural, hierarchical, cultural and technical limits complicate this process, but are also insightful for future projects. Our experience suggests that there is a need for a Matristic Design, which takes the holistic approach a bit further and challenges the local power dynamics, interest conflicts and aims to shift the anthropocentric perspective to a rather ecocentric one with matristic values at its core.

Future work focuses on new areas of human-wildlife conflict, how technology can help mitigate it and to identify the limits of technology. At the moment, we try to adapt the existing approach to the challenges livestock farmers in the rural areas of Germany are facing due to the fact that wolves are returning to Germany after they were extinct because of their recent inclusion in the European law on endangered species. Again, we must first attempt to understand the conflict before we can intervene. To do this, it is important to show respect and understanding not only for the wolves, but also for those affected, to design a world which creates a space for both humans and non-humans.

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