LionAlert – Participatory Design and Evaluation of an Interactive Notification System to Reduce Human-Lion Conflicts in Rural Botswana

LionAlert – Partizipatives Design und Evaluation eines interaktiven Benachrichtigungssystems zur Reduktion des Mensch-Löwe-Konflikts im ländlichen Botswana

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Abstract

In the Southern African country of Botswana, the Okavango Delta is famous for its abundance of wildlife. However, this popular tourist destination is also inhabited by many people, mostly farmers, who live in close proximity to the national parks. When domesticated animals' grazing land extends into predator territory, fatal conflicts are the consequence: around 250 attacks on cattle were reported in the four villages we researched in 2017, 87 % of them being by lions. Not only are the farmers' livelihood and safety endangered, but poor governmental compensation schemes also lead to frustration, a negative image and even persecution of lions.

To solve this problem and reduce conflicts to a minimum, the non-profit organisation *CLAWS* (Communities Living Among Wildlife Sustainably) has introduced GPS tracking of selected lions by means of attaching collars and establishing a warning system called *LionAlert*, where researchers notify locals via a text message to their mobile phones whenever a lion enters a critical area. While this has helped reduce attacks by around 50 %, a range of problems remain, among them a static signal area and time frame, network instability, the inefficient nature of manual warning as well as other factors which prevent warning recipients from reacting accordingly.

This Master's thesis deals with an attempt to solve these issues by iteratively designing and evaluating an interactive interface for a new, automatically operated version of LionAlert. For this purpose, a Design Case Studies and Participatory Design methodology has been applied (Schuler & Namioka, 1993; Wulf et al., 2018). Over the course of three weeks in August 2018, two rounds of workshops were conducted by an interdisciplinary team with 35 participants from three villages in the Okavango Delta. They served to determine the concerned parties' current situation, the adoption and usage of the current system as well as the potential for improvement, identifying the initial requirements for the updated system. An interface prototype incorporating participants' suggestions was then evaluated and discussed in the second workshop. Based on feedback from the workshops as well as by the observations of local researchers, a final prototype has been developed and eventually will be implemented in an automated version which features a tablet-based local warning station and an app for two different kinds of mobile devices. Further implications and limitations for mitigating the human-wildlife conflict via information and communication technology (ICT) are discussed below.

Keywords: Human-Wildlife Conflict, ICT for Development, Participatory Design, Design Case Study, Global South

Zusammenfassung

Das Okavango Delta in Botswana, einem Land im südlichen Afrika, ist berühmt für seine Artenvielfalt. Doch das beliebte Touristenziel wird auch von zahlreichen Menschen in direkter Nachbarschaft zu Nationalparks bewohnt. Wenn die Weideflächen ihrer Nutztiere mit dem Territorium von Raubtieren überlappen, sind fatale Konflikte die Konsequenz: etwa 250 Angriffe auf Rinder wurden im Jahr 2017 in vier untersuchten Dörfern gemeldet, von denen 87 % von Löwen stammen. Nicht nur die Existenz und Sicherheit der Farmer sind bedroht: unzureichende staatliche Entschädigung führt auch zu Frustration, einer negativen Wahrnehmung und sogar Verfolgung von Löwen.

Um dieses Problem zu lösen und Konflikte auf ein Minimum zu reduzieren, hat die Non-Profit-Organisation *CLAWS* (Communities Living Among Wildlife Sustainably) ein GPS-Tracking von Löwen mittels Halsbändern und ein Warnsystem namens *LionAlert* etabliert, bei dem Forscher die Einheimischen per SMS warnen, wann immer ein Löwe einen kritischen Bereich betritt. Während das bereits geholfen hat, die Angriffe um 50 % zu reduzieren, bestehen weiterhin viele Probleme, darunter ein statischer Signal-Bereich und -Zeitraum, Netzwerk-Instabilität, die Ineffizienz manueller Warnungen sowie Faktoren, die Empfänger davon abhalten, angemessen zu reagieren.

Diese Masterarbeit beschäftigt sich mit einer Lösung für diese Probleme, indem ein interaktives Interface für eine neue, automatisch betriebene Version von LionAlert designt und evaluiert wird. Dafür wurden die Methoden der Design Case Studies und des Participatory Design angewandt (Schuler & Namioka, 1993; Wulf et al., 2018). In einem Zeitraum von drei Wochen im August 2018 wurden in einem interdiszplinären Team zwei Runden von Workshops mit 35 Teilnehmern aus drei Dörfern im Okavango Delta durchgeführt. Diese dienten dazu, die aktuelle Situation der betroffenen Parteien, die Adoption und Nutzung des Systems sowie Verbesserungspotentiale herauszustellen, die die initialen Anfoderungen für das aktualisierte System identifizierten. Ein Prototyp des Interfaces mit den Aussagen und Vorschlägen der Teilnehmer wurde daraufhin im zweiten Workshop evaluiert und diskutiert. Basierend auf Feedback aus den Workshops sowie von lokalen Forschern und eigenen Beobachtungen wurde ein finaler Prototyp entwickelt, der schließlich in einer automatisierten Version implementiert wird, die eine Tablet-basierte Warn-Station sowie Apps für verschiedene Arten von mobilen Geräten impliziert. Weitere Implikationen und Limitationen für die weitergehende Linderung des Mensch-Tier-Konflikts mit Informations- und Kommunikationstechnologien (ICT) wird diskutiert.

Table of Contents

List of Figures

List of Abbreviations

CLAWS: Communities Living Among Wildlife Sustainably

DCS: Design Case Study

DWNP: Department of Wildlife and National Parks

HCI: Human-Computer Interaction

HCI4D: Human-Computer Interaction for Development

HWC: Human-Wildlife Conflict

NGO: Non-governmental organisation

ICT: Information and Communication Technology

ICT4D: Information and Communication Technology for Development

IS: Information system

PD: Participatory Design

PiOP: Pride in our Prides

List of Definitions

Cattle post: Typical for Southern Africa, a cattle post is a small separate settlement usually located near villages. It consists of enclosures for cattle as well as huts suited for permanent stay.

Kgosi: Chief of a Tswana village. Plural: *Dikgosi.*

Kgotla: Central court and assembly spot in a Tswana village where community meetings or juridical processes take place. The kgosi has their office in a kgotla.

Kraal: Enclosure or corral, usually made of wooden poles, used to keep cattle safe over night in a village.

Motswana: Member of the Tswana ethnic group, or more generally, inhabitant of Botswana. Plural: *Batswana.*

Pula: The local currency in Botswana, while also being the Setswana word for “rain”.

Setswana: Besides English, this is the official language in Botswana.

Rra: Common Setswana address for men, comparable to “Mr.” / “Sir” in English. The female equivalent is *Mma*.

Tswana: The dominant ethnic group in Botswana, which is followed by *Kalanga, Ndebele, Herero,* and *San* (or *Bushmen / Basarwa*). Also a name for a local cattle breed.

Veld: Term for the low grassland common in the Okavango Delta, as well as Southern Africa in general. This word is originating from Afrikaans.

1 Introduction

Living in a civilisation more or less separated from nature in the wild, we often forget that there are settlements and communities that live in close proximity to wildlife. As urban and managed rural environments have expanded they have abutted existing forests and grasslands and now compete with wildlife for habitat and resources. A conflict between these human settlements and inhabitants of the wild areas, we call Human-Wildlife Conflict (HWC).

Southern Africa is a well-known example for a setting where HWC frequently takes place. In this thesis, our journey takes us to the Okavango Delta in Botswana, a rich grassland area where humans and wildlife live in close proximity (Gusset, Swarner, Mponwane, Keletile, & McNutt, 2009). For the inhabitants of local villages which lie adjacent to national parks, cattle farming is the main source of livelihood as well as an essential status symbol. The other one is tourism, which can only persist if the natural environment is preserved (Ministry of Environment Wildlife and Tourism, 2013). However, predators frequently attack people's livestock, especially endangered lions, which results in hostility towards them as well as persecution by rifle or posion, even though hunting is forbidden by law in Botswana since 2014 (Barbee, 2015; CLAWS Conservancy, n.d.; DeMotts & Hoon, 2012; Gusset et al., 2009; Ministry of Environment Wildlife and Tourism, 2013). The effects are a disturbed ecosystem, an endangered tourist destination and an economically destabilised community.

There are several approaches to solving this problem – in Botswana as well as other communities affected by HWC – applied by government as well as NGOs, like physical fences and monetary compensation (Distefano, 2005; Ecoexist, 2019b; Gusset et al., 2009). However, these approaches have not been very effective so far for various reasons. Therefore, the priority should be to prevent HWC in the first place and at the same time generate a more positive attitude towards predators, so that they acknowledge them not only as a vital part of a functioning ecosystem, but also as a valuable source of income as a tourist attraction (Ertl, 2017). Working directly with the affected communities and involving them into conservation efforts, while respecting cultural characteristics, habits, and attitude towards technology, has proven to deliver the most sustainable effects (Distefano, 2005).

Communities Living Among Wildlife Sustainably (CLAWS) Conservancy is an organisation which aims to improve co-existence between people in areas close to wildlife and corresponding fauna, especially by reducing fatal conflicts to a minimum. Their project *Pride in Our Prides (PioP)* focuses on lions in the Northern Okavago Delta in Botswa-

na, especially on five villages particularly affected by HWC (CLAWS Conservancy, n.d.). It follows an educational as well as practical approach, whose central element is a semi-automatic information and communication technology (ICT) system called *LionAlert,* based on GPS collars on lions and established in 2016. Whenever lions wearing the collars cross a digital geofence, local researchers are alerted. With the help of a translator, they call or send a text message to people in the endangered area (Ertl, 2017; Weise et al., 2019). The cooperation between CLAWS and the University of Siegen has emerged since 2016, where the main goal has been to include ICT and human-centered design to address HWC by improving the alert system.

LionAlert has helped reduce lion attacks on cattle by 50 % (Weise et al., 2019). However, it has several shortcomings which need to be addressed. Therefore, this thesis is predicated on the following research question, using the example of LionAlert:

How can information and communication technology be used to create a sustainable solution for co-existence of people and wildlife, which maximally addresses local users' needs, fits their everyday life, and is nurtured by their support, using the example of a lion warning system in the Okavango Delta?

I attempt to find an answer to this question via Design Case Studies (DCS) (Wulf et al., 2018) and Participatory Design (PD) (Schuler & Namioka, 1993). The work was conducted by an interdisciplinary team of information systems (IS) researchers, an anthropologist, and biologists as well as research assistants. When I refer to "us", unless stated otherwise, I mean those team members that conducted the study and directly supported the work described in this thesis (see chapter 4.2 for a detailed description of the team). Based on a qualitative analysis by Ertl (2017) and the existing LionAlert system, we conducted workshops[1] to evaluate how the new system would need to be designed to meet users' needs and desires, and thus be effective, usable and sustainable. All the while, we were keeping in mind local technological, cultural and individual barriers. This also includes enquiries on experiences with, and use of, the current system with those who already received warnings. Taking into account the local hierarchy, values, attitudes, education, habits, ICT usage, and knowledge of participants, the goal was to design several interfaces for *dikgosi* – local village chiefs –, cattle owners, and herders.

During a three-week field trip in August 2018, our work was done through focus groups and interviews. Prior to travel, a first workshop guideline as well as use cases and user stories had been developed to support the PD process. Furthermore, a first, estimated design or representation for different gadgets and purposes had been developed and ite-

[1] Although these sessions can also be called "focus groups", "group interviews" or "group evaluations", I will broadly refer to them as "workshops" to reflect the openness and diversity of our approach which includes all of the above.

rated throughout the PD phase in the prototyping tool Axure (2017). Illustrations had been prepared to help illustrate the existing system and our envisioned system in an understandable way. This was crucial to determining which solutions appealed to our participants and to develop design ideas together.

We worked with two groups of six participants each from three villages in our study area: Eretsha, Beetsha, and Gunotsoga. Dikgosi, livestock owners and herders with diverse demographic backgrounds were recruited on-site by a research assistant and translator, from and outside the population who had already participated in the interviews conducted by Ertl (2017). The first workshops, following a focus group approach, were carried out to gain an understanding of the underlying practices of livestock management, technology usage, and experience with lion attacks, as well as the existing LionAlert system, which we complemented with our own observations in the field. Our aim was to derive users' ideas for improving the existing system, which were then used to adapt the LionAlert 2.0 design.

In the second round of workshops, all ideas were presented along with an iterated prototype which was evaluated by users. The interfaces were iteratively adapted based on user feedback for each workshop. Three types of gadgets were tested, each simulated on a notebook: A tablet, smartphone, and feature phone. Expert evaluations with other project stakeholders, namely biologists and research assistants, completed the set of requirements and adaptations necessary for an appropriate design.

Following the three-week participatory design phase, a final design was being developed back in Siegen. It is currently being made into a working prototype in cooperation with a student programmer based on a detailed analysis of the participant statements and feedback from other team members and an in-depth literature study. Once the prototype is deployed, an in-depth evaluation and appropriation study will follow back on-site.

In this thesis, I will first conduct a literature review to establish the state of the art concerning PD in developing countries, present the situation in the Okavango Delta (chapter 2), and describe the current version of the system, as well as potential for improvement (chapter 3). Subsequently, I will describe our DCS approach and methods of the PD workshops we conducted locally to design the autonomous and interactive new version of LionAlert (chapter 4). A detailed record of our results as well as the design evolution will be provided in chapter 5. I will then reflect on these results, whose focus is the design of a new, interactive LionAlert version together with the local communities, discuss limitations and derive lessons for future PD work with economically and technologically marginalised communities, while also providing an outlook on the further steps of our project (chapter 6).

2 Background and State of the Art

Before describing current research in this area, I would like to first explore the specific characteristics and problems of the Okavango Delta to understand the research setting and prerequisites. Therefore, I have dedicated the first two sections 2.1 and 2.2 of this chapter to the presentation of the location, Botswana as a whole, as well as the Okavango Delta in the North of the country. Ethnographical characteristics and specifics of the population reveal many important facts about the key stakeholders in our project. Grasping the political and social structure is crucial to successfully organising the project and communicating with local users, gaining their trust and support in the process. Their daily life, habits and attitudes are important factors in local human-wildlife conflict and its mitigation. On the other hand, wildlife characteristics and natural aspects such as climate and ecosystem significantly contribute to this as well. Also, it is essential to emphasise the level of local technological development and adaptation – in relation to LionAlert and ICT in general –, as it forms the foundation for our ICT-based project.

In connection with my research question, I have identified two larger components in my literature review: human-wildlife conflict and ICT for Development (ICT4D) together with PD in countries with low technological literacy, primarily the Global South. The latter term originated from an essay by Gramsci (1978), where the first economic distinction between North and South was made in relation to Italy, but was soon applied to the global economy and development politics (Dados & Connell, 2012). Nowadays, under the heading of Global South, we include nations in Africa, Asia, Latin America and Oceania which, compared to Europe and North America, are characterised by lower income as well as social and cultural marginalisation (Dados & Connell, 2012). According to Prashad (2014), this division was also influenced by the resistance of colonialised countries against their dominating states, and has led to the production of intellectual thought from these countries (Dados & Connell, 2012), referred to as “Southern Theory” by Connell (2007).

Participatory design has already been successfully applied in the Global South in recent years. Such projects, which are oriented towards solving problems in societies in the Global South via technology, are often comprised under the term ICT for development – ICT4D (Joseph, 2015) – or HCI for development, HCI4D (Chetty & Grinter, 2007; Dell & Kumar, 2016). Understanding underlying ICT and PD projects in the Global South as well as current situation of HWC in Africa will help guide our approach to the problem solution, demonstrating what generic issues might be seen across many differ-

ent contexts, thus making our approach applicable to relations with animals in other countries, communities, and circumstances.

In sections 2.3 and 2.4, I will first address human-wildlife conflict and examples from around the world to demonstrate that it is a current and growing problem which requires elaborate solutions. The existing mitigation efforts will be analysed according to their leverage point and effectiveness. This topic will be followed by examples of ICT4D and PD, applying different methodologies, both successful and unsuccessful, from which we derived lessons for our own and future research. In conclusion, based on these prior works, I will define our own research in terms of a gap which still needs to be addressed, namely the establishment of a local ICT system co-designed with communities and ensuring a long-term HWC mitigation.

2.1 Political, Cultural, and Economical Characteristics of Botswana

Before providing specific information on the Okavango Delta, it is necessary to convey a few facts about the Republic of Botswana in general. This Southern African, landlocked country borders South Africa, Namibia, Zambia and Zimbabwe. In 2017, the population was 2.29 million (United Nations, 2017). After being colonialised as a British protectorate, the country gained independence in 1966 with Seretse Khama as its first president (Parsons, 2019) and with Gaborone as its capital, located in the Southeast of the country. Pula (BWP) is the name of the official currency.

The republic is governed by a president (currently Mokgweetsi Masisi), while its 16 districts have separate councils and other administrative institutions. Part of these councils are the dikgosi, who are heads of the numerous traditional villages. 34 of them form the House of Chiefs, or *Ntlo ya Dikgosi* that has an advisory role in the government (Commonwealth Local Government Forum, 2017).

In comparison to other countries in Southern Africa, Botswana is depicted as a "political island of stability" (Alobo, 2002, p. 14, translated by the author). The failure of colonial models of democracy due to tribal conflict, dictatorship, corruption, and mismanagement in politics and economy is frequently reported on (Alobo, 2002; Düsing, 2002; Nord, 2004). In contrast to this, Botswana has been stably governed by a parliamentary multi-party system with a constitution, independent justice and fair elections since independence (Meyns, 2000). Law-abiding behaviour and the fight against corruption are regarded as virtues here (Charlton, 2012). According to a representative survey by Nord (2004), over 80 % of all citizens are proud of their country and identify themselves with their nation, while over 50 % have trust in their government.

However, if we look at the heterogenity of the population, this does not appear obvious. Botswana's ethnical structure is split in many different groups, making it the 38th country in the world regarding cultural fractionalisation (Fearon, 2003). The oldest ethnic group in the country are the *San*, also called *Basarwa* or *Bushmen* (1.3%, data from 2000 (Parsons, 2019)). *Tswana* is the name of the largest ethnic group (66.8%) which is divided into further, smaller groups. Other important ethnicities are *Kalanga* (14.8%), *Ndebele* (1.7%), *Herero* (1.4%) and *Afrikaner* (1.3%). A member of the Tswana group is called *Motswana*, the plural being *Batswana*. Also, any Botswana citizen can be called this regardless of their ehnic background. At the same time, Tswana and Kalanga both belong to the larger ethnic group of *Bantu,* who are characterised by the languages they speak. One of them is *Setswana*, the official national language besides English. As for religion, most inhabitants (70%) are Christians, with a smaller amount being Muslim, Hindu and the Middle Eastern religion of Baha'i (Knowbotswana, 2010).

Despite this diversity of ethnic and language groups, a national feeling has been developed and co-exists with a strong ethnic identity (Nord, 2004). It is not surprising that national identity is strongest for the majority group, the Tswana, who dominate the country politically, socially and economically (Düsing, 2002; Nord, 2004). The most economically successful areas are inhabited by Tswana, and other ethnic groups are underrepresented in councils and parliament, at least on a national level, even in the constitution of Botswana (Düsing, 2002; Government of Botswana, 1966; Nord, 2004). While this has not been regarded as a destabilising factor (Breytenbach, 1977; Parsons, 1985), political activity by the opposition minorities is increasing and could lead to ethnic tensions in the future (Düsing, 2002).

Other weak points of Botswana's political and social structure are the continuously unchanged ruling party, as well as the government's control of media such as radio and newspapers, which makes it difficult especially for lower educated citizens to form dissident opiniton (Düsing, 2002; Meyns, 2000; Nord, 2004). It gives rise to the question whether democracy in Botswana is democratic in practice, or is better characterised as a paternalistic state, a phenomenon that has emerged from hierarchical Tswana traditions (Meyns, 2000). Medial control could also be the reason why trust in and satisfaction with the government is highest for farmers, housewives, and pensioners (Nord, 2004). While the importance of political participation is recognised by over 70 % of citizens, the political opposition is weak due to fractionation and is denied the right to political activities inside the rural kgotla (ibid.).

Many ethnic groups in rural areas are still farmers and 50 % of the population live in rural areas (Düsing, 2002), but the discovery of a rich supply of diamonds in the country's soil in the early 1970s has boosted Botswana's economy so that educational and

employment options have multiplied (Acemoglu, Johnson, & Robinson, 2001). Two diamond as well as one copper and nickel mine have been established within a decade, and Botswana has entered into the international trade arena (Meyns, 2000). The importance of mining has suppressed the significance of agriculture: many farmers have become miners, others have joined the tourism industry (Alobo, 2002). The mining industry accounted for over 70 percent of exports in 1986 (Hill & Mokgethi, 1989). Minerals (diamonds and niccolite) and beef have been at the top of the country's export list (Alobo, 2002; World Integrated Trade Solution, 2017), while mining accounts for under five percent of the country's employment (Iimi, 2007). Often, Botswana's history after gaining independence is characterised as a success story (Acemoglu et al., 2001; Alobo, 2002; Meyns, 2000): The diamond trade has helped Botswana achieve the status of an upper-middle income country within 30 years (Sarraf & Jiwanji, 2001). Its GDP, economic growth, and human development index have been outstanding among Sothern African countries (Alobo, 2002; UNDP, 2018). Effective governmental management of the mineral boom and cooperation with the private sector without complete privatisation enabled a continuously robust economy relative to other Sub-Saharan nations (Alobo, 2002; Sarraf & Jiwanji, 2001). The stable political situation is also named as a reason for this effect: "*In countries where the government's power is precarious, excess spending and suboptimal saving may result from interest group pressures*" (Hill & Mokgethi, 1989). According to Meyns (2000), Botswana's political system, competent leadership, as well as sustained growth and development are factors which have contributed to its extraordinary position in Southern Africa from a political and economic point of view.

The economic growth following from the diamond boom allowed investment in the social area, including educational and health institutions (Alobo, 2002). School attendance is mandatory since 1980 (Meyer, Nagel, & Snyder, 1993). Over 80% of all children go to schools, where the amount of girls is higher than boys (Alobo, 2002). While over 80% of the population is literate and educated (Mutula, Grand, Zulu, & Sebina, 2010), this does not necessarily apply to older people or inhabitants of rural areas (Hanemann & Ulrike, 2006). Furthermore, even though the access to school and higher education is maximally facilitated and governmental education programs promote training in specific sectors, Botswana faces a shortage of local skilled workers in several areas (Alobo, 2002).

One notable economic sector in the country is tourism. Around 80% of the country are covered in the Kalahari Desert and 17% of its area is dedicated to wildlife conservation (Main & Warburton-Lee, 2002). Botswana has ten major national park and game reserves, among them the Makgadikgadi Pan, the Central Kalahari Game Reserve, the Chobe National Park, and the Okavango Delta with Moremi Game Reserve. The emphasis lies on sustainable tourism, where only relatively few companies are licensed to

provide limited tours into the national parks (Lohmann, 2000; Mbaiwa, 2005; Parsons, 2019). Tourism has also had an impact on the infrastructure. At present, 93% of transport still takes place on roads (Ministry of Transport and Communications, 2011). However, with five major airports, over a hundred aerodromes (Alobo, 2002) and dozens of air charter operators, the most efficient means of transport is via air, especially considering unfavourable road conditions and the amount of private roads which are not accessible to everyone.

2.2 Ecosystem, Infrastructure, Society, and Technology in the Okavango Delta

Located in the North-West of Botswana, the Okavango Delta is a 28,000 km^2 large inland delta protruding from the Okavango river. The rich grassland is home to over 600 different animal species (Ramberg et al., 2006). Due to Botswana being on the Southern hemisphere, the hot and humid summer lasts from October to March, and winter from April to September. Temperatures can rise up to 38 to 44 °C in summer and drop to 1 °C during winter nights. Compared to the rest of the country, to the North, the climate gets a little warmer and more humid: the temperature is usually between 6 and 34 °C during the year (Climates to Travel, n.d.). The Okavango Delta, like the rest of Botswana, experiences a dry and a wet season. Rain season falls into summer and is usually from November to March, while winters are mostly dry (Batisani & Yarnal, 2010). Heavy summer rainfalls flood the delta and limit the cattle movements, thus contributing to seasonal variety of HWC – an aspect on which I will elaborate in chapter 5. There is a yearly precipitation of 455 mm (compared to 308 in the Kalahari Desert, Southern Botswana) (Climates to Travel, n.d.). However, global climate change has caused rainfall to decline across the country in recent decades (Batisani & Yarnal, 2010).

The delta is not only home to a variety of wildlife species and plants, it is also a crucial resource for the communities living at its border. Formerly, people of San origins lived inside the delta as well. Since 2014, the Okavango Delta is on the UNESCO World Heritage list (UNESCO, 2014). As a result of preservation efforts, communities living inside the delta had to move out and settle down at the national park borders. With the human settlements expanding, HWC has increased: wild animals regularly intrude upon human settlements at the borders (J.J. Blanc et al., 2007; Ramberg et al., 2006).

Our particular study area encompasses five main villages: Seronga, Gunotsoga, Eretsha, Beetsha, and Gudigwa (see Figure 1). There are at least 44 cattle posts in-between, and the area is inhabited by around 5,000 people, and the number is growing (Weise et al., 2018). The area is divided into 51 zones (NG). North of the main road which passes the

villages is NG11, while NG12 is the area in the South. NG12 is also where the next biggest national park, Moremi Game Reserve, begins. The villages and cattle posts are connected by a dirt road which is not maintained and is full of potholes; a fact which is lamented by many locals. To access areas further than Seronga to the West, travellers have to cross the Okavango river on a ferry to reach Mohembo West, just north from Shakawe. This ferry transports three to five vehicles, depending on the size, and the free ride takes around 15 minutes in one direction. A bridge across the river is being built, but the process has lasted for several years. The next major city in the country, Maun with a population of 55,000, is 375 km and around 4 hours of driving away. Apart from an insufficient road infrastructure, people in our study area have limited access to water, electricity and network, which is why we can call them "marginalised" (M. Stevens et al., 2014).

Ethnic groups that live in the Okavango Delta are *Bayeyi, Hambukushu, Dxeriku, Bugakwe*, and *Xanekwe*, who speak different languages and have different traditions, and are not limited to Botswana (Bock & Johnson, 2002). The former three belong to the Bantu ethnic group, the two latter ones are part of the San. Most locals are subsistence farmers and own livestock. Cattle and crop farming is the main source in the Okavango Delta, although this does not apply to all rural areas across the country, where relatively few households have cattle and mainly engage in subsistence farming. Many have to provide for their families by working in larger towns or in another country (Parsons, 2019). Livestock is not only a source of income, but also a status symbol (Ertl, 2017). Therefore, they are seldom slaughtered or sold, but rather kept and bred to main-

Figure 1: Map of the study area in the Okavango Delta

tain the reputation in the community. Because of veterinary restrictions due to foot-

and-mouth disease risk in the area, selling milk and meat outside the Okavango Delta is currently difficult for farmers. Some farmers also work or had worked in tourist industry, while other employment options in the area are very limited.

Concerning the local political and social structure, each village is governed by a village chief, the kgosi, who is also head of a council. The next officials in this hierarchy are the junior kgosi and chairs as well as vice chairs of committees such as the the Village Development Committee (VDC) and Farmers' Committee (FC). Almost every village contains a *kgotla* in its centre, an open court where the kgosi's office building is located, and where residents can meet, discuss, and legislate as well as bring proceedings. This system is a characteristic of the dominant Tswana culture and during public kgotla meetings, the right to participate and speak up is still to some degree defined by citizens' age, gender, ethnicity, and hierarchical status (Lekorwe, 2011). Although kgotla meetings are the most frequent form of political participation, even ahead of votes, citizens have different degrees of influence depending on the kgosi (Nord, 2004). While in the pre-colonial era, the kgosi acted as an absolute political as well as spiritual authority, today, they are most highly recognised and influential in rural areas (Düsing, 2002; Nord, 2004). Trust in dikgosi is even higher than for the president or the ruling party (Nord, 2004). Traditional leadership has been an influential part of the political system. In total, the government in Botswana is characterised as "*a very centralised system of local government […] accommodating traditional government structures within its strategy of social and political control*" (Düsing, 2002).

Technology usage is very diverse in Botswana. Even though the majority of citizens are using a mobile phone (Joseph, 2015), the people in question do not regularly look at their phone, do not have network access, or cannot read the alert text messages (Hanemann & Ulrike, 2006; Mutula et al., 2010). Concerning technology, establishing better networks and telecommunication, connecting communities, establishing an infrastructure in healthcare and business, and making payment more efficient have been the main goals of ICT4D projects in Botswana, while the number of computer and internet users has been rising very fast as compared to other Sub-Saharan countries (Alobo, 2002; Joseph, 2015). Understanding that some people do not have access to power or internet, while being disrupted by occasional network problems (Ertl, 2017), is crucial to understand the appropriation of LionAlert which will be the topic of chapter 3.

2.3 Human-Wildlife Conflict and Solution Approaches

The conflict between civilisation and wild nature is ancient and is a consequence of the growth of human settlements. Attempts to separate wildlife from human settlements have been failing at places where wildlife population growth has caused animals to en-

ter neighbouring human-controlled areas. Rural communities living in close proximity to national parks are especially affected. The livelihoods and sources of food and income of local people, as well as their safety, are at stake. Distefano (2005) has conducted a comprehensive review of worldwide HWC cases and mitigation approaches, which can be found on every continent. I have used this review a basis for the analysis of HWC examples and solutions, as well as comparison with the local situation in the Okavango Delta.

We can find examples, for instance, in India, where lions, tigers, and snow leopards enter human settlements and attack domestic animals and even people (Madhusudan, 2003; Mishra et al., 2003). Peruvian farmers are affected by ocelots, pumas and hawks (Naughton-Treves, Mena, Treves, Alvarez, & Radeloff, 2003). In North America and even in some European countries, wolves frequently attack all types of livestock. In Germany, for example, the return of the wolf in some areas has caused a heated debate as these endangered predators have been responsible for hundreds of sheep deaths in the last decades (Reding, 2018; Reinhardt & Kluth, 2007). Especially the *big five* cause enormous existential problems for the human cohabitants in Africa: Elephant, rhino, buffalo, lion, leopard.

A common form of HWC in the Okavango Delta is livestock predation (Holmern, Nyahongo, & Røskaft, 2007). In our study area, there are currently over 11,000 cattle, while cattle herd size in the Okavango Delta can range from one to 700 animals, and on average, people own 36 cattle (Weise et al., 2018). The common practice in rural Botswana is that livestock roam the veld during the day and at night are brought to an enclosure or corral, which is called a *kraal* in Botswana. This is mostly done by men, while women are responsible for household, fields and smaller livestock. Excavations have confirmed the century-old tradition of this practice (Van Waarden, 1987). However, only few local livestock owners can afford the time and effort required to bring them into their kraals, if they possess one – otherwise, cattle roam the veld without any enclosures. Apart from free-roaming livestock, the Okavango Delta veld is regularly crossed by 12 or more lion prides (see Figure 2).

This population encompasses at least 43 individual animals, consisting of 28 adults and 15 cubs. In the whole of Okavango Delta, around 2,000 lions are currently residing (Björklund, 2003). People experience attacks on their livestock mostly by lions and hyaenas, but also by leopards, cheetahs, and wild dogs (Gusset et al., 2009; Kgathi, Mmopelwa, Mashabe, & Mosepele, 2012). These attacks affect 63.7% of all livestock owners in the area (Weise et al., 2019). Most losses have been reported in Gunotsoga, while Beetsha has received most alerts (see Figure 3). In 2017, the losses have caused a

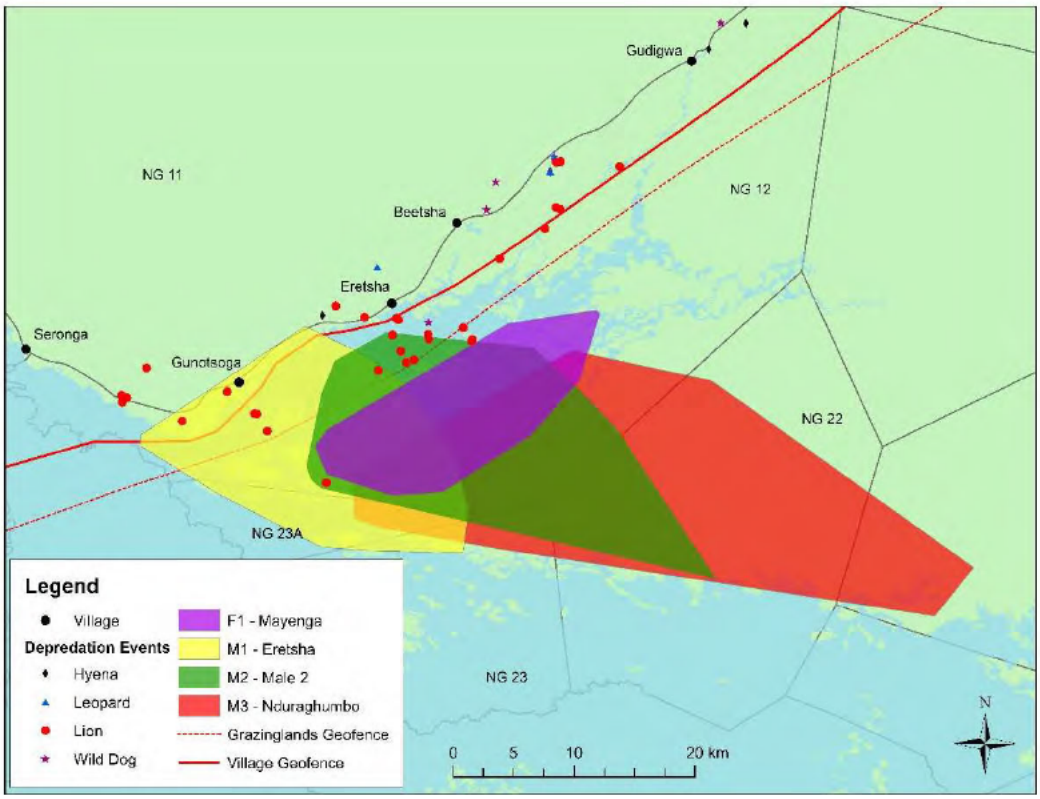

Figure 2: Map of the lion territories tracked by PioP, as well as livestock predation cases recorded in the area. Image by CLAWS

financial damage of 64,030 $ (ibid.). Lions 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.

While we intuitively associate HWC with predators, these are not the only leading cause for losses and monetary impact in many areas. Herbivores like elephants, bush pigs, warthogs, tapirs, and monkeys are especially are a threat to crop farmers in India, South America, and Africa, and can cause even more damage than predators, while baboons also attack livestock or even people (Distefano, 2005; Kgathi et al., 2012; Madhusudan, 2003; Naughton-Treves, 2014; Naughton-Treves et al., 2003; Spinage, 1990). In our study area, particularly the extraordinary high elephant population is "*a matter of urgent concern*" (DeMotts & Hoon, 2012).

To be able to effectively mitigate HWC situations, we need to understand the reasons behind them. According to Distefano (2005), the central long-term reasons are a growing human and livestock population, land degradation and overgrazing in agriculture causing habitats and food sources to decline, and climatic factors, shifting natural seasons especially in Southern Africa. Most conflicts arise because humans as well as their livelihood simply border to wildlife habitats: domestic animals, being an attractive prey, are grazing in the same areas where wildlife is roaming, and crops are readily accessible

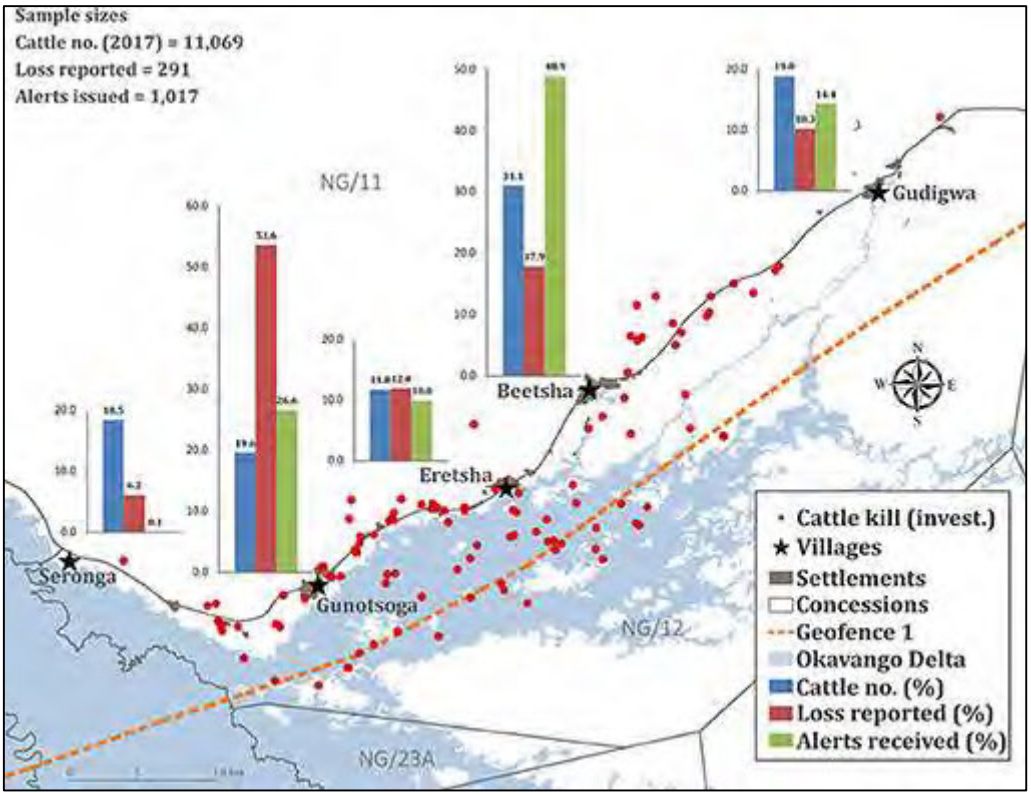

Figure 3: Numbers of cattle, losses to lions, and alerts for lions in the five villages in the study area. From Weise et al. (2019)

from forests and velds. Often, the decreasing and fragmented area of wildlife habitats as well as lack of prey forces animals to look for food sources and living space elsewhere, including human settlements. In the example of jackal conflict in Israel, farmers themselves provoke it by illegally dumping livestock carcasses (Yom-Tov, Ashkenazi, & Viner, 1995). In some cases, damage is incorrectly attributed to another, unrelated species, which is then persecuted without any attempt to resolve the conflict.

People directly affected by HWC often resort to hunting wildlife or destroying wildlife habitats to enlarge their crop fields in an attempt to compensate for the damage they suffered (Distefano, 2005). This persecution results in an endangered status of predators and other species in Africa, which affects wildlife diversity and ultimately the whole ecosystem (Dickman, 2010; Distefano, 2005; Hazzah, Borgerhoff Mulder, & Frank, 2009; Loveridge, Searle, Murindagomo, & Macdonald, 2007). Predator attacks on cattle in Botswana have led to the shootings and poisoning of lions (Okavango Community Trust between 2009 and 2014), threatening to lower their endangered population.

Therefore, HWC does not only affect humans and domestic animals, but also wildlife itself. In fact, HWC is the leading cause for species extinction worldwide, since a large proportion of endangered species are threatened because of human intervention (Ogada, Woodroffe, Oguge, & Frank, 2003). Concerning lions, based on current studies, the overall population is declining throughout Africa (Bauer et al., 2015; Hazzah et al.,

2009; Riggio et al., 2013). Current estimates suggest that about 35,000 lions remain in Africa. Riggio et al. (2013) show that lion populations are surviving in about 67 areas all over Africa, only 15 of which will hold more than 500 lions. In the Okavango Delta, the number of lions is just high enough to ensure the long-term recovery of the population – provided it is not further reduced (Björklund, 2003).

Governmental and non-governmental organisations (NGOs) react to the situation of declining numbers of wildlife species with conservation efforts. The most obvious solution would be to relocate rural communities living close to wildlife to an area less affected by HWC (Madhusudan, 2003). Also, organisations apply physical barriers like walls, (electric) fences or hedges, and even utilise natural barriers like mountains (Distefano, 2005; Ecoexist, 2019b; Gusset et al., 2009). CLAWS Conservancy' project Scent of a Wolf, for example, is developing a scent-based barrier to address HWC caused by wolves around the Yellowstone national park in Montana, USA (CLAWS Conservancy, 2014). *Ecoexist* has devoted itself to reducing the damage elephants cause to crop farmers in the Okavango Delta by using electrical fences and, in the long run, reduce persecution of elephants in Botswana (Ecoexist, 2019b).

The effectivity of such approaches varies: while enclosures can effectively protect livestock from being preyed upon (Ogada et al., 2003), some types of barriers are only effective for certain species, not stopping others from trespassing (R. E. Hoare, 1992; Shivik, Treves, & Callahan, 2003). While Ecoexist's fences have reduced the damage on the crop fields, the the uncontrolled expansion of the elephant population causes further damage to the local flora and increases the risk of fatal human-elephant encounters. Furthermore, elephants have found ways to destroy the fences so that a combination of scaring devices and actual electrical shocks is the most effective way to keep elephants away from settlements and fields. Furthermore, they produce high costs, and as to predators, isolating or even translocating them can throw the sensitive ecosystem off balance (R. E. Hoare, 1992; Lohmann, 2000; Treves & Karanth, 2003; Vijayan & Pati, 2002).

Such strategies can be labelled as *preventive*, while short-term, conflict-reducing measures fall into the *mitigative* category (Distefano, 2005). These can include monetary compensation or insurance programmes, which are often too low or take a long time to be issued (Madhusudan, 2003), reflecting the limited availability of governmental national funds. In many successful programmes, resources originate from external funds (Mishra et al., 2003). As for German wolves, the government has been funding prevention measures such as fences and guard dogs rather than compensating losses, while incentives for sustainable agriculture are also a measure taken in India (Mishra et al., 2003; MUGV Brandenburg, 2010). One solution adopted by the government of Botswana to counteract the decline of the lion population was the es-tablishment of a hunt-

ing ban, which sought to protect all of the wildlife living in the Okavango Delta (Barbee, 2015).

At the same time, such conservation efforts perversely have the opposite effect to that intended, such that an increasing wildlife population leads to even more HWC (Distefano, 2005). For species which are not endangered, hunting is used to keep the number and their impact under control, as is the case with wolves in North America and Europe, as well as elephants in Southern Africa (DeMotts & Hoon, 2012; Distefano, 2005; Treves & Karanth, 2003). The hunting ban in Botswana, established in 2014 (Barbee, 2015), has led to an increase of elephant population so that currently, there are 20,000 elephants in the country (Ecoexist, 2019a). This has led to food scarcity and results in them destroying crop fields and coming across humans on village roads. Often, these encounters end fatally due to the elephant's attempt to protect their herd, especially the young ones. During our stay in the field, we heard of fatal encounters between elephants and people on streets at night. Whenever an elephant kills a person, an animal from its herd has to be shot by the rangers to convey the impression that the government is helping the affected locals.

Another dimension of the hunting ban is economic: Hunting generates income especially from tourism, which can then be used for conservation and community development. Banning it, along with other governmental and non-governmental conservation efforts, was met with praise from the global community, but not necessarily from local inhabitants who suffer from their close proximity to wildlife and from the perceived reduction of employment opportunities. Furthermore, it has not stopped poachers and frustrated locals affected by HWC from continuining their work (Barbee, 2015). While hunting is not always effective, it can not only lower the potential for HWC to some extent, but also can reduce poaching and convey to affected inhabitants the impression that something is done in order to help them (Treves & Karanth, 2003).

Often, the complexity of local communities' interaction with wild animals is overlooked by official mitigation approaches (Bauer, 2003; Dickman, 2010; Zhang & Wang, 2003). People affected by HWC often show a negative attitude and little affection towards the protected animals, since the conservation efforts are not helping them (Dickman, 2010; Madden, 2004; Nygren & Rikoon, 2008). Sometimes, the damage is subjectively regarded as much higher than its actual extent, while in other cases, it is put into perspective by religious beliefs in favour of the wildlife causing the conflict (Distefano, 2005). Lions are often perceived as dangerous in the Okavango Delta (Ertl, 2017), though the last fatal lion attack on a person was recorded decades ago. Concerning our project's own experiences, one livestock owner had followed a lion into the veld with a rifle and a dog after a fatal attack on his cow, and was wounded by the predator but recovered

(Weise et al., 2019). This demonstrates lions are only a threat to human safety when they are actively persecuted. Usually, they avoid people (Schuette, Creel, & Christianson, 2013).

This gives HWC a political as well as social dimension. These wild animals contribute to the local economy by attracting high numbers of tourists (Arntzen et al., 2003; Boast, 2014), and provide an additional motivation for protection. The most effective efforts to mitigate HWC, which are also applied in Botswana, thus focus on human behaviour (Baruch-Mordo, Breck, Wilson, & Broderick, 2009; DeMotts & Hoon, 2012; Treves, Wallace, Naughton-Treves, & Morales, 2006). After all, the success of the conservation process will depend on the cooperation of local people (Riggio et al., 2013). As we have seen, HWC is often influenced by the way people interact with natural resources and wildlife. A need for education and guidelines to help people themselves prevent and manage HWC in the first place is thus paramount. Herding with guard dogs as well as utilising fires and torches has proven to be most effective method to keep away predators in 85% of cases (Gusset et al., 2009; Ogada et al., 2003; Patterson, Kasiki, Selempo, & Kays, 2004; Woodroffe & Frank, 2005). Urging cattle into kraals at night ("kraaling") for their protection has also proved as an effective strategy against livestock predation (Kgathi et al., 2012; Weise et al., 2018).

Larger conservation efforts carried out directly by locals are usually managed by community based-organisations (CBOs). These associations can be found in different economic sectors such as tourism and manufacturing from natural resources, which increase living standards by offering income opportunities and compensation, while preserving natural resources and wildlife population (Arntzen et al., 2003).

In addition to this, there are technical approaches such as electrical collars for wildlife or devices which emit sounds, light or scents whenever a wild animal approaches; however, they are associated with a high deployment and maintenance cost and effort, while not always conforming to legal and ethical standards in animal welfare (Shivik et al., 2003). However, a good way to include affected communities' opinion and ensure their participation is by using ICT specifically tailored to local requirements. For HWC, so far, we can find little evidence of technology-based mitigation approaches.

One example is an autonomous warning system that alerts of condors near windmills in Mexico. Sheppard et al. (2015) have developed this system based on a GPS transmitter on condors and a geofence (see Figure 4). It alerts wind farm managers whenever a condor approaches their wind farms within a radius of 40 km. Alerted managers can then stop the wind mills in time and thus reduce the mortality rate of an endangered species. Other projects incolving ICT to address certain problems in the Global South in communities are described in the following section.

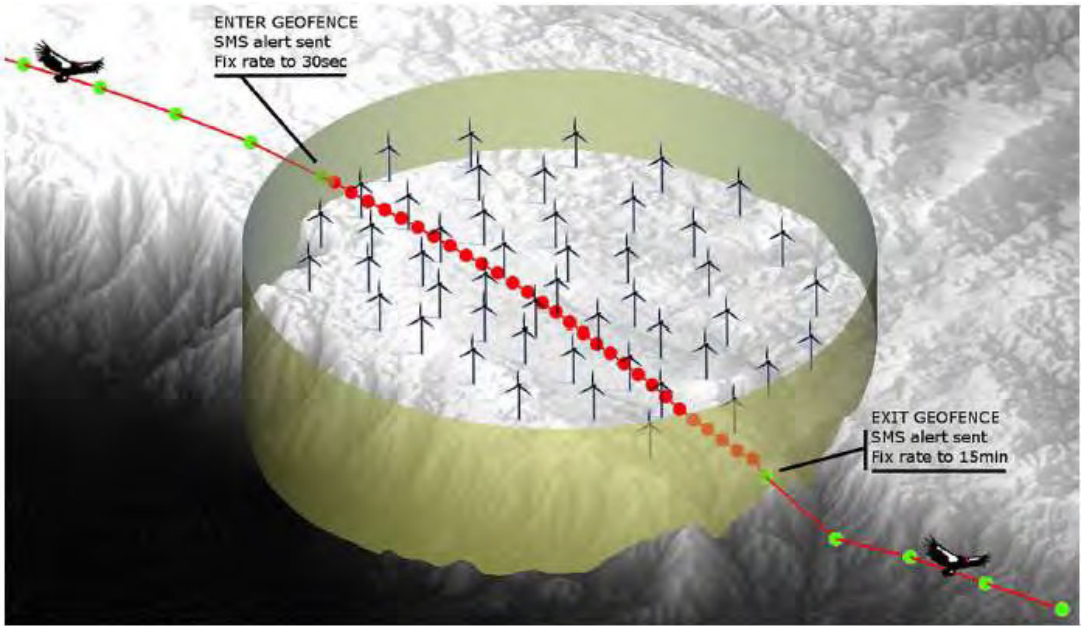

Figure 4: Illustration of an autonomous, GPS-based condor warning system for windmill operators in Mexico. Taken from Sheppard et al. (2015)

2.4 ICT for Development and Participatory Design in Areas with Low Digital Literacy

All over the Global South, ICT and mobile connectivity in particular has led to more accessibility in recent decades (Aker & Mbiti, 2010; Garside, 2009). However, these countries still have limited access to ICT as compared to the Global North (Titlestad, Staring, & Braa, 2009). The adoption of ICT in the Global South is hindered by several political, social, infrastructural, and economic aspects, and depends on a number of individual factors (Kapurubandara & Lawson, 2006; Ssewanyana & Busler, 2007). Numerous governmental and non-governmental projects have attempted to improve the situation in these areas. Among others, education, access, healthcare and agriculture are domains which can be effectively supported by ICT (Aker, 2011; Dell & Kumar, 2016).

In general Wulf et al. (2018) show how ICT can and should be embedded in local practices and in this way can encourage cultural, health, democratic and economic infrastructures. In turn, this means relevant technology can be made accessible to more citizens and organisations and thus improve information gathering, modernise healthcare, digitalise banking, make business processes more efficient and profitable, as well as reduce poverty on a national level (Baliamoune-Lutz, 2003; Byrne & Sahay, 2007; Elovaara, Igira, & Mörtberg, 2006; Joseph, 2015; Ssewanyana & Busler, 2007). This is particularly important in the context of ICT in the Global South. However, this is not

straightforward. The design of novel ICT is sometimes complicated by bureaucracy and fixed structures which do not allow flexible changes (Byrne & Sahay, 2007; Madon & Sahay, 2002). For this reason, the relative autonomy of mobile technology has been a focus for HCI4D researchers because it is a relatively low cost and flexible means to promote autonomy and financial independence, access to education and healthcare support, as well as income opportunities (Aker & Mbiti, 2010; PwC, 2012). Unsurprisingly, feature phones have been of interest (Dell & Kumar, 2016). In contrast to mobile phone-related studies in "developed" countries, there has been a larger focus on access as well as economic and developmental aspects, and the mobile is seen as an opportunity for wider goals to be met (Donner, 2008). According to a literature review by Donner (2008), most ICT4D projects related to mobile phones have been carried out in urban areas, where there are few infrastructural issues and the overall usage is more highly developed. Some rural areas, although many are using mobile phones, are still disconnected because the opportunities offered by ICT are more limited, or are not always recognised as the technology has not been designed with them in mind (Garside, 2009).

Therefore, once this infrastructure has been established, a more specific approach is to develop ICT specifically targeting and directly involving marginalised groups, such as rural or forest communities, or those with a lower education status, in order to solve certain problems which they may face. Often, users with low digital literacy are addressed by ICT4D projects. Digital or ICT literacy is defined as "*the 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*" (Van Joolingen, 2004, p. 5). Because a large proportion of people in the Global South have not had access to ICT to the same extent as in other parts of the world due to costs or infrastructure, communities around the world have not had the opportunity to gain the same level of digital literacy. This aspect poses a challenge to PD in the Global South, but can be addressed by interdisciplinary teams which have the potential to study the target group from different academic perspectives, thus establishing an understanding of local cultural aspects and requirements (Crabtree et al., 2013).

There have also been approaches to conduct workshops for designing applications together with children, mostly based on paper prototypes (Gubbiotti et al., 1997; Walsh et al., 2010). They are to some extent comparable to workshops in ICT4D, because digital literacy is not yet fully developed in either group. Computer Clubs, introduced at two locations in Palestine, are further examples of transformative policy aimed at developing digital iteracy among marginal groups (Aal et al., 2009; Yerousis et al., 2015). The Computer Clubs follow the action research approach, involving local volunteer tutors, specifically focusing on areas with a high percentage of migrants.

The impact of low digital literacy can be reduced by taking into account the common technology which is locally used. In Tanzania, eKichabi is a USSD-based phone directory application for feature phones (Weld et al., 2018). This feature phone app was developed in three stages (similar to Design Case Studies) and was well received, depending on users' experiences with mobile phones and physical ability. It is also possible to use existing systems and tools to address a specific problem in a community: Pruneau et al. (2018) have worked with Moroccan women to document and share information about flooding in different media forms on Facebook. The study had two main benefits: The users could learn how to manage and share their knowledge, while they were also able to analyse the problem and develop effective solutions using design thinking. By conveying the necessary techniques, these results are sustainable although no new ICT artefact is developed.

Lack of basic literacy is often a barrier to using ICT and a challenge to PD. For most user interfaces, the ability to read is necessary and cannot be guaranteed in developing countries (Dray, Siegel, & Kotzé, 2003; Gubbiotti et al., 1997; Hanemann & Ulrike, 2006; Raza et al., 2018). In fact, almost a quarter of the world's population cannot read and write (Maamouri, 2000). Language also influences other modes of communication: metaphors, (abstract) figures, tables, hierarchies, and symbols are perceived differently, based on culture, language, and education (Dray et al., 2003; Irani, Vertesi, Dourish, Philip, & Grinter, 2010; Sherwani, Ali, Penstein Rosé, & Rosenfeld, 2009; Vitos et al., 2017).

To solve the problem that text is not always accessible to communities in the Global South, other approaches involving other modalities have been used. Many projects addressing illiterate communities rely on imagery. As an example for successful integration of ICT into such environments, the CyberTracker is a highly adaptable, but easily understandable gadget used for locating and therefore preventing environmental damage by inhabitants, especially in rural and forest areas (Ansell & Koenig, 2011). It has been developed in a user-centered and iterative process with illiterate users and thus relying on graphic imagery and navigation. Similarly, Vitos et al. (2013) have developed an anti-poaching smartphone app for indigenous people in the Congo. The app utilizes an image-based, decision tree-structure menu oriented towards and designed as well as evaluated with illiterate forest communities. Raza et al. (2018) utilised another modality with a discussion platform based on voice recordings in Pakistan, which was positively received by the users. Sherwani et al. (2009) have analysed several education interfaces including videos and speech, addressing users from oral cultures. They conclude that user interfaces require more than choices about modality, but also require an understanding of information perception and learning techniques specific to the particular culture. Designing for oral cultures means a closeness to the users' world, incorporating

vividness, clearness, and redundancy, as well as moving away from hiearchies and abstract concepts, while the language style should be adapted to that of oral speech. This can be done, for example, by adapting interface communication to the communication inherent to the target group, as well as offering tutorials.

A common insight from these studies is that pictoral or auditory interfaces, while they can overcome the literacy barrier, still require a deep understanding of the relevant culture (Hussain, Sanders, & Steinert, 2012; Sherwani et al., 2009; Vitos et al., 2017). HCI4D should explore the ways to use multimodal and multi-language interfaces, trying to approach a universal usability (Dell & Kumar, 2016). Several authors (Medhi, Sagar, & Toyama, 2006; Sherwani et al., 2009; Vitos et al., 2017) have established concrete design principles for oral cultures:

- use imagery and numbers instead of text
- supplement the visual interface with voice
- include concrete graphics which relate to users' real world instead of abstract concepts
- adapt these representations to the specific culture
- use additive speech and logic instead of hierarchical (sentence) structures
- make it usable with as little interaction as possible, such as clicking or scrolling
- offer tutorials and support throughout the usage.

Despite these challenges, there has been evidence of concepts established in the "developed world" being transferred to a different culture (Aal et al., 2009; Yerousis et al., 2015), while facing problems with the technical, legal, and social infrastructure. Such problems are not uncommon in ICT projects in the Global South. The local technical and legal infrastructure does not always allow the implementation of novel ICT4D (Chetty & Grinter, 2007; Mutula et al., 2010). This is another reason to use systems that are already in widespread use among the participants and thus require minimal adaptation (Weld et al., 2018). Rural areas tend to be located away from public electricity grids and lack access to a range of resources that might be considered commonplace in more urban areas. Communications, including both the provision of internet and roads linking these areas to bigger cities, are poorly or not at all maintained (Jacobson, 2007).

Another difficulty for ICT4D projects lies in the methodology: the PD process itself reies on shared cultural understandings. ICT usage habits and understanding differ very much across cultures and make PD challenging (Chetty & Grinter, 2007). ICT and digital literacy are widely regarded as advantageous, but not as a priority in the Global South, and should be carefully adapted to cultural aspects in the context the particular system is used (Albirini, 2006). If there is a mistrust of or diffidence about technology, fear or refusal can be a consequence of frustration by careless exposure to ICT in this process (Chetty & Grinter, 2007; Vitos et al., 2017). This also applies to aspects such as

cooperation or criticism: For example, in Southern Africa, PD mostly works better in a group, were explicit criticism is uncommon, and negative sentiments are expressed more circumspectly (Chetty & Grinter, 2007; Gubbiotti et al., 1997; Sherwani et al., 2009; Vitos et al., 2017). In an evaluation, tasks should be embedded in a setting to make them concrete and foster engagement of users with the interface (Sherwani et al., 2009). The presence of a foreign researcher can also influence both the PD process and the results, while involving a mediator from the community or even asking more experienced or skilled participants to help the others can help reduce this effect (Sherwani et al., 2009; Vitos et al., 2017). Protocols as well as real-life tasks should be designed and adhered to in order to make sure all circumstances are considered and the process is clear without misunderstandings and disappointments (M. Stevens et al., 2014; Vitos et al., 2017).

Critics characterise some PD studies in the Global South as "*bungee research*" (Dearden & Tucker, 2016), meaning that researchers conduct short field stays to do research and validate a system, but the development and resulting presentation, for the most part, takes place in foreign countries or communities. Here, there is a risk of neglecting users' needs and missing the chance to create a sustainable benefit for both sides. Several ICT4D projects have succeeded in benefitting development, while others have not reached their specified goals mostly due to lack of user participation in a top-down and a technology-centered approach (Dodson, Sterling, & Bennett, 2012; Dray et al., 2003; Garside, 2009).

Among other solutions, researchers suggest conducting more consistent, long-term projects where the cultural background and usage implications are studied more closely and in a deep way, as well as assigning as much responsibility as possible to the local experts and users instead of foreign researchers, who can better estimate and contribute to a long-term benefit for the specific community (Dearden & Tucker, 2016; Dray et al., 2003; Garside, 2009; Puri, Byrne, Nhampossa, & Quraishi, 2004). Instead of creating concrete products, the goal should be to enable locals to gain the necessary skills and create concepts by themselves, thus establishing a "participation culture" and opportunities for sharing knowledge (Fischer, 2008; Garside, 2009; Hussain et al., 2012; Puri et al., 2004). This would increase project sustainability, create a long-term benefit for the particular society, as well as a sense of community ownership (Dearden & Tucker, 2016; Garside, 2009). Apart from this, Byrne and Sahay (2007) argue that PD needs to take into account indirect users of information systems, namely those stakeholders and community members who do not interact with but are affected by these nonetheless.

The process of knowledge acquisition, analysis and sharing predominantly by locals in rural contexts is called *participatory rural appraisal,* an approach involving document

analysis, interviews and mapping (Mascarenhas, 1991). Collaborative mapping has been successfully applied in the AfriScout app, where pastoralists in Kenya, Tanzania, and Ethiopia are supported in having an overview of local water sources and pasture for their cattle herds, as well as the land qualities, disease warnings, and other characteristics (Project Concern International, 2019). This app has been developed on the basis of satellite data used by local policy makers, has been validated with users and shown to reduce the users' need to scout for suitable pastures. However, communities in the Global South are not always familiar or experienced with conventional maps, where common systems such as landmarks should rather be used (Elovaara et al., 2006; Mascarenhas, 1991; Medhi et al., 2006).

To sum it up, for ICT4D to be successful, it has to be maximally oriented towards users' language and skills, understanding of the world, and communication strategies, as well as the problem it is trying to solve. Cultural sensitivity ensures trust, readiness for participation, as well as a positive impact for the end users. Furthermore, their long-term participation increases the chances for a relevant, effective, and sustainable ICT solution. This can be achieved by establishing multi-cultural teams, where the project can benefit from and further develop local team members' skills. These can iterate the ICT system by themselves, while knowledge can be shared and increased within the community.

2.5 Research Gap: User-Centered Development of an ICT Solution for Human-Wildlife Conflict

In the research outlined above, approaches to solve HWC have relied primarily on mitigation. Few studies have qualitatively researched the human side of HWC, while many have attempted to address it by financial intervention or physical barriers. Similarly, those involving ICT are focused on technology rather than the people using it. Effective solutions for HWC, however, always have to keep in mind the long-term effects. Only through a successful incorporation into and adaptation by the local community can the solution be sustainable, while preserving both the ecosystem and the way of life of the local community. Additionally, it is the best way to establish a trustful relationship and ensures users are effectively applying the solution provided while further improving it by themselves.

To understand the reasons for the conflict and cultural aspects as well as attitudes, expectations, concerns and needs of the local community experiencing and suffering from HWC, an on-the-ground approach is therefore necessary. Conservation cannot be a standalone concept but must be embedded into the respective community interacting with the wildlife and resources one is trying to preserve.

Furthermore, mitigation approaches have seldom utilised state of the art ICT developments to approach the problem. Southern Africa has had increasing access to mobile technology and the internet and in Botswana itself, the development process has particularly focused on the availability of mobile networks and the internet (Mutula et al., 2010). Despite this, there have been few efforts to use advantages of this availability to solve HWC. While many people in the Global South are still sceptical about technological innovations, at the same time, these spark curiosity and uncover a willingness to learn. Therefore, we see a great opportunity in integrating ICT into community-based conservation projects. A prerequisite is a careful introduction in terms of culture, habits and individual perception of the particular situation.

In conclusion, there is a lack in projects that aim to solve HWC both on a technical and social basis, resulting in ICT technology that has seldom been designed together with all stakeholders. As for the Okavango Delta, the usage of and attitudes towards technology in the concerned villages has already been examined and reveals a diverse picture (Ertl, 2017). This makes the recruitment of different stakeholders necessary for successful PD to appeal to a large proportion of the user group, and to make the system effective and efficient.

While the underlying LionAlert system has been largely externally developed by experts, it has already proved to be effective and appreciated by its users. However, there is a lot of room for improvement. In our own study, we further have to consider infrastructural imbalances that occur once in a while around the located area to secure our future service of the system, maybe taking even older technical artefacts into account (Ertl, 2017). For our solution, we have considered individuals from diverse demographic backgrounds and social roles: farmers, villagers, tourist guides and dikgosi. To effectively mitigate the local human-wildlife conflict, we co-design an interactive system whose goal is not only to appeal to all key stakeholders as much as possible, but also to effectively prevent future fatal encounters between lions, cattle and people, while improving people's attitude towards the conflict animal.

By considering all lessons learned from the research described above, we set out to answer the research question introduced in the first chapter:

How can information and communication technology be used to create a sustainable solution for co-existence of people and wildlife, which maximally addresses local users' needs, fits their everyday life, and is nurtured by their support, at the example of a lion warning system in the Okavango Delta?

In the literature review, we already identified the reasons that previous projects have failed and what can be done to reach the goal more effectively. Before I describe the methodology we used, in the following chapter, I will outline the status quo of Li-

onAlert and its shortcomings, and will provide a starting point for the development of an optimised solution.

3 LionAlert 1.0: An Approach to Enhancing Farmer-Lion Coexistence

Before elaborating on how we can effectively address HWC in the Okavango Delta, an introduction into the current efforts, undertaken by the Pride in Our Prides project by CLAWS Conservancy, is due. The information in this chapter has been largely retrieved from meetings with PioP project members in Siegen and Botswana, their scientific publications, as well as communications over social media such as WhatsApp, Instagram and Facebook[2]. PioP focuses on mitigating conflict between lions and livestock owners in five main villages which border the Northern Okavango Delta. The decisive point for its start was a particularly large case of lion poisoning after this conflict had escalated, and after people had lost a large number of cattle. While poisoning is still ongoing and additionally affects species like vultures, it has been reduced ever since the project started.

The conservation approach largely consists of educational, social and material support conducted by local members. PioP attempts to reduce HWC by involving the local communities, namely by educating them about lions and herding practices. One of the reasons for HWC in the Okavango Delta is that there are only few herders in the area or people who regularly herd or kraal their cattle, or have younger family members who do so for them (Weise et al., 2018). PioP members are helping the local communities with trainings on herding. In these workshops, cattle owners learn about effective and sustainable livestock management to prevent overgrazing and land degradation, as well as measures for their protection against predators. Also, communities have named the lions observed by PioP in special meetings in order to establish an emotional connection to "their" local animals. As a result, the community is intended to develop a feeling the lions belong to them and that monitoring has a beneficial effect on the local HWC. In addition, the project helps farmers by building stronger and higher kraals to protect livestock. The beneficiaries are regularly selected via a lottery system.

Another role of local PiOP members is to be the first contact person when livestock owners experienced an attack or see a lion roaming their surroundings. In case of an attack, the team members visit the location to record the damage and determine which predator was responsible. After this, the officials are informed so that the affected farmer can receive appropriate compensation. If someone sees a lion or lion tracks, they

[2] For CLAWS social media channels, see: https://www facebook.com/clawsconservancy/ and https://www.instagram.com/clawsconservancy/

compare the information with the current GPS locations of tracked lions, and can issue an additional alert to let others know a lion is nearby.

A significant part of PiOP's human-wildlife conflict mitigating strategy, and the component around which this thesis evolves, is a GPS-based alerting system called LionAlert. In this chapter, I will introduce the current status and functionality of the LionAlert system (3.1) and describe what we know about current usage and appropriation in the field (3.2). Finally, I will address its shortcomings on which basis we can build our project (3.3).

3.1 Presentation of the System

LionAlert has been implemented by a local research team in the Okavango Delta in 2016. It is based on collars attached to individual lions, each of which contains a GPS sensor and a preprogrammed digital geofence. It consists of static digital borders, one of which is set around the grazing land (6.5 km from the villages, on both sides) and the other one around the villages (2 km), see Figure 5. The distance between these borders is called the geofence. At the time of our stay in the field, four lions in the study area were collared; the number has since reached ten according to CLAWS' social media channels. These collars send a signal to a server which is located in Germany every two hours. Such collars usually last three years until the battery depletes, which is when the collar automatically detaches itself from the lion.

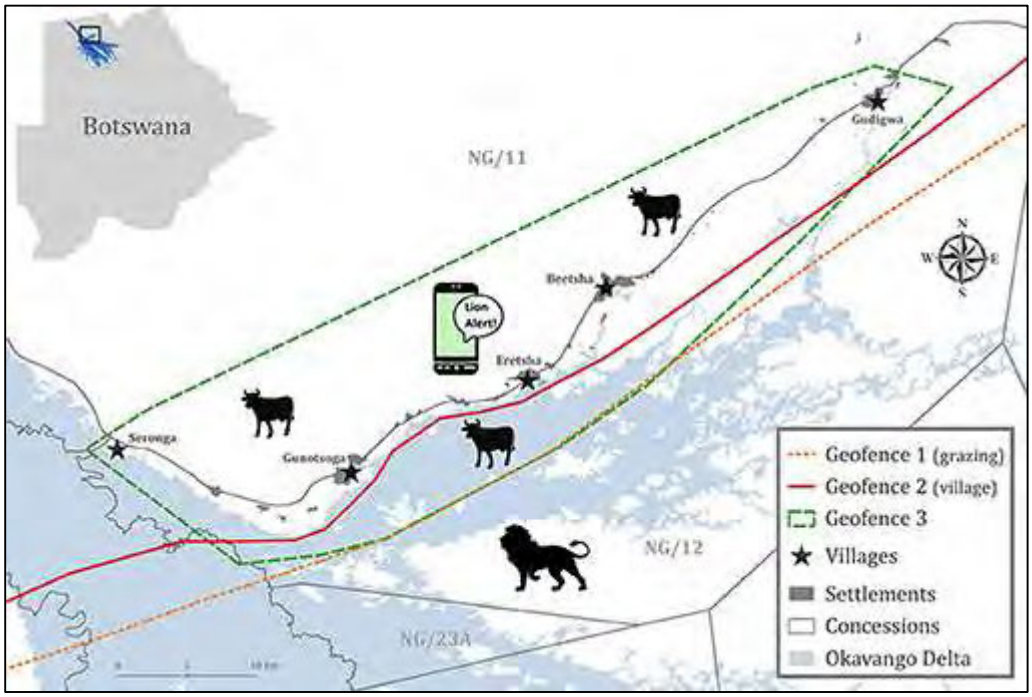

Figure 5: Map of the geofences currently included in LionAlert. From Weise et al. (2019)

A local biologist and member of CLAWS has access to the GPS data that the collar transmits. Where the collar's GPS sensor determines a lion has crossed one or two of the geofence borders, an alert is issued to them via mobile phone and email. The biologist then retrieves the lion's coordinates on Google Maps and determines which area is within the lion's reach. Depending on the lion's movements, he decides whether there is the potential for an attack, or if the lion is only passing or moving away from the geofence. In case of an attack threat, he notifies a local research assistant, who functions as a translator at the same time, and tells him which villages or cattle posts are concerned.

The assistant's task is to notify the dikgosi and farmers in the threatened area, meaning 8 km from the animal's position, that a lion is close. Initially, only the dikgosi were notified in accordance the village hierarchy. The chiefs, in turn, had to forward the message to other villagers. However, this approach turned out to be inefficient and unreliable: For example, dikgosi could be outside network reception, miss the message at night, or neglect to notify someone for personal reasons. Therefore, the research assistant collected information on potential recipients from all five villages and the cattle posts in-between affected by HWC. Now he has a list of 64 participants with their names, phone numbers and locations, as well as information on literacy if given. Addi-

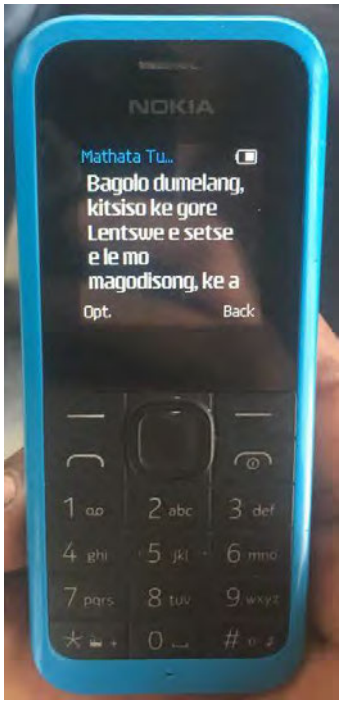

Figure 6: LionAlert warning message in Setswana on a user's feature phone, including the lion's name, place of detection, and moving direction

tionally, he has a separate list of those who have already been contacted in order to keep a record of how many lion alerts there have been at which locations.

The research assistant informs people via a text message in Setswana (see Figure 6), or via phone call for those who cannot read. On his smartphone, he has created groups for specific areas (around seven for each village, with only two each for Seronga and Gudigwa), so that he can send an alert to the respective group with one click. Information included in this alert are the lion's name, location (village or cattle post), and the approximate direction from which is is coming.

3.2 Appropriation and Impacts

After LionAlert has been introduced, PioP launched a pilot study between 2016 and 2018 (Weise et al., 2019). As a result, there have been 1017 alerts in four villages (Gunotsoga, Eretsha, Beetsha and Gudigwa) and 273 reported lion attacks (see also Figure 3). The LionAlert system has helped reduce the number of attacks by 50 % (Weise et al., 2019) and can therefore be called a successful HWC mitigation strategy in combination with educational and material approaches by PioP. Also, it has contributed to improving locals' attitude towards lions in general and the conservation efforts carried out to preserve this endangered species (Ertl, 2017; Weise et al., 2019). Acceptance is highest among better educated Batswana and those who already worked in the tourism industry, and therefore understand the importance of wildlife conservation (Ertl, 2017).

How exactly does this support look in the actual usage context? People who can read the lion alert texts often forward them to those who are not on the recipient list or orally warn illiterate villagers. Livestock owners who employ herders usually forward the messages to them, as they do not take care of their cattle themselves. Because recipients also usually reply to the message they receive, the research assistant calls back those who did not reply to confirm they got the alert. However, as we learned in literature and our own interviews, alert recipients do not always have the time to look at their phones and read the messages in time (Ertl, 2017). Therefore, measures are not always taken when someone receives a LionAlert.

Such measures depend on the recipient location, time of the day, and other circumstances. Users often resort to kraaling livestock, lighting fires or heading to safety. Further measures and influencing factors are described in detail in chapter 5. While LionAlert has already helped reduce livestock predation by lions in the Okavango Delta and therefore preserve inhabitants' livelihood, there are many aspects which can still be improved to make it more effective, efficient and satisfactory.

3.3 Aspects for Improvement

This approach encounters quite a few problems which I aim to address by this work. First, the distance of two hours between the GPS signals is very high, which makes it impossible to determine where the lion is at the moment, where and how fast it is moving and how it behaves. However, this problem is linked to the collars' battery life, now lasting three years, and the resulting material expenses and the costs of tracking down the lions and attaching the collars. Several approaches to solve these problems are being pursued but are outside the scope of this work and will be discussed in the sections 5.6 as well as 6.4.

Second, the tracking is restricted to the established, static geofence and the lions tracked, which does not include all lions living in the study area and does not cover all relevant areas. Currently, only four of the 12 prides are covered. Their movement and the required warning area changes throughout the seasons and depending on many other factors such as water level and cattle grazing movement, but cannot be adapted. For example, lions coming from NG11 are not tracked. These and other problems will be elaborated on in chapter 5.

Also, the notification chain is very inefficient, unstable and unreliable, especially considering incomplete networks and possible infrastructure breakdowns (Mutula, Grand, Zulu, & Sebina, 2010). Especially because the attacks mostly occur at night, the concerned villagers might not be reached in time. The process of individual notification also needs a long time and the involvement of only two people in the process produces a bottleneck. One of the main tasks of the interface is therefore to automate this warning process and reach as many people as possible, while considering their literacy and technological equipment.

Another problem lies in the attitude towards the project, lions, and tourism in general (Ministry of Environment Wildlife and Tourism, 2013). As has been disclosed in prior interviews and observations with 36 inhabitants (Ertl, 2017), ranging from farmers to tourist guides and dikgosi, individual character and skills, education and experience plays a big role in this attitude: some people do not recognise the benefit of this solution and would like to see the lions dislocated and their local culture undisturbed, while others support the idea and comprehend the long-term effect which killing or displacing lions would have both on the ecosystem and on the economic situation in the Okavango Delta. Therefore, the socio-cultural aspect of LionAlert needs to be emphasised in a new iteration. To increase understanding and acceptance and to find a working solution which addresses people's needs and concerns, a close cooperation with the local people is necessary.

Automated warnings as well as the implementation of flexible geofences is an essential part of the project. This is taking place in Siegen by a member of our project team and programmer, under supervision of members in Botswana. A central aspect of improvement, which is done within the scope of this work, is making LionAlert interactive and adaptable. This should increase accessability, while giving our users the opportunity to contribute to a more efficient warning process and thus HWC management. On the long run, we would like to address attitude and encourage a local "*participation culture*" (Fischer, 2008).

The focus of this master thesis lies on the user interfaces which will ensure the community involvement in LionAlert 2.0. In the initial design plan, these interfaces should be able to fulfil different requirements:

- Consider and include as many devices and channels as possible: Feature phones, smartphones and pagers, as well as collective media like radio, TV, physical siren, public displays, etc.
- Feature to register as a new user of LionAlert
- Allow entry of personal information such as phone number, social function, preferred type and content of information as well as livestock situation
- Fast, simple and understandable notification via numeric code, text, image, sound or voice message depending on individual preferences, literacy, technical possibilities and skills
- Possibility to review past alerts and have an overview of the current warning line
- Functionality to enter additional (geographic) information on lion sightings and attack spots, so that this information can be reviewed by local researchers and used for an adaptation of the warning line or individual alerts
- Option to learn more about lions and receive advice on behaviour by utilising text, image, voice and video.

According to the idea of ICT4D and PD described in 2.4, we worked closely together with local communities to reach this goal. In what way we tackled this and how we adapted our methods as well as initial system outline in the process, I will address in the next chapter.

4 Methodology: Developing an Interactive LionAlert Application via Participatory Design and Design Case Studies

To produce an accessible and usable system which effectively ameliorates the problem of HWC in the Okavango Delta, we were seeking to increase cooperation with and acceptance by the local users. This is why we chose the approach of Participatory Design (PD) (Schuler & Namioka, 1993). Our project is concerned with design for a particular context and target group, which we are looking to iterate and maximally adapt to the usage context. At the same time, it should be transferable to similar problem contexts. Therefore, we also apply the concept of Design Case Studies (DCS) (G. Stevens, Rohde, Korn, & Wulf, 2018).

Before I outline our specific set of tools and methods and describe our research methodology, I will give an introduction to PD and DCS (4.1). A general overview of our research design in the Okavango Delta will be given in 4.2., while in 4.3, I describe how we prepared our study in the field. 4.4. to 4.7 will be concerned with the particular steps of DCS, which will be described in detail including the changes we made to the methodology throughout the process.

4.1 Definition of Participatory Design and Design Case Studies

According to Titlestad, Staring and Braa (2009) as well as Puri et al. (2004), Participatory Design includes processes of "mutual learning" which is beneficial for our goal, since we would like to understand our target group's working processes, problems, needs, and wishes, while we need to give them an understanding of an ICT artefact which exceeds the experience with general technology characteristic for the area. Muller (1993) defines PD as "a tradition of user participation in workplace decisions in improving the quality, productivity, and satisfaction related to computing systems". Therefore, PD is not understood as a single method, but rather as an approach offering different sets of tools and techniques, which can be adapted to the specific context (Kensing & Blomberg, 1998).

PD has emerged in Scandinavia from a context of organisational politics where the balance of power between management and workers was to be democratically restructured in times of a perceived technological threat to workforce (Kensing & Blomberg, 1998).

It has been progressively acknowledged as a contribution to design work since the first international PD conference in Seattle in 1990 (ibid.). Originally, it was practiced in the professional world and per definitionem does not necessarily involve technology (Kensing & Blomberg, 1998; Wagner, 2018). However, here, we explore its potentials in an everyday context specifically associated with ICT support.

Parts of this approach came from the notion of *action research*, a discipline which implies combining research with ongoing activities or problems inside a certain organisation to improve underlying processes and actions, and subsequently derive academic insights from executing these changes (Hayes, 2018; Hinchey, 2008). Mostly, action research it is associated with education, as opposed to other early movements which emphasised the workplace context. It can be participatory, involving democratic approaches, or practical, where a strategy for improving work or education processes is developed (Hinchey, 2008). Change in the respective group can be induced or accompanied by an ICT artefact (Hayes, 2018). Similar to PD, action research methods are iterative and directly associated with researcher participation in the concerning processes (Hinchey, 2008).

To what extent and by which means users can and should participate in PD, however, is an issue still highly debated in this research area (Wagner, 2018). For ICT projects, design together with users usually means they are incorporated into the creative process, where an expert eventually incorporating users' ideas into mock-ups (Bødker, Ehn, Knudsen, Kyng, & Madsen, 1988; Muller, 1993). In our case, we follow the approach of *user participation in design* (Mumford, 1993), which involves "*not only users participating in design but also designers participating in use*" (Puri et al., 2004, p. 48) and based on certain leading questions on participants' working practices, how they can be improved, and according tasks. For users who are not tech-savvy, paper and pens, predesigned interface elements, and icons can be used for so-called paper prototyping (Muller, 1993; Snyder, 2003).

Our own methodological approach was integrated into Design Case Studies, a set of methods which emerged from design research, starting in the 1960s (G. Stevens et al., 2018). We can categorise this approach as "*research for design*" (Frayling, 1993). Their purpose is to iteratively develop innovative ICT artefacts which support practices or solve problems in a given social or organisational context, and to research over a longer period of time how practices adapt to the newly introduced tool and vice versa. Thus, DCS represent an on-the-ground approach to design by directly addressing users' requirements and wishes (G. Stevens et al., 2018).

Design Case Studies generally consist of three iterative phases: in the first phase, the researchers closely analyse given (social and collaborative) practices in the field with

and without present ICT tools, which is called the *context study* (G. Stevens et al., 2018). This usually happens via qualitative empirical research: observations, interviews, focus groups, and researchers' participation in the given practices. A practice is understood as the way people interprete a certain situation, compare it to known patterns, and eventually choose appropriate methods and tools to react to the situation, all the while managing problems and enhancing and sharing their knowledge, skills, and techniques (Schmidt, 2018, p. 90).

Second, the researchers design an innovative ICT artefact based on these findings (*design study*), where potential changes in given practices should be considered. Design approaches, steps, and stakeholders should be clearly defined, but are not determined by the methodology itself.

Finally, during the *appropriation study,* the artefact is introduced to the users, followed by a long-term evaluation on appropriation and the effect on their practices. According to Stevens and Pipek (2018), appropriation "*refers to the establishing of new social practices in the light of new technologies*" (p. 139), but does not necessarily happen in a fast or even immediately perceptible pace. Regarding appropriation, the artefact should be adapted to a heterogenous and dynamic context either by customisation or by openness in the way it can be used (ibid.). In accordance with the iterative cycle, the artefact may be repeatedly redesigned and tested. This part of DCS is also called *evolutionary prototyping*, which includes a cycle of sketching, prototyping, testing and evaluation (Thoresen, 1993). The result should be insights which inform the further artefact iteration, while considering changing or unpredictable circumstances and how users manage them with and without the introduced artefact (G. Stevens et al., 2018).

4.2 Methodological Approach for LionAlert 2.0 and Differentiation

Our approach differed from the DCS procedure defined above to the extent that a version of the ICT artefact already existed before we entered the first phase, and that a short-term evaluation was conducted while a long-term appropriation study has yet to be carried out. In the latter, particularly unpredictable results can in principle be observed through qualitative means (G. Stevens et al., 2018). We followed the DCS and PD approaches by conducting workshops in an HWC-affected area in the Okavango Delta, North-Western Botswana, including interview and co-design phases in our study area. Before this, we gathered research, requirements, expectations from local experts and team members, as well as information on local users, and pre-designed a first draft of the new system. This first step will be elaborated on in section 4.3.

Three villages in the Okavango Delta were considered: Gunotsoga, Eretsha and Beetsha. These places were chosen from the initial five, on the one hand, because lion attacks and resulting alerts were particularly frequent here, based on prior analyses (see Figure 3). On the other hand, although there have been significant HWC cases there as well, authorities in Gudigwa did not wish to further cooperate with PioP.

Our interdisciplinary team consisted, on the one hand, of five researchers from the department of Information Systems and New Media of the University of Siegen: two HCI researchers – Konstantin and myself –, the anthropologist named Victoria (Vicy) Wenzelmann, Helmut Hauptmeier, the media scientist, and one programmer who did not travel to Botswana but is responsible for the system development in Siegen. On the other hand, four members of CLAWS Conservancy completed the team, two biologists – Florian (Flo) Weise and Andrew Stein – as well as two local research assistants Mathata (Pro) Tomeletso and Christopher (Chris) Dimbende. Flo is based full-time in the study area, while Andrew conducts frequent field trips from Massachusetts, USA. As the seventh member of our team, Pro's role is that of a translator whose central role of knowledgeable and stable intermediary ensures the sustainability of the project. Chris was only occasionally available and involved in the project mainly during the final evaluation. All local team members are also end users of the system. The workshops themselves were conducted by Vicy, a few times substituted by Konstantin, and myself, as well as Pro, with constant support from the other team members.

Our whole field trip to Botswana lasted 25 days, from August 8th to September 2nd, 2018. In the Okavango Delta, we stayed at a camp in Eretsha from where we could easily reach all villages by car. Within this period, our workshop and PD phase in the field took three weeks, while the rest was taken for travel from Maun where our plane landed, stocking up on food and other necessities, and exploring the area. In the first and second week, we conducted the context study via a first round of focus groups with semi-structured group interviews, which, on the one hand, served to learn about the participants' daily practices related to livestock management and HWC, as well as their experience with, appropriation of, and attitude towards LionAlert. On the other hand, we wanted to present the functionality of the current system and to gather ideas on how to make it more effective, efficient and satisfactory for the users. Focus groups were chosen due to a limitation in time, and because in a homogenous sample whose members are mostly acquainted with each other, we wanted to be able to compare participants' statements and benefit from a common creativity and encouragement (Creswell, 2007). This context study and its analysis will be described in more detail in section 4.4.

As a supplement in all DCS phases, we gathered data from various sources: meetings with the project team, casual conversations with local potential stakeholders, and observations in the field, thus combining it with field research and ethnography to some extent (see section 4.5). Thus, we complied with the principle of a case study using several data sources (Creswell, 2007).

In-between the workshops, we designed a second iteration of the interactive LionAlert 2.0 prototype (section 4.6). After we gathered all insights and ideas from the first workshop, we were able to provide a design which was adapted to our participants' needs and wishes. Additionally, in our design study, we worked with our local biologist and research assistant, so that we could incorporate their requirements and ideas as well.

Our second round of workshops for the appropriation study phase was conducted in the third week. It mainly served to evaluate our prototype, but also to present and discuss other participants' ideas (section 4.7). Again, we evaluated it together with other stakeholders in the project to ensure it met the requirements of all users and effectively contributed to solving the problems that had occurred with LionAlert. These evaluation results enabled us to create a final prototype approved by potential users, and take a first small step in the last PD stage.

To record our results from the workshops, we used both video and audio recording as well as field notes. Our recorded material served to better reconstruct participants' behaviour, reactions and statements. Quotations from the workshops and field notes including informal conversations and observations are provided throughout this thesis to support or emphasise certain aspects. We previously asked each of our participants to sign a declaration of consent to make sure we could use their statements as well as their voice and visual recordings anonymously. We guaranteed that this would be purely for the sake of research within the scope of our project (see Appendix A). Field notes were also taken during and after observations, meetings and in informal conversations with locals (section 4.5). Every evening, extensive further documentation was written to capture our insights and understandings arising during the day. Quantitative data has been calculated using Microsoft Excel 2010. In addition, I constantly compared participants' verbal expressions with information provided by our observations, meetings as well as related research to validate the data. Because of the large number of sources which influenced the design to a varying degree, I could not apply a single and consistent qualitative data analysis approach. However, all information I consider relevant and its impact on LionAlert 2.0 has been gathered in this work.

Back in Siegen, we created a final prototype based on all workshop results, stakeholder requirements, and the technical possibilities discussed with the programmer. In the fol-

lowing sections, I will describe all steps in detail which we undertook to achieve a final prototype of LionAlert 2.0 following an adapted DCS and PD procedure.

4.3 Establishing Requirements, Use Cases and Stakeholders

Before travelling to Botswana, we held several meetings and established email correspondence with all team members to achieve a consensus on the goals of our field trip as well as the means we would use to reach them. First of all, we needed to understand how the current system worked in order to explain this to our workshop participants. Furthermore, for the design of the new version, we determined the technical basics as well as the required data input, which is recorded in chapter 3.

To prepare the workshops, we drafted a guideline including an interview protocol which we later adapted (section 4.3.1) along with a declaration of consent for video and audio recording. We further assembled lists of workshop materials, such as post-its, pens, and sticky tape, as well as prepared an illustration to explain LionAlert to our participants (see Figure 7). All documents were later printed in Maun and in Beetsha. Apart from this, we determined what we needed to record our workshops and what

kind of templates we required to demonstrate the new prototype on different gadgets. The lessons learned during our literature review (chapter 2) helped us adapt our workshops and the final design to the needs of our future users, such as choosing the right group size, workshop length, and modes of participation.

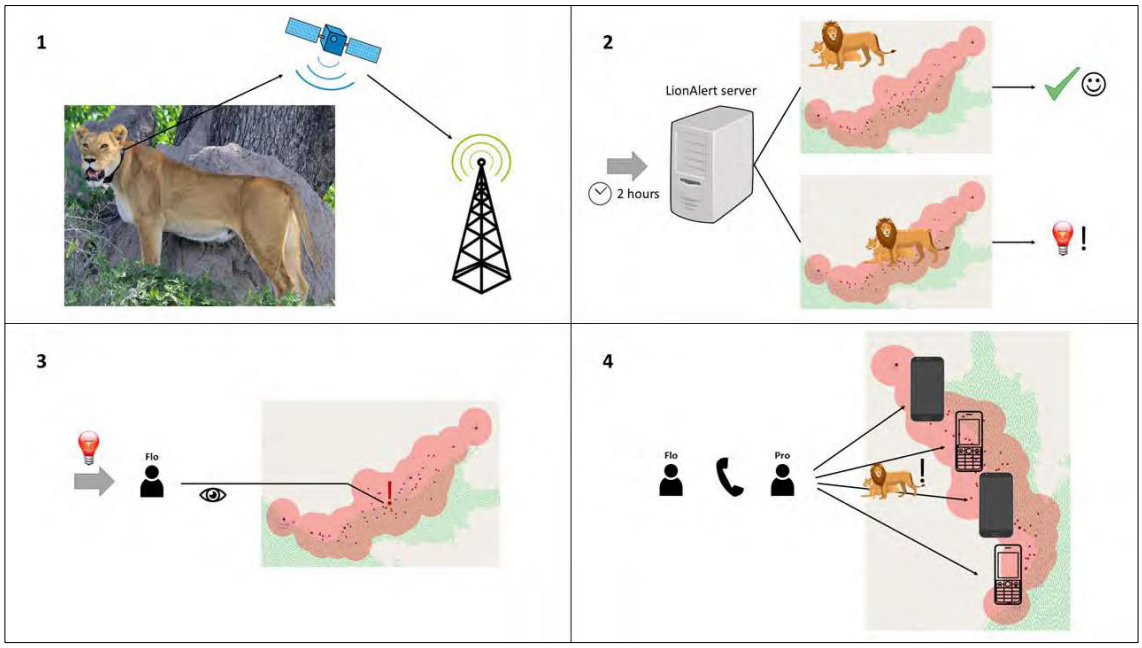

Figure 7: Illustration to demonstrate the LionAlert functionality to our workshop participants

With regard to the participants, we first needed to know the stakeholders and how many people we could recruit to participate. Even though we first thought about incorporating rangers, biologists, teachers, tourist guides, and lodge managers, in the end, we decided to only consider dikgosi and livestock owners since these were most affected by the problem we needed to solve, and most readily available.

For a better understanding of the participants' required and desired options for using the system, we also developed use cases and user stories together with the whole team. We identified three general use cases (see Appendix B):

1. Receiving and reacting to a lion alert
2. Reporting a lion sighting
3. Entering a new user.

After arrival in our study area, we had two meetings before our first workshop: one with the biologists and one with the research assistant of our team. The first meeting was intended for a better understanding of the current system's functionality as well as aspects required for a further iteration. With Pro as the research assistant and translator, we discussed the workshop procedure and how to best approach our participants, setting up a protocol for orientation (for the final workshop guideline, see Appendix C).

4.4 Focus Groups in the Okavango Delta

In our preliminary team meeting, we established a list of people to invite to our workshops. We told Pro which kind of participants we would like to include, and he suggested people and a group structure. We formed two groups for each village with six participants each. He was personally acquainted with every participant and selected people who owned livestock, had experience with LionAlert and could contribute to the group dynamic. The first group for each village consisted of the respective kgosi, Village Development Committee (VDC) chair, Farmers' Committee (FC) chair, and several livestock owners and herders from the village and different nearby cattle posts, while the second one included the VDC vice chair and mostly farmers. Pro also acted as the contact person and invited the participants by calling them, as well as reminding them of the appointment on the day of the workshop.

Of the 36 participants we invited, two did not attend entirely and an additional one only joined the second workshop without having been invited. In consequence, our actual sample size was n=35. We planned to conduct two rounds of workshops but in the second round, we could only carry out one for two groups because of low attendance, so that in total, we had eleven workshops (six focus group and five evaluation sessions). 28 of the respondents were men (80 %) and their age ranged between 21 and over 80

years. Women were rather difficult to recruit, mostly because they are not concerned with cattle and therefore have had little contact with LionAlert and PioP in general. For the ability to read and write, it was difficult to ask directly in some cases, as we perceived it as a rather delicate matter. Many older people can be assumed to not be able to read or write, while it is not always evident for younger ones. In total, we identified about a third (37.14 %), or 13 people, as illiterate by asking and observing.

Apart from the participants themselves, the times of the workshops needed to be determined. Each session was set to last up to two hours. Weekends, especially Sundays, were excluded: According to Pro, most local Batswana go to church on Sundays. Furthermore, dikgosi and chairmen sometimes had appointments outside the village, so they had limited availability. Eventually, we arranged to complete the first round of workshops in the first two weeks. We usually scheduled one workshop in the morning (9am) and one in the afternoon (2pm) in accordance with participants' availability. For a list of workshop participants and schedules for each group, see Appendix D.

Our workshops took place in the central areas (kgotla) of each village. We were assigned a tree-walled house with a table and several chairs. One exception was Eretsha, where sessions were carried out in an open area without a wall and table, so that we had to fix our illustrations and map on surrounding trees. Two researchers from Siegen as well as Pro were present to ask and observe. In Eretsha, we sat in a chair circle together with our participants to encourage a more open discussion culture instead of conveying the impession of an interrogation setting. In roofed kgotla buildings, we sat around the table. Despite our efforts to avoid sitting opposite our participants, most of them took a seat on one side while we were already seated on the other. One exception were the dikgosi who mostly came to our side. We arrived a little earlier than the scheduled time to be able to set up chairs for our participants and put a pen from the university of Siegen as a small gift on every place, buy *magunyas* or "fat cakes", sweet, deep-fried dough balls very popular in the area, as snacks from a local seller, tape our map to the wall or tree, as well as to prepare and test our recording technology. In a few cases, participants asked to pick them up from their homes if they had problems walking long distances.

In this first workshop, our first aim was to find out more about the participants themselves, their way of taking care of cattle, their experience with lion attacks and alerts, as well as their use of technology, by a group interview. Before every session, the local custom required a prayer. One volunteer said a prayer in Setswana, while everyone present sat still with their heads bowed. After the prayer, we introduced ourselves and our project, as well as the aim of this particular workshop. All throughout the workshop, there was an English – Setswana and Setswana – English translation by Pro. Then, we asked everyone else to introduce themselves including their name, age, origin, and oc-

cupation. If a kgosi was present, he also added a short greeting to the people present from his side. To make the whole process more transparent, we explained the workshop structure and procedure to everyone and asked if there were any questions. Then, before starting the recordings, we asked for the attendees' consent.

Once we started recording, we asked open questions about the participants' typical day as a farmer, how they manage cattle, what experiences they had with lions, and with LionAlert in particular. We asked one person to start talking, usually the kgosi or the person on the left to us. While they were speaking, we added questions from our side, such as:

How many cattle do you have and how do you manage them?

Before the system, what did you do if you knew a lion was approaching? How did you find out?

How do you react if you see a lion or tracks?

After everyone has told their story and we had no more questions, we proceeded with a mapping exercise to learn where most lion attacks occured and to observe local mapping. We asked participants to stand up and gather around the map we have previously taped to a wall or tree and handed them sticky dots. Their task was to mark spots where lion attacks on their livestock has happened (see Figure 8). With this part, we not only wanted to confirm and compare the usual focal points between the villages, but also see how LionAlert users approach mapping and how they perceive the area's geography.

Figure 8: Mapping lion attack spots together in the first focus group

Here, because ability to read a map increases proportionally to the ability to read a text, we could best observe who was literate and who could only join the discussion based on explanations by Pro and the others.

Following this, we continued with an explanation of the current LionAlert system. To introduce this, we asked people whether they understood the functionality and could sum it up in their own words, then. Here, we used either the wall or a tree to stick our illustrations one by one, while explaining the system's functionality and workflow (see Figure 9). To add more variety and see which approach works better, we

alternated printed out illustrations and drawn cards. Conveying the aspects step by step should help express the individual steps which lead from the lion's collar to an alert on a recipient's phone. This was done approximately like this (numbers in brackets indicate a new card added to the wall):

I put a lion picture on (1) and asked if they knew what GPS was; after a silence, I explained the collars communicated with a satellite (2) and only then reached the computer every two hours (3). At the computer, there is Flo monitoring a map (4). The participants did not know about the geofence, especially about two of them (5). I explained to them what it was and that it determined whether an alert was issued or not. If the lions are outside the red area, everything is okay and there is no alert (6). Otherwise, an alert

is issued (7) where Pro comes into the picture (8): Flo has to call him (9), so that he sends an alert to cattle owners in the area (10) (Excerpt from the field notes of August 15th, 2018).

After answering participants' questions, we, in turn, asked them what they thought of the system, and what they liked or did not like about it. Once a discussion started to arise, we proceeded to the creative part.

This was a 10-minute task to collect workshops attendants' ideas for improvement of human-lion coexistence based on LionAlert. Our participants were asked to draw or

Figure 9: Two versions of LionAlert illustrations used in the first focus groups

write their ideas on how to improve the system in small groups of two or three (see Figure 10). Because this part included sticky notes which we later organised on a "big paper", this approach is similar to the *cooperative inquiry* method described, among others, by Walsh et al. (2010). Our participants were free to seek a place other than the table or chair circle so they could discuss and write down in privacy.

While participants were working, we paused the recording technology as well as prepared snacks and soft drinks with plastic cups. Once the ten minutes were over, we announced a small break for relaxing, eating and drinking. We asked everyone what they preferred, poured the desired drinks and offered magunyas. The breaks were also the time for informal conversations between the participants. As a final element, we asked every group to show and voice their ideas, which were subsequently discussed in the group as a whole. After this discussion, we thanked the participants for their attendance and cooperation. We also invited them to the second round of workshops, and explained what these would be about. The session was finished with another prayer.

Data from these focus groups, recorded on paper, video, and audio, was analysed for statements which refer to the following aspects which help inform the design of LionAlert 2.0:

a) Livestock management practices
b) Human-wildlife conflict
c) Appropriation of LionAlert
d) Ideas to improve the design and functionality of LionAlert.

Such expressions were subsequently filtered from field notes, supplemented by video and audio recordings in cases where an expression was ambiguous or unclear, and where a quotation needed to be retained. Data was directly interpreted in terms of design implication. Ideas, expressed both orally and on paper, could be clustered in categories similar to those in Weise et al. (2018). The design in the second phase was mainly informed by the results of the focus groups, as well as meetings with system stakeholders.

4.4.1 On-the-fly changes in first workshop methodology

Similar to the prototype design, we constantly iterated our methodological approach to be able to gain more valuable insights from the workshops, while making the experience worthwhile for our participants. Our first guideline included a very general procedure, the recommended number of participants and length, as well as some basic questions we needed to answer for an appropriate prototype design. After discussing the

Figure 10: 10-minute idea generation for a new LionAlert iteration

procedure with Pro, we added the specific sample size, characteristics and planned num ber of workshops. A more specific structure and tasks for the participants was added:

1. Greeting and introduction: 40 minutes
2. Mapping and system presentation/discussion: 20 minutes
3. Interview: 30 minutes
4. Creative part: 15 minutes
5. Discussion: 20 minutes
6. Closing: 10 minutes

We could consider cultural requirements such as the opening and closing prayer as well as the greeting by the kgosi, and determine what we needed to carry out necessary preparations: buy snacks and drinks, pick up participants, and arrive earlier to set up everything. Other major changes in the third version were more specific questions, which we also could develop after having discussed with Pro, such as:

Do you often see lions or other predators? Do you feel personally threatened by them?

How many alerts did you received before and at which times of the day?

What do you do if a lion alert comes in?

While the first guideline developed back in Siegen did not contain specific time frames, we adapted it in the second version after discussing it together with Pro. However, in practice, timings became flexible. Although each workshop was intended to last two hours, with the actual overall length ranging from two and a half to three hours. The duration was dependent on six aspects:

1. The time it took for our participants to express their opinion, concerns and experiences, especially with livestock management and the use of LionAlert
2. Collaborative mapping took a significant amount of time (around 20 minutes, compared to the assigned ten) since this task produced a lot of discussions
3. Our explanation of the system influenced the workshop length, because we wanted to make sure that every participant was on the same knowledge level
4. The break, sometimes took longer than expected
5. Discussing the ideas our participants brought to paper extended the length of the last workshop part
6. The time needed to translate from English to Setswana and vice versa almost doubled the time needed for the workshops.

We then restructured the procedure to take these factors into account (see also Appendix C):

1. Greeting and introduction: 20 minutes
2. Interview: 30 minutes
3. Mapping and system presentation/discussion: 30 minutes
4. Creative part: 15 minutes
5. [Break: 15 minutes]
6. Discussion: 20 minutes
7. Closing: 10 minutes.

Also, we pointed out which aspects to emphasise and explain in more detail: For example, the fact that we could not realise every aspect of the PioP project like building kraals, and that we were not there to teach anyone, but rather to gain knowledge ourselves. Further, we made a note to ourselves to start the interview by asking about participants' typical day instead of cattle management to encourage more open narrations. By learning which parts of the system workflow are rather difficult to understand, we could alter our explanations and make them more vivid. Practical aspects were also added based on experiences in the field. Such "lessons" included providing a container to protect the magunyas from ants; bringing plastic instead of actual glasses for better transport; and securing the paper with more tape against the wind.

4.5 In-between Meetings and Informal Observations

Besides the first meetings before the workhops started, we had several opportunities, planned and unplanned, to discuss and observe anything related to our project and the local culture. These opportunities allowed us to gain insights on culture, livestock management, nature, and implications for our design of LionAlert 2.0:

- Conversations with our local camp owner in Maun, on drives as well as in the camp in Eretsha

- Attending an event by Ecoexist dedicated to elephant conservation in Seronga, where the problem and the approach to this solution was presented in the form of a community theatre play. At the event, we had the possibility to speak to the organisers as well as get to know the local dikgosi
- Conversations with the Flo and Pro in our respective camps as well as a long drive to Maun, where we discussed our workshop insights, local daily life and customs, as well as future research publications
- Speaking to locals outside the workshops while they visited our camp and while being on errands (shops and fuel stations, printing, ferry, etc.)
- Watching a healing ceremony where a healer and several other people were dancing, singing and drumming all night through to help a sick person
- Riding a *mokoro* – traditional long boat – along the Okavango river, while observing and learning about the local fauna
- Boarding a 45-minute scenic flight over the Okavango Delta starting from Maun
- Accompanying a herder kraaling his cattle
- A closing meeting with Flo, Pro, and Chris, to get feedback on our third iteration of LionAlert 2.0 and the underlying requirements from their side.

4.6 Design of LionAlert 2.0

After this first round of workshops, we summarised, categorised and analysed the results of the interviews and the ideas our participants had. We gathered them from our field notes, audio and video recordings. Participants' practices, needs, problems and wishes guided the design of the interactive LionAlert interface. Furthermore, observations and conservations we already had so far were also incorporated into this design

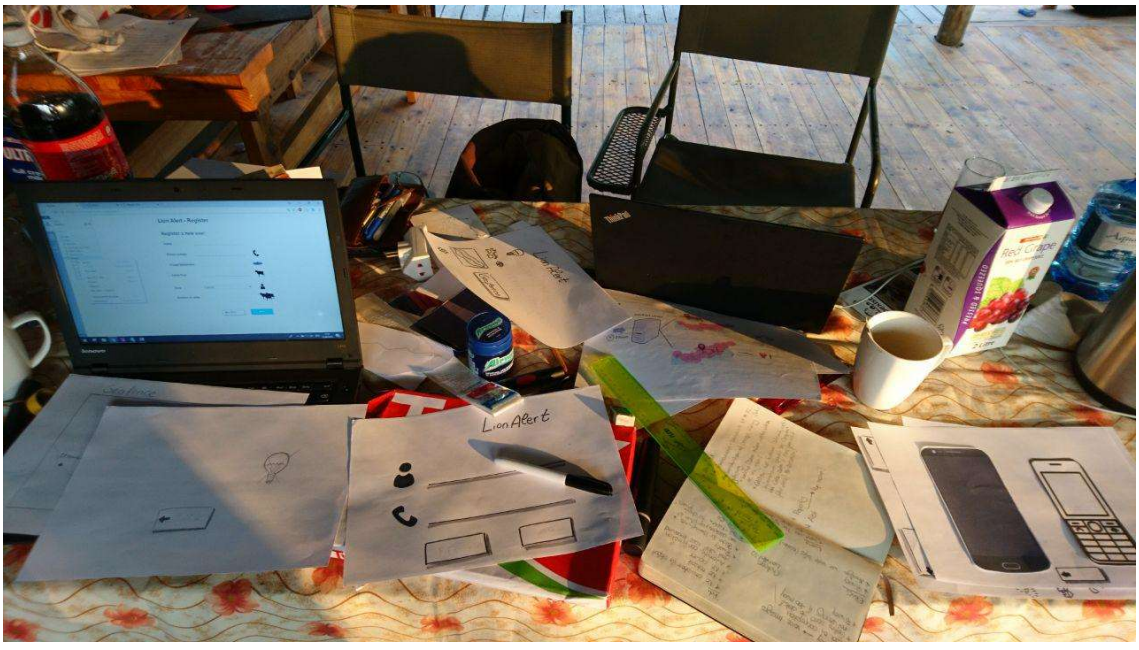

Figure 11: Design process for LionAlert 2.0 in the Eretsha camp

Before digitalising the prototype, we first used drafts on paper and created a paper prototype as suggested by Snyder (2003), see Figure 11. This served two purposes: First, to get a better idea of the workflow behind the system. Second, we wanted to use these drafts to not overwhelm participants with technology, as well as to be able to design the prototype together with them. This way, we planned to instantly incorporate their ideas on the interface and encourage them to manipulate it themselves. By doing so, participants should gain an understanding of our design's prototype character and participation should be enhanced. For later interactive prototyping, we used the tool Axure (2017).

4.7 Evaluation and Iteration via Participatory Design Workshops and Expert Evaluation

The evaluation workshop was carried out with the same groups as the first one, and we adhered to the same times. However, this time, significantly fewer participants could join. While in the first round, we had a total sample of 34 participants, here, we could only evaluate with 22 users. The only complete group was one of two from Beetsha. In Gunotsoga, we only had one second workshop due to a very low number of participants (n=6). One additional participant who happened to be around and has not previously been with us joined this group.

Similar to the first workshop, we used a guideline for this round of sessions and planned for a total length of two hours (see Appendix C). Again, we began with a prayer and

before starting the workshop. We also briefly reminded the participants of its structure, and the fact that the interface is still under construction and not a ready product, but a prototype meant for trying it out. Additionally, we stressed that this is meant to be co-design: at any time, they could express ideas, concerns and suggestions. The ideas our participants wrote down or drew on the memos in the first round were organised by us on a DIN A3 poster and presented to all groups in the second workshop. We discussed and explained what can be released in the scope of our project and what cannot. By the end of the discussion, we asked whether our participants came up with additional ideas in the meantime.

Then, we proceeded with reminding them of the current functionality. Here, we used the printed illustrations and repeated the workflow steps, while also pointing out the shortcomings of the current LionAlert version: its necessity to rely on two people at any time of the day and its inefficiency due to the long timeframe from the lion detection in the geofence to the alert on their phones. Additionally, we prepared cards with drawings of a computer. After explaining the system, we put on them the image of a) Flo receiving the alert and b) Pro sending it out. This demonstrated to people that these parts of the

workflow will be replaced by computers in the new version, which should make it more efficient and reliable.

Also, we explained to our participants that this automation process requires further data, such as information on the users: their location, herd size, cattle movements and much more. We intended to emphasise the users' role in the LionAlert 2.0 development as well as improvement and show why their input is important. Before presenting the interface on the computer, we also defined the general idea behind the system, how the participants could join LionAlert, receive and access relevant alerts, and view the current geofence, as well as enter their own sightings of lions and lion tracks.

To test the effectivity, efficiency and satisfaction with our prototype, we applied a usability evaluation approach. One volunteer per group was assigned to actively use the different interfaces on a Lenovo notebook (see Figure 12). All others were asked to comment and suggest improvements on the design. We observed reactions and attitudes, potential difficulties and obstacles, and asked for opinions and data security-related issues in-between, for example:

Is it okay for you to give the computer this information about you?

Is this illustration understandable for you or would you do it differently?

Would you prefer to receive a message even when there is no current alert?

Figure 12: Group evaluation of LionAlert 2.0 at a notebook with one active user

Some of the most important input types for us was the desired alert modality (text, image or sound, or a combination), the preferred interface and alert language, as well as what the alert should contain.

We started with the registration interface, where the volunteer was asked to register as a new user of LionAlert. Once they were redirected to the success screen, we showed them the log-in and the menu, encouraging the user to explore different functions of the interface.

After having guided through the menu points on the warning station tablet, we took a break which we used for asking questions which we missed or to which we did not get a reply in the first round: Participants' age, literacy, and the phone they were using. To document the available phones, we asked people to put theirs on the table and took a photo. Also, we asked what kind of functions and apps they were using on their phones in their daily life.

After the break, we proceeded with demonstrating the feature phone and smartphone interfaces. We showed the notification of a new registered user and a lion alert first, before letting the volunteer explore the rest of the prototype functions. For features not incorporated into the interface, we explained them in words and added the fact they would be incorporated in the future. Such functions were full USSD reports or audio notification for an alert. To demonstrate the latter, we had recorded Pro reading out a recent alert.

In addition to the workshops, our final iteration of the LionAlert 2.0 prototype was informed by other team members: Flo, Pro, and Chris in Botswana, and the programmer in Siegen. Instead of carrying out a usability test, we asked specific questions based on results from the second round of workshops. While the design itself was meant primarily to appeal to livestock owners and dikgosi in the Okavango Delta, the purpose of this evaluation was to clarify the relevant and realisable features for other stakeholders. In follow-up meetings with all team members in Siegen, we clarified the last details for the functionality and finalised the mock-up in Axure, which will be incorporated into the new system.

4.7.1 On-the-fly changes in second workshop methodology

Before starting the evaluation, we planned to carry out A/B tests alternately using our hand-drawn drafts of the interfaces and digital versions. However, in the first workshop with the paper mock-ups, we experienced problems due to wind conditions and the time and effort associated with this approach. After discussing it with our research assistant, he suggested using only the digital prototype so that no one would feel disadvantaged. Therefore, from the second workshop, we carried our demonstration on a computer. For

each subsequent session, we iteratively adapted the design incorporating participants' suggestions.

Because the guideline for this workshop was more open and did not contain specific time frames and strict procedures (see Appendix C), we could adapt the process to the group mood and interests. For example, we could alternate the order of the functionalities we showed to our participants and the questions we asked about them. .

While a walkthrough approach worked well for the registration interface, technology shyness and lack of experience kept users from freely exploring the rest of the prototype. Therefore, we had to guide this process and tell users where to click next. This was particularly evident for the phone interfaces, where it was very unusual for our attendants to imagine using a phone while, in fact, using a computer, even after encouragement from our side. To avoid confusion and to shorten the time required for the test, we clicked through the prototype ourselves while demonstrating and explaining what we were doing, what was on the screen and why. By asking questions on what our participants like about the interface and what not, how understandable it was to them, and what they would change, we were still able to gather valuable insights for LionAlert 2.0 improvement.

5 Results

In the following, I will present the results of Design Case Study. Starting with the preparations and the first prototype for LionAlert 2.0 (5.1), I will continue with results from the first round of workshops (5.2) and other opportunities for context study (5.3) and how we incorporated them into the second version of the prototype in the design study phase (5.4). Eventually, insights from the shrortened appropriation study with the user as well expert evaluation (5.5) were a prerequisite for the final design (5.6).

5.1 Preliminary Design of LionAlert 2.0 and Team Contributions

Conversations and meetings with our team members produced many valuable results, which influenced the design of both the workshops and the prototype itself. The first ideas emerged before our field trip, where we learned about the system status quo and develop first guidelines and designs. However, our impressions in Botswana and experiences in communicating with the locals determined our much more substantially, so that we developed most ideas on-site:

"*We discussed the workshops and LionAlert designs a bit, where Vicy contributed valuable ideas such as:*

- *using USSD for reporting a sighting or attack (just as we had used it for activating data on our new SIM cards)*
- *sending a text message*
- *being guided through an automated process after calling*
- *creating a comprehensive map of the villages and surroundings, so that people can indicate their location by SMS or voice message with terms known to them ('I am at Rra XY's house/at the rock near the tree…')*

Also, she suggested to cut out the interaction or workflow illustration elements and to put them together along with the people, instead of showing them the whole illustration" (Excerpt from the field notes of August 9th, 2018).

In the following, I will present the prototype itself which was designed before arriving in the Okavango Delta, and what we learned from meetings with local team members on-site before we started our workshops.

5.1.1 First iteration of LionAlert 2.0

As mentioned in chapter 3.3, the new version of LionAlert should run on three devices: A tablet, a smartphone, and a feature phone. All designs have been developed in Axure (2017). We followed the principles established in chapter 2.4, namely making the interface as simple as possible and including different modalities by utilising images instead of text whenever possible, reducing scrolling, and including only the relevant information used for the particular task. Because we had yet to learn about the local symbolism in the Okavango Delta and types of visual expression with which people are familiar, we resorted to symbols known by ourselves (e.g., a red lightbulb for "alert" or a cog for "settings").

The tablet interface was later to be realised in the form of a *warning station,* set up in each village kgotla. These would be connected to the local network and receive alerts the same way as through users' phones. The purpose of such stations should be to allow users to sign up for LionAlert, display current alerts, the current geofence, as well as report sightings of lions (see Figure 13).

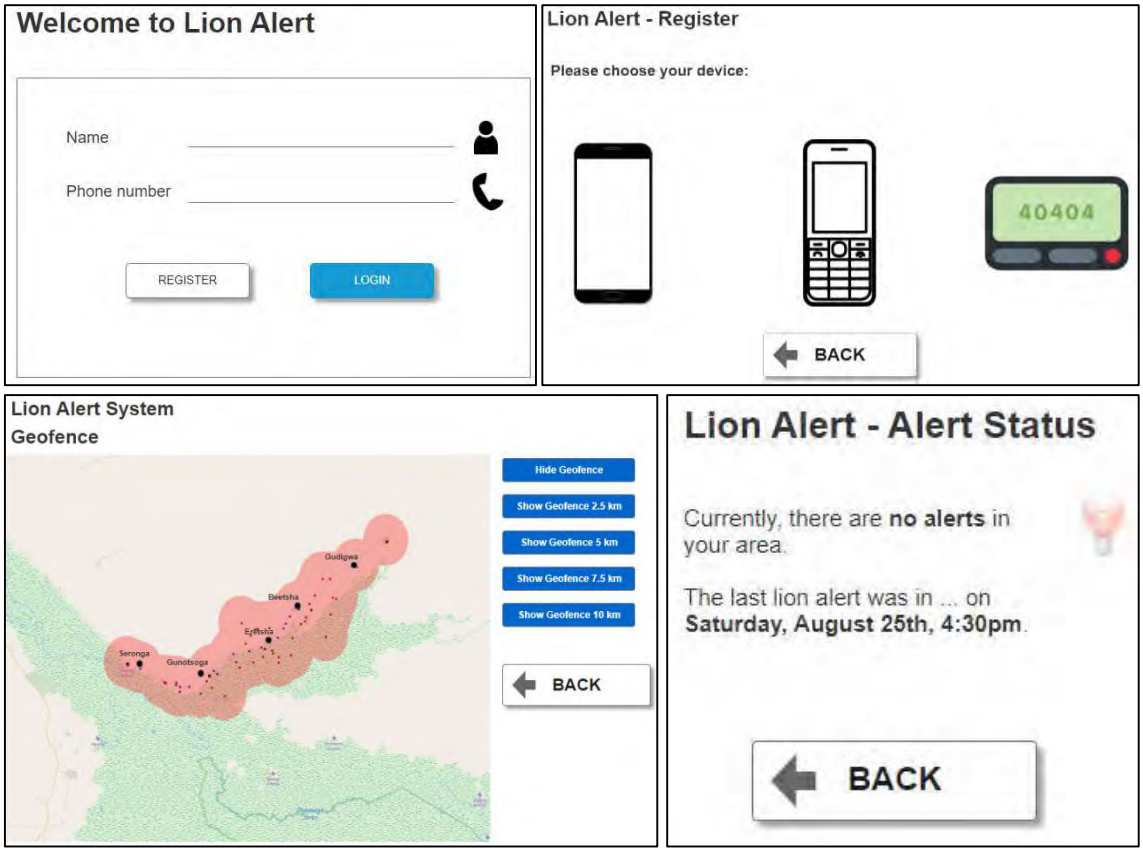

Figure 13: Excerpt from the first prototype of LionAlert 2.0 on a tablet: Login screen, registration, geofence, and alert status

Users can register for LionAlert by filling out a form. On registration, the user enters the following personal information:

- Name
- Phone number
- Village
- Cattle post
- Social function: Kgosi, farmer or herder
- Number of cattle

Furthermore, they have to choose their mobile device (smartphone, feature phone or pager), and the type of alert they would like to receive (text, voice, image, or number code). The interface has been realised in English because a translator was not yet available back in Siegen. After registration, the user should receive a "Welcome to LionAlert" message on their phone to let them know the registration was successful, and be able to use the LionAlert 2.0 menu.

This menu, as well as the registration option, should be also available on smartphone (see Figure 14) and includes the following options:

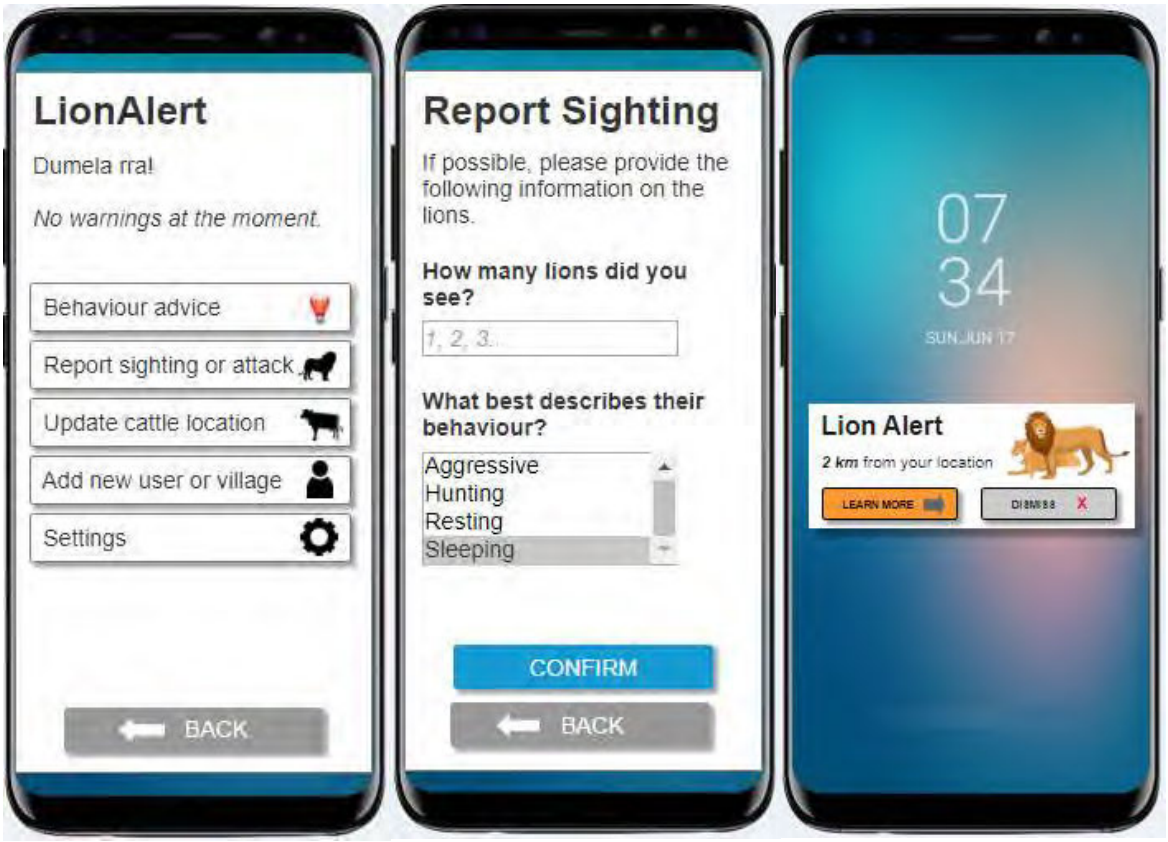

Figure 14: Screenshots from the smartphone prototype of LionAlert 2.0 with the menu, excerpt from reporting lion sightings, and an alert push notification

- Reviewing current or latest alerts in the user's area
- Receiving advice on how one should behave in case of an alert or a lion sighting
- The opportunity to report when one has seen a lion or lion tracks
- Change settings such as user details or location of one's cattle
- View the current geofence on a map in different versions: from a 2.5 km to 10 km radius
- Add new users or locations to the database.

When reporting a sighting of a lion, a user must indicate the location, time, number of lions, and their estimated behaviour. Once the reporting has been completed, the user sees a "success" screen.

The behaviour advice we included in our prototype and gathered from conversations with our team members reads as follows: "*When you get an alert, please urge your cattle back into your kraal and seek refuge in your house. If you do not have a kraal, use dogs, lights, sound and fire to scare away lions. Please take care of your own safety.*"

For the feature phone, the implementation looked a bit simpler because we could not use images, but only menus which are usually predefined in these phones (see Figure 15). For reporting, we simulated an USSD interaction which we encountered setting up our own local SIM cards upon arrival in Botswana. Concerning the alert, apart from the voice option, there is the option of text and an ASCII-symbol image of a lion.

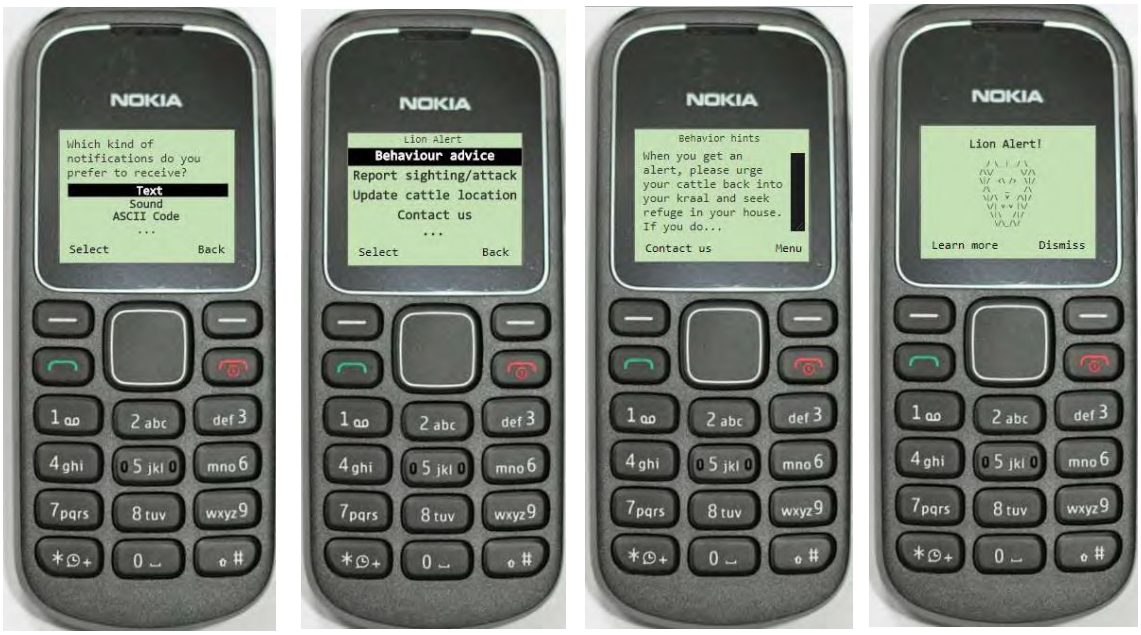

Figure 15: Feature phone prototype for LionAlert 2.0: Registration, menu, behaviour advice, and alert notification

5.1.2 Team Meetings before the Workshops

We discussed the status quo of HWC, LionAlert, and our own ideas in the first team meetings in Eretsha with Andrew, Flo, and Pro. The most important insights concerned human-wildlife conflict and the appropriation of LionAlert, which we later had to compare with the results of our workshops. The biologists and research assistant described the population, among them our potential users, as very diverse in a demographic, religious and political sense. We learned about the local hierarch, where each village is governed by a kgosi and junior kgosi, elected for life, together with their representatives. From their salary, dikgosi can, but are not obliged to employ more workers.

Concerning technology usage, most people possess feature phones which can display text and symbols, while younger people increasingly use smartphones. A large proportion of the elderly are illiterate, as are many middle-aged locals who did not dowell at school. These people mostly use their phones for calls and when they receive a text, they ask others to read it out for them. According to Pro, most cattle are owned by people who cannot read and write.

Furthermore, we learned about the significance and number of cattle and herd size, but also about livestock management (section 2.3). Because of the foot and mouth disease problem, beef cannot be sold outside the area, so cattle are mother a status symbol than an actual source of income. We had previously been warned of directly asking people about the number of cattle they had, because it could be a delicate matter, but our team members denied this and encouraged us to ask everything we would like to know. However, because livestock owners irregularly take care of their cattle, they do not always keep track of their exact herd size and find their herd mostly by the bell they attach to the lead cow. There is no herding, mostly since school obligation has been introduced, and cattle are only kept in kraals during the night. However, not everyone possesses kraals or is kraaling their cattle every day, which increases the number of attacks. There are several reasons for people not to build a kraal:

"*To construct a kraal, I would say it's not that expensive, because normally, what they use is our local material. They don't have to go and buy poles or wires. It's only to take an axe, then chop the branches. Then you set up a nice kraal. So for others, I would say, maybe they don't care or they are lazy. Others are, I would say, they are those whom you can see: no, this person needs help, because he is [...] too old"* (Pro in the meeting on August 14th, 2018).

To help people who do not have the opportunity to build a kraal or to fortify an existing one, the PioP project has introduced a lottery system. The benefactors receive a kraal which is made of strong, 2 m high wood poles, which are driven into the ground deeper and more densely than is usually done. Building a kraal requires one month, or more for

bigger ones. So far, 20 kraals had been built in this way. The World Bank has also joined the efforts of building kraals out of mashwire. However, they are sometimes put into the wrong areas or inappropriate soils and are more difficult to repair because of lack of materials.

Also, we learned the number and names of the lions currently collared, which have been given to them by villagers in specifically dedicated kgotla meetings. Apart from developing a feeling of belonging, this helps distinguish the individual animals and understand that not all of them cause trouble. However, in reality, the villagers' impression is still that the lions belong to the local PioP biologist and he is responsible for them. In one case, they resisted a naming without Flo for this reason. All collared lions at this point were female and their names have a meaning in Setswana which describes the lion's character: Wetu ("Ours"), Mayenga ("Decorated by the Gods"), Maleherehere ("Sneaky one"), Shishatiya ("Approaching one").

Before LionAlert was introduced, whenever villagers saw a lion or corresponding tracks, they reacted by alerting others and calling the local government's Department of Wildlife and National Parks (DWNP). Their task was to scare the predators away using rifles. In rare cases, they even translocated the animals, which is why many people are in favour of translocation and frequently talk about this. Nowadays, they can report sightings to local PioP members. The same is done with the attacks: The DWNP has outsourced the task of recording the local kills to PioP. Here, the time, location and culprit of the attack has to be noted and forwarded to the DWNP to make sure they can award compensation to the affected livestock owner. This has to be done while the carcass is still fresh, so that researchers can reliably determine the predator responsible for the attack. However, this is not always possible: There could be too many attacks at a time, or some longer distance away, or no vehicle available. In addition to livestock predation, crop field destruction by elephants is another problem for the local farmers – but this is outside the scope of PioP, while the problem is addressed by other organisations like Ecoexist.

Lions are sometimes shot while wearing the collars, which is noticed by the researchers who then collect them. In our three study villages and Gudigwa, there have been 273 reported lion attacks on cattle. Most attacks happen in the veld, around four km from the villages, in the dry season and in the early morning: "*We do have the most conflicts when it's dry [...] because cattle go following water, and most of the water is further [...] that's where most of the predators hide in waiting*" (Pro in the meeting on August 14th, 2018).

Cases of lions jumping into kraals were also recorded. However, lions do not normally attack people – only when they are hunted, as happened the year before. We learned

more details on how LionAlert works so we could better describe it to our participants, while also hearing about its success in reducing attacks by 50 %. The same figure has been named by Flo referring to lion alert recipients taking action after this alert. In the remaining share of cases, people cannot properly react to them because the attacks happen at night: the balance of power between human and lion is shifted and lions are in advantage due to better eyesight. When livestock owners receive an alert at night, they usually go back to sleep and rely on government compensation if one of their livestock is killed. Even though compensation is often paid out years later, it is sometimes even higher than the actual cattle's worth, so people prefer to receive this than undergo efforts to protect their livestock. Some people, however, kraal their livestock on the next day until the lion has left.

During day time, they make decisions on the basis of the lion's distance and time they have until it has reached them. In some cases, they call Pro back to confirm the distance, but he usually does not reveal this information: "*Some will just call me to confirm how far is the lion, then I'll say: no, it's just near your cattle post or it is in the grazing area*" (Pro in the meeting on August 14th, 2018).

If it is still safe to go out, the most common reaction is to kraal their cattle where possible. Furthermore, if livestock owners see other herds near their own, they also urge them closer to the respective kraal to help others. Otherwise, if the lion is too close, they stay inside and "wait it out". Being in the veld or at a cattle post, lion alert recipients usually go home to bring themselves into safety. Sometimes, other wildlife like elephants keep livestock owners from leaving their home. One reaction for frustrated livestock owners is to hunt lions with a rifle if they are in the area, but due to the personal risk, the government ban and the efforts of PioP to convey the importance of predators for the ecosystem, culture and tourism, this happens very rarely: "*Even one of the persons who didn't like the lions at first [...] changed a lot. If there's a conflict, he will just call me and tell me that: no, the lion's this side, come and assist*" (Pro in the meeting on August 14th, 2018). However, to prevent this, livestock owners opposing lions and corresponding conservation efforts need to be convinced that a coexistence is possible.

The local research assistant Pro told us that if he receives an alert for his own cattle, he notifies other farmers around him, especially his family, and helps them kraal their livestock. To illustrate the diversity of attitudes towards livestock management, he described one case where a farmer received an alert for his cattle around Eretsha while being in Seronga himself and called Pro to ask about the distance and whether he could kraal his livestock for him. After he received a negative answer, he went up to kraal his cattle on his own.

Our team members gave recommendations on what should actually be done when an alert is coming in, notably that villagers should gather in groups and include dogs if they have any, produce noise, make fire and set up scarecrows to keep the lion(s) away. Kraaling is a good reaction as well, but livestock owners should always favour human life over that of cattle. If a lion is too close, they should therefore stay at home and make sure their children are safe as well. In case they are directly confronted with a lion, they should stand still and appear as confident and threatening as possible. This knowledge was conveyed in kgotla meetings and workshops, so that practically everyone is aware of it.

Discussing the status quo of the system, we learned how the geofences had been established:

"*If we look at the geofence which we set […], it's like we just used the main channel […]. Then when we put the trackers from cattle, it indicated that most of the conflicts just happened within four km around the village, of which our geofence was about five to six. […] Even with the collars, it's like they don't operate the whole day just to save the battery. So with lions, while the collar is not transmitting, they can come and approach and kill cattle. […] We can try to extend the operational hours of the collars*" (Pro in the meeting on August 14th, 2018).

Departing from the issues discussed in 3.3, we identified specific technical and design requirements for the new system. The current collar failure rate is 50 %, while some collars "die" before they are empty. New, more reliable and less costly collars are considered which allow to input GPS only and dynamic warning lines programmed externally. Lions will get new types of collars which contain only GPS, but no preprogrammed geofences. Therefore, these should be dynamic and adaptable by an algorithm which is using parameters like the seasonal water level, which greatly influences grazing areas, and cattle movements in real-time. Because this changes its character, we will call it *warning line* to distinguish it from the previously established static line. This dynamic feature should also enable to establish more than one warning line, while prolonging the battery life of the collars by including less technology in them. At the same time, the GPS signal time of two hours should be changed so that alerts come in instantly. Machine learning should enable this feature by predicting attack probabilities. This will be based on parameters like lion movement speed, which Flo was still calculating himself, and the abundance of wild prey. Additionally, the algorithm should consider that lion tend to strike again in places where they were successful in the past.

The decision which lions to collar is based on the pride they belong to; at least one lion per pride should be in the system to ensure safety. If more lions are collared, it will be possible to apply a master-slave system: Once the system knows which lions (slaves)

belong to which pride (master), it can check whether they are in master vicinity. If not, after a certain time, new prides could be formed within the collar system, once the biologists have confirmed the new constellation. However, it has to be considered that a flood, which is quite common in the Okavango Delta can break up a pride.

Another problem which can occur is lions staying longer on the "wrong" side of the warning line. One case was reported where a lioness gave birth to and raised cubs while staying within the geofence all the time. How should the system behave and how often should it issue alerts? In these cases, the system should only give an alert once the lion leaves the area, and otherwise remind locals every three days that it is still there. If the alert occurs, there is the potential of villagers getting too used to the alerts and not taking them seriously.

PioP members also considered collaring cattle. This has been previously done to collect data on cattle movements, but has been abandoned due to high costs and efforts: these collars would have to be changed each month, which means a lot of stress for the herds. Furthermore, collars on cattle raised false impressions in livestock owners. After collared cows had been killed by collared lions, locals believed that the collars communicated with each other and were responsible for the kills. Kgotla meetings had to be held to resolve this issue.

With a new LionAlert, however, collaring livestock can be reconsidered, but only for the lead cow of each herd. For now, providing a manual cattle location for the algorithm would produce a number of practical problems, such as: by what means should it be entered and how often? Collaring cattle would be especially useful for communal herding which would be the ideal approach for solving HWC together with the alert system. Researchers could add the parameter of cattle movements to the real-time warning line algorithm instead of relying on historical data which are subject to change. In addition, communal herding would reduce the number of lion attacks by simply increasing the herd size, and therefore making hunting it a larger risk for the predator. One herder per communal herd could still receive lion alerts and learn where he needs to move his herd to avoid a confrontation. Additionally, purposeful movement could prevent the land degradation that happens when the herd is kept in the same area for a long time. However, cooperation between livestock owners is difficult in the Okavango Delta: personal conflicts, sometimes even within families, inhibit teamwork. Furthermore, if not all livestock owners participate in this system, their smaller herds would be at disadvantage and an easy target for predators.

Considering the receiving gadgets, we have to make use of as many channels as possible: TV, radio, mass media and sirens are possible ICT for making alerts more effective, especially because the options of GSM phones are limited. The warning station is the

first step towards this, combining local and mobile phone alerts where everyone can be reached even when they are not in their usual area.

As for the design of the alerts and interface, our team members emphasised that they should be in Setswana, i.e., a local language understood by everyone, and should especially appeal to illiterate people. Some of the local languages have never been alphabetised, so they cannot be used for text alerts. To display the alert area, instead of using text, we could use pictoral representations. Colour codes were suggested, for example yellow "near grazing land", orange for "grazing land", and red for "village". Consequently, we would not have to tell people the exact location and distance to prevent possible shooting of the lions. Giving people suggestions on what they should do during an alert was not recommended, because people "*do what they want*" (Flo in the meeting on August 12th, 2018) and standing in front of a lion feels completely different from reading about it. Most people already know what to do, and sometimes cannot prevent an attack anyway.

An automatic reply option was desired by Pro to confirm users have received an alert instead of relying on manual replies. The system could also inform him if the alert has not been received or read, for example, due to lack of network connection or absence of the receiver. Conversely, users should have the option to see current and past alerts using the interface. To save their money and encourage them to do so, this could be done via USSD. Furthermore, more people are getting alerts than are on the list by being notified manually, for example, illitarate users or herders who are warned by the livestock owner. Because among them, there many who are in need of these alerts, it is necessary to add them to the list by enabling registration.

To register new users for LionAlert, the operators would need at least the following information from users: Name, phone number, location of the herd, and the person who should receive the alert. The latter aspect is necessary if someone is not looking after their own cattle. So far, Pro has manually decided who to notify in such cases. As for reporting lion or lion track sightings as well as attacks, there was the suggestion to include the opportunity a photo in real time to make it easier for the researchers to analyse the situation before even being on-site. Of course, this would imply the usage of a smartphone.

Power and network instability are further technical issues which can render any automatic alert system useless in case of a collapse. Such cases can happen, for instance, if the government manually shuts down the internet while carrying out criminal investigations which prevents people from warning each other: "*If there is no reception, there is nothing we can do*" (Pro in the meeting on August 14th, 2018). Backup systems are therefore necessary. Furthermore, not everyone has the opportunity to regularly charge

their phone; Pro, not having power supply at home, has to rely on others to do so. Solar panels can therefore be a valuable addition to cattle posts, where livestock owners most benefit from lion alerts. However, in attempts to provide them, they have frequently been stolen. This leads us to the necessity for a safe installation of the warning station, and a person in charge to monitor it to make sure nothing gets damaged or taken away.

Moreover, there are several cultural aspects and challenges which must be addressed when iterating LionAlert – not only from the system, but from the user side via education. These aspects include inappropriate reactions to alerts, disinformation on and a negative attitude towards lions, irregular herding and kraaling, as well as a lack of cooperation between livestock owners. Furthermore, some people are not in their area when the alert comes in, if they work in another place or are on holiday. Solutions have to be found to make sure someone else can take over and react to alerts for them, or cooperation within the village has to be promoted, so that e.g. neighbours can take care of others' cattle.

Concerning our workshops, our team members gave us aspects to consider. We established locations, times, target groups based on hierarchy, and participant numbers. Apart from this, we determined what the aim of the workshops was for each stakeholder. Biologists Andrew and Flo stated the information they needed to know in order to successfully iterate the system:

- Which type and frequency of alerts users wanted
- What improvement suggestions they had for the system
- In addition, they were interested in how locals felt about personal safety and whether they felt threatened by lions
- Concerning the absence problem, they wished to find out whether an alert outside the local range is desired.

To extract the ideal results from our workshops, we agreed on an appropriate procedure. It should be adapted to the local discussion culture, where there is usually one leader and not everyone is talking. As education in Botswana is not directed towards critical thinking and creativity, we would have to use methods which bring out people's own opinion and ideas. To solve the problem of low participation, we would have to personally address people to engage everyone in the discussion. In the worst case, if the group cannot be made to participate at all, we should arrange a backup group. The topic of lions and HWC is especially problematic, as a great financial and personal damage is caused by lions, and therefore the possibility of a negative attitude. At the same time, we had to consider that not everyone is informed by lions and some people do not even know what they look like.

Since local people already had interview fatigue because of the many projects going on in the area, we needed to design the workshops to be as engaging and efficient as possible, find a common language and clearly communicate the benefit. First of all, participants needed a comprehensive and vivid explanation of the technical background and functionality of LionAlert to understand what is being improved. Using simple terms as well as visualisations is vital due to low familiarity with technology. Also, they needed to understand that our aim was to protect them and their livestock, and that they were an integral part of this effort. We had to be cautious mentioning cattle trackers should be done carefully since we did not have the resources to provide them. We were therefore asked to emphasise the importance of herding and a communal solution to help solve the HWC. To make sure could everyone adequately contribute, we agreed upon regularly asking our research assistant for feedback and discussed the procedure with him. Also, we were "warned" of usual demands people have when being confronted with PioP: hiring more people to locally work for the project, giving them smartphones, translocating lions, and other costly changes. We needed to counter these requests by saying that there is not enough money and that LionAlert is only one part of a large undertaking where all aspects need finance and support. Furthermore, translocation would not solve, but rather relocate the problem. Armed with this knowledge, we started our workshops where we received an insight into livestock owners' opinions, struggles, appropriations and daily life.

5.2 Results of the First Workshops

In general, we experienced positive attitudes towards us and our project from our participants. Nevertheless, we usually started our workshops half an hour later than planned, because time in Botswana is a relative concept instead of an absolute one, but also because people were busy with their duties in the village and sometimes had longer journeys to undertake to arrive at the kgotla. Until everyone arrived, we welcomed each new participant by shaking hands and greeting them in Setswana with an obligatory "how are you?". We briefly introduced ourselves and offered them a seat. Sometimes we started while still waiting for one participant, after they had informed Pro of their delay. A few participants did not show up at all for different reasons.

As for the discussion culture, most attendees took part in the talk, where those with a higher hierarchy tended to speak up more often. Women were an exception: As we found out, livestock predation rarely concerned them so that they felt, they had little to add to the topic. Most of them spoke only when directly addressed. Only in one group in Beetsha where the gender ratio was 50:50 and the VDC vice chair was female, was the share of contributions approximately the same.

In the following, I will summarise participants' views on different topics in the workshops. These are categorised in statements related to livestock management and HWC, opinions on and usage of LionAlert, and suggestions for improvement. All information included in this section, unless not stated otherwise, reflects our participants' subjective opinion and statements, and does not necessarily correspond to the facts. For this reason, it is later compared to, and discussed in comparison external references and our own experiences (section 5.3 and chapter 6). All citations by participants are marked in italics and indicated together with the role, gender, age, and location; they are either provided in their original version or as a translation by Pro, if voiced in Setswana.

5.2.1 Livestock management and HWC

Many workshop attendees were farmers without having any other employment, except for kgosis and members of the VDC and FC, and one participant who said he was additionally a carpenter. Every participant owned livestock, the amount being between one and 220 cattle in total, while not everyone wanted to or could tell us their number of livestock. Herds are often shared within the family, while participants indicated they owned between 5% and roughly a third (38%) of the family cattle themselves. Individual, smaller herds usually range from five to twenty animals. People with a higher status in hierarchy (dikgosi, VDC and FC chairpersons) usually have more cattle (80 to 220 individuals).

Livestock is mostly kept and milked, but rarely sold apart from cases where school fees are required. Local farmers buy cattle among each other. While all cattle owners are men, women usually take care of goats and chickens. As one participant put it: "*I am a lady, I cannot take care of cattle. But I have [some]*" (farmer, F, 40+, Beetsha). Goats and other domestic animals, unlike cattle, are not kept in kraals, but roam the village freely. Wild dogs sometimes hunt the goats, but as it is not mentioned often and does not lead to further discussion, this seems to be a minor problem as compared to attacks on cattle.

Most people told us they were kraaling their cattle almost every day, especially if there had been a lion alert the night before. One participant in Gunotsoga came late to the workshop because he was taking care of his cattle. Since many people keep their livestock at a cattle post, they must first travel there from the village. For most farmers who kraal, the daily routine started with taking care of their cattle in the morning by milking them and examining them for sickness or damage to the kraal. Then, they released them into the veld for grazing. Small calves were left behind in the kraal to protect them from predators, as well as to ensure their mothers come back to the kraal in the evening by themselves: "*If we keep the calves behind, we know that the elders will come back*"

(livestock owner, M, 52, Beetsha). Usually, cattle are collected in the late afternoon, sometimes they were said to return by themselves. Kraaling is also an opportunity for social interaction among the livestock owners to talk about cattle and other topics beyond. Lighting fires around the kraal apparently also attracts the cattle, so they return in the evening following the lights. One participant even set up a salt lick at his kraal, which he claimed was very attractive to the animals and eliminated the need to manually gather them every day. One participant additionally planted a lablab tree (a species of bean) popular with cattle at his kraal so "*this is one of [his] herders*" (Farmers' Committee Chair, M, 83, Beetsha).

Livestock owners recognise their cattle by brand marks, ear pieces and individual colour patterns. Bells make it easier to find them, but for economic reasons, only the lead cow in each herd carries a bell. Also, in the veld, cattle scatter a lot and divide themselves into small groups, which makes them more difficult to retrieve and vulnerable to predators. A significant factor for attack probability and location is the season: cattle go further from the villages and cattle posts in the dry season than in rainy season to find water and edible grass, which is when most lion attacks happen. Then, they often meet predators at the water, where lions can lie in waiting. Lions also leave the delta and come closer to the settlements, following the cattle. This results in attacks close to the villages, while one participant told us he had an attack right behind his house. The cats follow livestock because they are slower and bigger than their natural prey, e.g. impalas, making them an attractive prey.

When their livestock are too far away, many owners do not have the time and energy needed to go find them. There are more cases in which kraaling is not possible: when the water level is too high, when farmers are busy during ploughing season, when they are away to look for employment or attend a funeral, when there are heavy rains, or when wildlife like elephants are around. In the latter case, because elephants can be dangerous if approached too closely, people are too scared to enter the veld. According to one participant in Gunotsoga, there were 19 cases of people being killed by elephants. Due to the difficulties in managing livestock, many people are not aware of their exact herd size and only realise days after that a cow is gone, which is where they take action: "*If one is missing, we will just search for it until we find it*" (kgosi, M, 48, Eretsha).

Some families have a specific family member to take care of the cattle, but some of the older participants especially are not able to manage cattle effectively. According to them, herding was done by children previously, but this has ended due to primary school education becoming free and therefore accessible for everyone from 1980 (Meyer et al., 1993). Young people are increasingly moving into towns to seek em-

ployment. However, not everyone neglects their livestock if they lack the means to take care of them. If, for instance, women are alone with a herd because their husbands are away and their children are in school, they can employ a herder to kraal for them. This person usually receives one cow as payment for one year of support. Others ask neighbours to help out for shorter time periods. However, there is a difference between kraaling and actual herding, which is done very rarely in the Okavango Delta: "*Nowadays, there are no herders who will just go and stay the whole day herding with their cattle*" (kgosi, M, 70, Gunotsoga). Others understand that a lack of herders only increases the problem: "*Because we are not herding, that's why the lions take our cows*" (livestock owner, M, 52, Beetsha). On our suggestion to include herders, they said this particular job is not popular due to very low payment and reputation. While most people claim that reputation is associated with income, others disagreed and said that, for example, members of the government are more respected than tourist guides, although they might earn less. In addition to this, even with low wages, few people can afford a herder for themselves. Nevertheless, participants praised the herder workshops carried out by PioP as being helpful for them.

The economic significance of cattle, which increases the damage suffered by HWC, became particularly evident when a participant said: "*Lions make us poor*" (livestock owner, M, 80+, Gunotsoga). An extreme case was a participant in Gunotsoga whose herd of 20 was reduced to one because of lions, while he was sick for over a month and could not take care of the cattle. Gunotsoga was the village where most absolute and relative losses occurred: Livestock owners in the second group have lost up to 25 cattle and herds were reduced by up to 95%. In this group, discussion participation was highest: everyone wanted to contribute an answer to our questions, while many simply agreed with or repeated other participants' statements. This led to workshops in Gunotsoga being the longest. When asked why they think some livestock owners suffer greater losses than others, they attributed this to the herd size where the relative loss is lower. People who are affected to this degree have the feeling they can no longer support themselves properly, especially when they have family members who are ill. Some were speaking about their losses and poverty with tears in their eyes. The heaviness of spirit was enforced by the fact that one participant had lost a calf the night before the workshop. About the second workshop in Gunotsoga, Vicy wrote in her field notes (August 23rd, 2018):

"*The participants' plight and sorrow is almost tangible, they have all suffered grave losses. They are very polite to us and understand that we only work for a small part of a small project, but they are still quite impatient with having to attend a workshop where they are asked again for their experiences – instead of being given instructions, tools and methods for improving their situation*."

Apart from explaining why we needed their input to further improve their situation, we responded to the need for suggestions by referring to the herder workshops, while Pro gave them some information and practical hints after the session.

Lions are not the only wildlife which cause trouble to the locals. Cattle are also killed by hyaenas and cheetahs, while smaller livestock are preyed on by wild dogs. According to participants' estimates, hyaenas are as great a problem in and around Eretsha as lions, having fatally attacked at least 12 cattle as compared to ten killed by lions, while most cheetah kills occur at cattle posts near Beetsha. Still, the "*number one [predator] is [the] lion*" (Livestock owner, M, 48, Beetsha). In Gunotsoga, elephants were named as the biggest problem apart from lions: "*We just stand in the middle and don't know what to do*" (livestock owner, M, 24, Gunotsoga). According to residents, elephants are a great threat for crop fields which they destroy, depriving farmers of valuable food sources, but they also render it difficult to take care of cattle: Livestock likes to mix with elephant herds and are therefore impossible to gather by people, though temporarily protected from lions. However, when the latter approach, cattle run away indiscriminately. Another factor is elephants destroying kraals when searching for the edible trees, so that lions can come inside and attack. However, they can also do so if the kraal is simply too unstable or too low, i.e. "*most of [their] kraals are not lion-proof*" (VDC Chair, M, 48, Beetsha). New, stronger and higher kraals seem to reduce the problem of lion attacks. Once a predator enters the pen, cattle start panicking and can further destroy the enclosure while running away. Sometimes, lions kill not just one, but up to six cows in one attack, increasing the damage.

Botswana's government grants financial compensation to those who lose cattle due to predators, which depends on which predator was responsible. Lions lead to the greatest compensation compared to wild dogs, hyaenas or cheetahs. Participants even claimed to not get any compensation for hyaena attacks at all. Apart from this, they lament that the money reaches them very late, even though they immediately report kills to PioP, the police, and the DWNP: sometimes, they even have to wait five to ten years. This gives livestock owners the feeling the government does not care about them. Compensation received is used to replace cows lost to predators, while the kgosi in Eretsha said he buys sweets for school children for this money.

As we asked participants to mark frequent attack spots on a map with coloured sticky paper dots, we could see that for many of them, interpreting maps was a skill they have not acquired. It was proportional to the education level, which we estimated to be based on hierarchy. At the same time, they could navigate using the names of nearby cattle posts, lodges, and islands. Therefore, we gave the dots to the translator and asked him to mark the places the group suggested. Mostly, dikgosi and chairpeople were in charge of

assigning the spots. Determining the attack spots resulted in long and lively discussions among all group members.

If we look at the finished maps (see Figure 16), it becomes evident that attacks mostly occur on the grazing lands surrounding the villages, sometimes also in the villages themselves. As participants explained to us, the lions arrive from the Moremi Game Reserve in the South. Many more attack spots have been identified around Gunotsoga than around Eretsha and Beetsha. They stretch out towards other villages and cattle posts as well, since many residents have their livestock there. Consequently, they get alerted for these places, instead of their place of residence. There are fewer kills beyond the main channel, which is the basis of the geofence.

Before LionAlert was introduced, villagers had been looking for lion tracks or vultures, which are a sign of a recent kill. Lion roars also tell them that a predator is near and its direction, so that they can kraal their cattle in time before they are in danger. Cattle from a herd which has been attacked looked distressed or scared, and sometimes even come back to the kraal earlier which alarms their owners. In case of a sighting or attack, they warned each other via phone calls and informed the DWNP as well as the police. If they met lions out in the veld, they did not scare them away, but rather waited until they left by themselves: "*Because they know, if people meet with them, there is always conflict between them*" (VDC Chair, M, 32, Eretsha). To further protect themselves and their livestock from predators, they usually resort to torches and fires, which they light around the kraal at night or take with them when going to a cattle post. Others said lions were not scared of fires and this measure would only work for hyaenas.

Some people used dogs and noises like "*swa, swa, swa*" (livestock owner, M, 35, Beetsha) to scare away predators when they were near the village. Some dogs are trained to protect cattle, especially calves, and their presence and barking apparently sends lions fleeing. Elephants, however, are frightened neither by fire, light nor noises. One participant was wearing a rifle during the workshop and another said, hypothetically: "*If I have my rifle, I can shoot [the lion]*" (livestock owner, M, 52, Beetsha). At the same time, he also said: "*I don't want to shoot the lion because it brings for the young ones income and employment*". We have seen that participants understand the economic importance lions have for tourism. Shooting is therefore only used for scaring the predators, while PioP and the DWNP are informed afterwards. Most people understand that wildlife and domesticated animals must coexist. This notion is delivered by religion, education as well as PioP efforts.

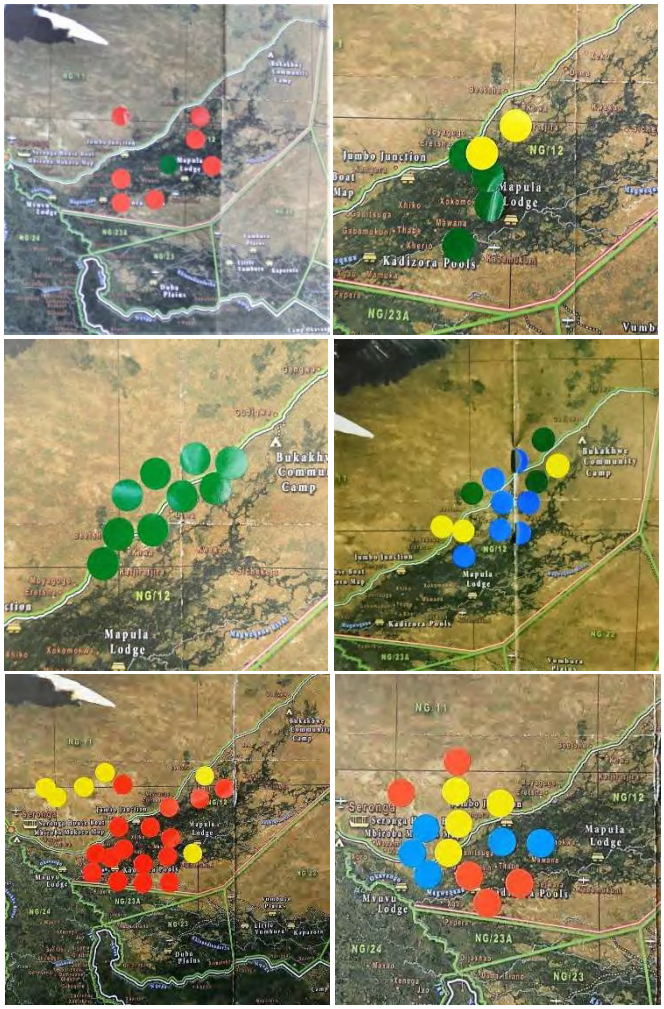

Figure 16: Frequent lion attack spots marked by workshop participants. From top to bottom: Eretsha, Beetsha, and Gunotsoga

Whenever participants receive an alert, they "*try and do [their] best to bring their cattle into kraals and make fires around their kraals*" (kgosi, M, 70, Gunotsoga). They can also urge their cattle into another direction away from the lion. Gathering their cattle, they first try to find it near the lion's estimated position based on the alert, as they expect it to follow the herds. However, this is only possible if the lion's distance is great enough. When asked about personal safety, participants did not voice any concerns: "*Nowadays, those lions, they are very scared of people*" (kgosi, M, 50+, Beetsha), so they rarely see one. Nevertheless, they are not taking unnecessary risks and only leave when it is safe. Otherwise, they stay in their yards because they understand the lions are still moving. There, they gather in groups and take dogs, torches and fires with them, prepared to scare away potentially approaching lions. When they see lion tracks, hear lion roars or spot elephants, they refrain from walking into the veld and kraaling. As an example, during a workshop in Gunotsoga, one participant said he heard lions roaring the night before, so he did not kraal his cattle and did not know whether they were safe.

Many do not risk leaving their house during night due to these reasons. Some go out and light fires around their house, others go back to sleep, but the alerts at night are disturbing and result in less rest for them. However, some farmers still resorted to kraaling their cattle the following morning. Alert recipients also pass on the message to others, even to those who alse receive them, to make sure everyone is informed about the situation. Neighbours help each other as well: when kraaling their livestock, they can also take other herds with them. Those who already light fires around their kraal increase the number of them after an alert.

5.2.2 Experiences with LionAlert

From these results, we can conclude that while effective livestpck management is difficult for many catte owners, they have learned to take appropriate measures to prevent HWC also by using LionAlert. Before we could gather their opinion on the current system, we needed to explain it using our illustrations (see Figure 7 and Figure 9). When we asked what users already knew about the system, we often provoked long discussions among the participants, or silence at other times. Everyone was informed about the collars which send a signal to the computer, and which ends up as an alert on their phone. What happens in-between, however, was unknown. In particular, they were unfamiliar with how the signal is processed and what the computer does. We had to explain the concept of GPS, which was a term recognised by most participants but produced confusion about how it works involving satellites and towers, and how long it takes for this signal to reach the server. The geofence and its role in LionAlert was similarly new to many users. We explained the process of the GPS signal being subsequently processed by the server and reaching Flo's computer if an alert occurs. For explaining what happens at the computer, drawing an example movement of a lion to illustrate how its position and the way its movement is interpreted by Flo was an effective illustration. Consequently, we described his task to alert Pro. The last step of alerting individual livestock owners was recognised. After the presentation, we answered the few questions that participants asked to paint a complete picture of the process.

LionAlert was perceived positively and people generally had the impression that it helped them, wishing to use it further: "*The system is okay*" (Livestock owner, M, 52, Beetsha). The alerts not only let them know that their livestock might be in danger and taught them to take case and action, but also help them determine which places to avoid as to not encounter a predator themselves: "*If we know the direction where the lion is, we know where not to go*" (Herder, M, 40+, Eretsha). However, after the presentation, they pointed out several problems with the system.

Many people realised "*the process takes a long time*" (VDC Chair, M, 48, Beetsha), and from their own experiemces described the notification as delayed and claimed alerts came too late. This was based on cases where a lion had been seen or had killed livestock even before the alert was issued. Because the signal is only updated every two hours, a lion can be much nearer than the data PioP have on their computer suggests. Another flaw they identified was the reliance on a few people: If one's phone is off and they do not receive an alert from the system, the whole alert system will not work.

In some areas, fewer alerts have been issued: for instance, there have been no alerts in Gunotsoga for several months prior to the workshop. Users attributed this to the system not working properly, them missing alerts, or PioP not alerting them on purpose, while, in fact, no collared lions had been approaching their village in a longer time. Many kills have been caused by uncollared lions. To remind people to take extra care during the dry season, where most kills occur, Pro had sent out a message to all LionAlert recipients telling them to beware of lions once the water level is falls.

Because of the complexity and severity of their problems, in Gunotsoga, participants do not feel LionAlert should be the focus of the improvement efforts: "*You are supposed to modify this, but we like it*" (farmer, M, Gunotsoga, 59). Instead, they suggested measures against elephants, such as lifting the hunting ban and relocating them. However, they still had many ideas on iterating LionAlert and resolving HWC focusing on lions. Others expected us to present their ideas to the government, who are perceived as the only agency that can really resolve HWC in this area.

5.2.3 Participants' Ideas to Improve LionAlert and Reduce HWC

The suggestions our participants offered can be categorised into the following four groups: Geographic intervention, material support, personal support and education, and system improvements. In the following, I will explain these categories in more detail and additionally discuss them referring to insights from other team members.

Geographic intervention. Here, we can distinguish between direct lion relocation and measures to shift their habitat. Translocation of lions combined with fences around them to separate them from villages and grazing lands, in a sort of national parks, was a frequently expressed idea (see Figure 17). Some were referring to existing buffalo fences. Participants suggested to supply them with donkeys or even elephants inside these enclosed areas, should there be a lack of wild prey, so they would not have to prey on cattle. Lions could then still be collared and villagers could be alerted if a lion leaves the park.

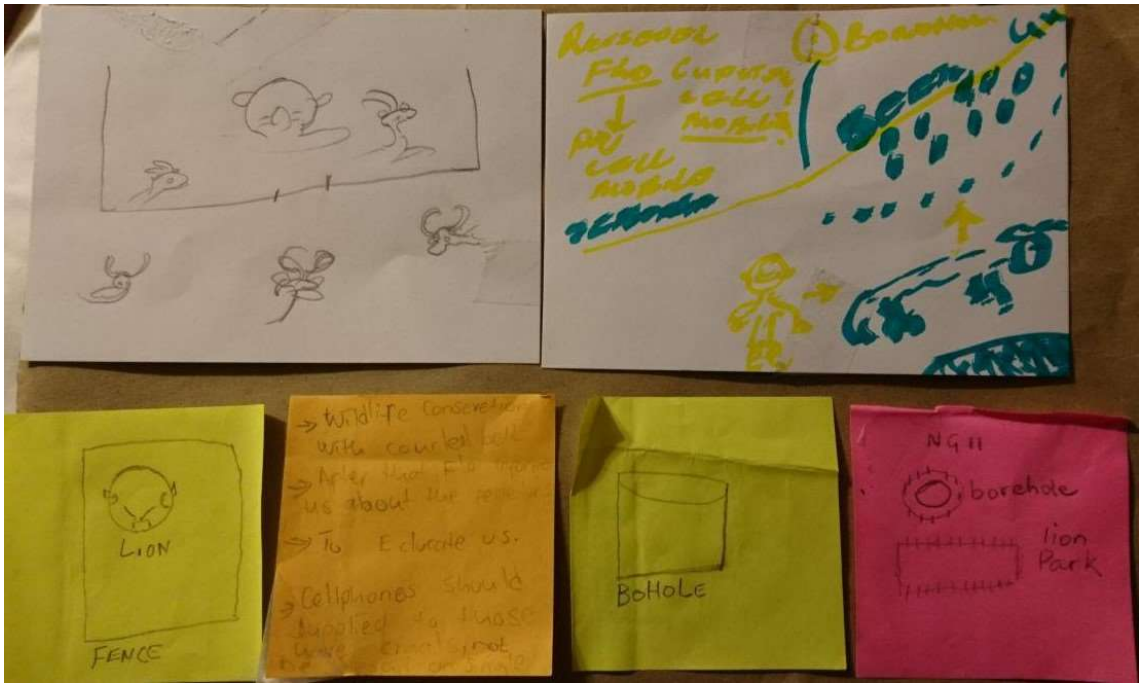

Figure 17: Participants' ideas for a HWC solution referring to geographic intervention

In order to bring cattle further away from lions, many participants suggested drilling boreholes in NG 11 (the area north of the main road crossing the villages). This way, cattle should be able to find water up in the North and be out of reach of lions who come from the Moremi Game Reserve in the South. According to some locals, lions would not get this far because there would be no water on the way there, so they would seek other locations. Others, on the contrary, proposed creating boreholes near the kraals because the lions would be easier to chase away from these.

Geographic measures require a very high budget and effort we currently cannot afford. As mentioned above, translocation would only relocate the problem instead of solving it. Buffalo fences are not effective against lions and elephants, while huge parts of them are destroyed during slash-and-burn land clearance measures each year. The effectivity of boreholes in NG11 is questionable at least until the exact lion and cattle movements are recorded. Therefore, this idea was not well received by at least some participants in the second workshop.

Material support. Most ideas could be assigned to this category (see Figure 18). It includes any kind of technical or physical equipment, as well as financial support suggested by participants for themselves or for project members. For the livestock owners, in order to establish more security and make alerts more effective, many participants stated they need better and stronger kraals, as some lions have already attacked cattle inside a kraal which was too low and not stable enough. As lions can jump into low enclosures, barbed wire roofs were suggested by two participants. There were cases of

elephants destroying kraals and exposing the cattle to predators or making them run away into the veld, becoming easy prey. One suggestion was that kraals could also be equipped with lights charged by solar panels and active during night to keep predators away.

Furthermore, participants suggested that "*the project should supply smartphones to the herders*" (herder, M, 40+ Eretsha). Others proposed to equip kraals with phones for

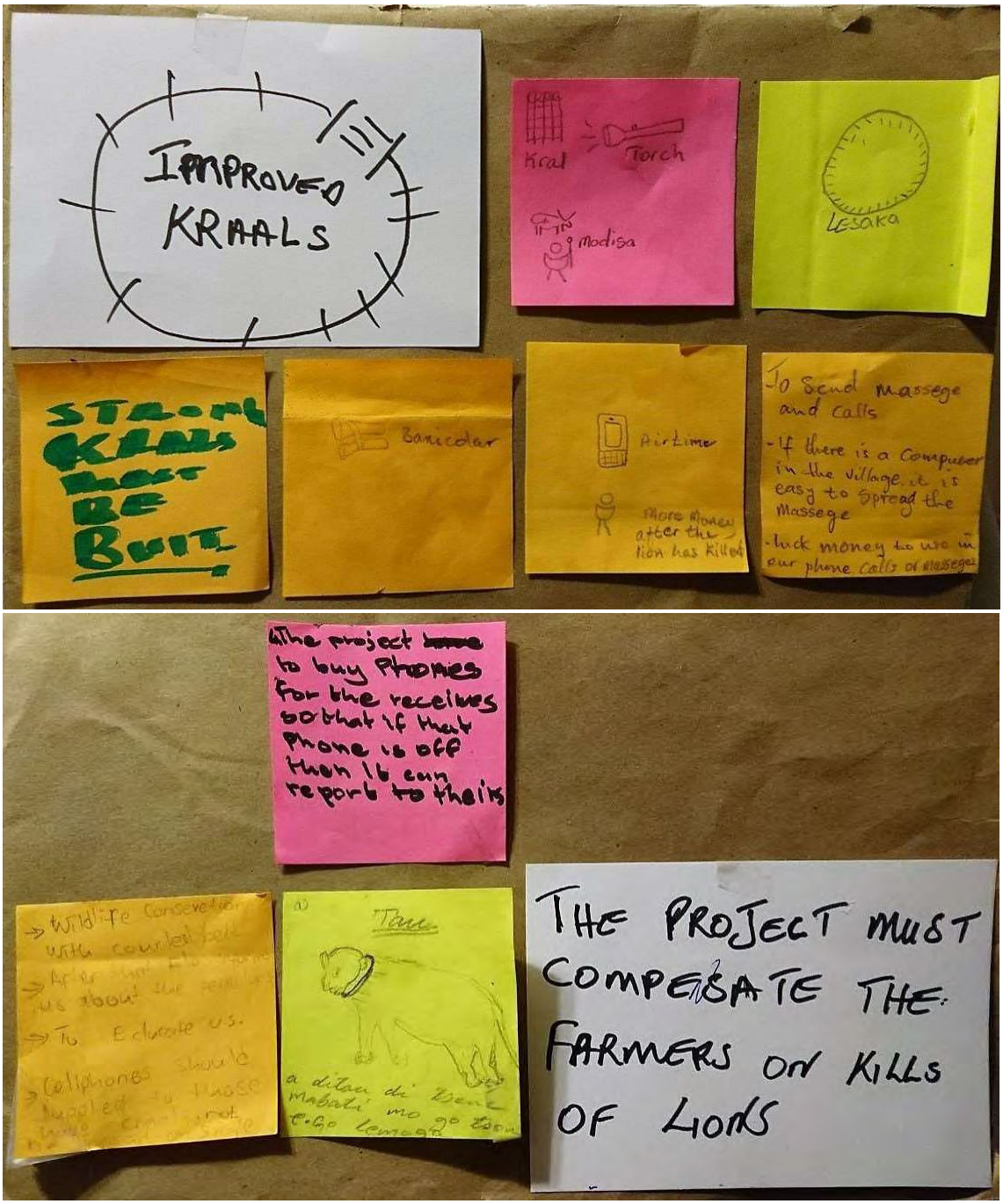

Figure 18: Suggestions for human-wildlife coexistence expressed in the category of material support in the first workshop

emergencies, because individual mobile phones frequently run out of battery or airtime. Not only herders and livestock owners, also Flo was considered to be someone who should receive two mobile phones or alternatively a stationary office phone in case a mobile phone gets broken, the battery dies, or it fails to connect to the network. This way, it should be ensured he can receive an alert when a lion is inside the geofence. To be able to react to alerts and scare away lions, participants stated they would like rifles, torches or "bangers" (firecrackers) that sound like guns. Binoculars were also requested by one participant to be able to spot cattle better and tell whether or not it belongs to one's own herd without undertaking physical effort or putting themselves in danger.

For the project to be more effective, many people agreed that more lions should be collared, with a particular focus on the female ones because they are the ones who are hunting. Other predators like hyaenas and cheetahs should also be included, as they cause incidents which also have to be reported to PioP by livestock owners. A few people suggested involving the government to provide a budget for more collars. Participants also expressed the wish for a computer set up at every village so that specifically trained locals are able to monitor the lions. This suggestion addresses several problems: jobs could be created for locals, the workload is divided among several people instead of relying on few project workers, and digital literacy should be promoted. One person even suggested to provide a plane for PioP so that they could transolocate lions who cause trouble.

The financial aspect included the provision of airtime, because many have experienced the problem of not having enough money on their phone when they received an alert.

With airtime, they can pass on alerts by sending messages and calling others to wwarn them of approaching lions. Reliable and reasonable compensation granted to livestock owners who lost their cattle should be provided by the project as well. Because some people are under the impression that PioP can "control" collared lions, compensation for damage caused by them, in their opinion, should be higher, since these attacks are preventable. Also, some people suggested the government should supply them with money to employ herders.

This category includes many reasonable suggestions which give an insight into peoples' poor material situation. Firecrackers, or so-called "bangers", had previously been used by the DWNP, but their availability on the market is very restricted. Other material cannot be supplied due to lack of finance. However, building stronger and higher kraals is already being done by PioP and will be continued. Barbed wire, according to Flo, only makes sense for leopards, as lions cannot jump over the higher kraal poles. As for now, six more lions are collared and there are more to come, which is a vital prerequisite for the project to become more successful. Other wildlife is not included in the system and

is currently not in planning, because PioP is focusing on lions at the moment. By establishing the warning station in the future and assigning a local to monitor it, although no additional position will be created, the desire for a local computer will be partly fulfilled. Also, cattle owners would not have to rely on their mobile phones to receive alerts, but be able check them at the warning station. We aim to make it possible for people to communicate with PioP even without having to pay by including USSD in our LionAlert 2.0 application. Additionally, a deal with one of the local telecommunication companies could be further considered to make sure there is enough airtime to pass on alerts.

Personal support and education. PioP and our team consists of team members from different disciplines, but without the cooperation of livestock owners whose situation the project seeks to improve, we cannot reach our goals, even having achieved financial, technical and material prerequisites. Therefore, to ensure the project success, both sides are important and should be enforced. On the PioP side, employing more people for the project was a frequently stressed aspect, as having only two researchers alerting them seemed inefficient to many. Suggestions ranged from two alert receivers to five employees to one person for each village and cattle post (see Figure 19). The kgosi, who knows where villagers have their cattle, should receive his own computer for monitoring lions, which he can use to spread alerts himself. Additionally, more DWNP employees could be appointed to prevent lion attacks: After an alert, they should immediately head out to the lion's position and scare them away, as it happened before the LionAlert system, albeit often too late according to our participants, due to a lack of vehicles. Arm ed DWNP workers should further help livestock owners kraal their cattle after an alert and retrieve potentially killed cows before they are eaten by lions.

Moreover, some participants would like to know more about lions in general, their life and behaviour, how to react when they encounter one, and how to take care of their cattle more effectively. The latter aspect was important to herders who need to be trained accordingly. Also, the importance of lions for the tourism industry should be explained, particularly to young people who are likely to join the tourism sector. Communal herding was mentioned, which might also be promoted. Workshop attendees, in our project as well as in the herder trainings, should act as multipliers of this knowledge. When confronted with possible new features of LionAlert 2.0, participants emphasised the need for training and support in adopting the new interactive system.

Involving more people is not only outside PioP's budget, but would also require corresponding instruction effort. The more people have access to lions' GPS positions, the higher the risk that poachers might abuse this informaton and hunt the endangered animals. However, education is an aspect we seek to include as much as possible in the

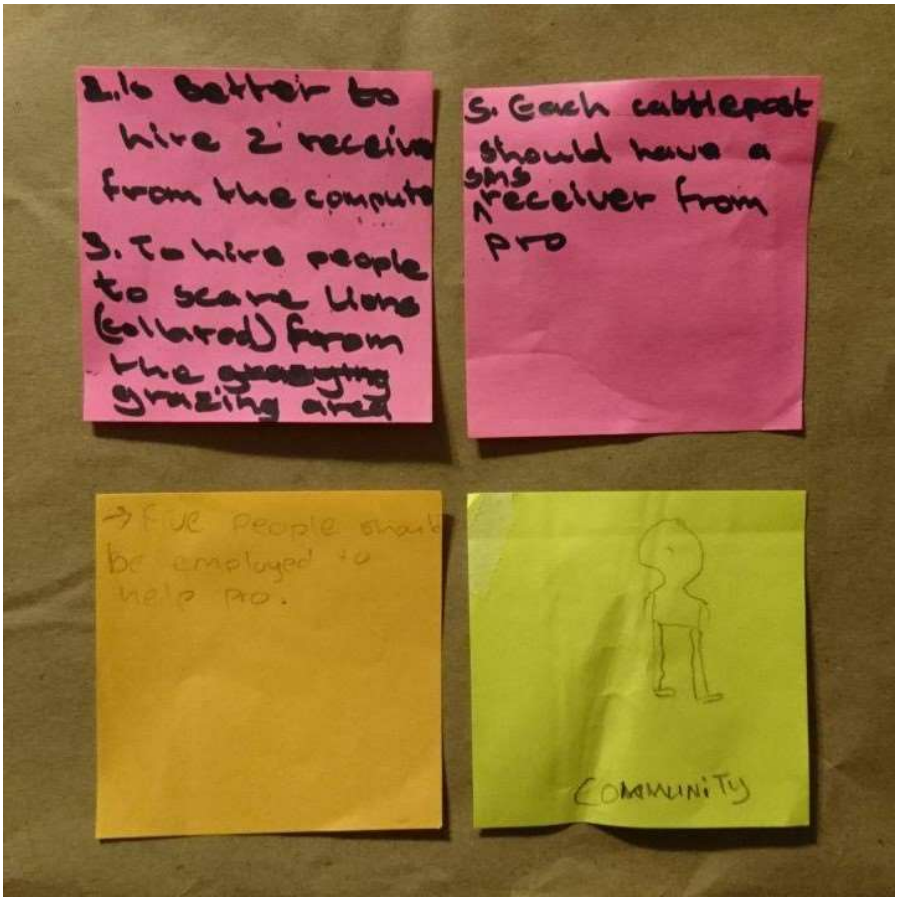

Figure 19: Personal support and education ideas to improve the LionAlert approach

new version of LionAlert. We saw it as a sign of progress that people expressed interest in this topic. PioP is already carrying out regular herder workshops to develop a sense for the importance of a proper care for cattle, and how it can help reduce HWC.

System improvement. Respondents mentioned several improvement suggestions concerning LionAlert itself, such as extending and modifying the geofence, so that people are warned earlier, and reducing the time between GPS signals from two hours to 30 minutes Figure 20). Due to this, warnings should be more frequent and contain more details like the lions' precise position. According to some participants, they would like to receive alerts when lions enter and leave the geofence, while they also want to be regularly updated on their position in-between "*at least three times a day*" (VDC Chair, M, 32, Eretsha). Alerts should arrive without delay and reach everyone at the same time. The opinion on whether messages should be sent regularly even if lions are far from the participants' location differed greatly. Also, alerts should be understandable for everyone: Text messages are useless for those who cannot read. Workshop attendees further wished to be able to trace back past alerts, in order to be sure they did not miss any.

Together with an increased number of collars and gadgets to distribute alerts more efficiently, these suggestions concerning the system mostly accorded with our own aim: To make the system efficient with a dynamic and up-to-date warning line, ensure that recent and past alerts are accessible to everyone concerned, and include all information needed to help save livestock and people from confronting lions. However, there are a few issues which still need to be discussed. If we increase the frequency of alerts, there are two kinds of risks: One is that recipients get used to them and their reactions could be delayed (desensitisation). The other is inappropriate reactions and panic: If people are notified and take safety measures too early without there being an attack threat, this can lead to stress and a resulting negative attitude (oversensitisation). To effectively sensitise people to the risk and reduce the attack probability, an effective alert ratio must be found. Furthermore, if the position is sent too frequently, this makes it easier for poachers or frustrated livestock owners to track down and attack the lions. However, according to CLAWS, there has been no evidence of poaching in the area.

Conclusion. Our participants expressed a wide diversity of ideas and improvement suggestions which we later forwarded to those responsible for the project. While not all of them can be realised in the near future, they demonstrated what our participants really want and need, and gave them the opportunity to express themselves in a creative way apart from discussing in front of everyone else. Many problems and suggestions we encountered were consequently incorporated in LionAlert 2.0. The fact that only few suggestions directly concern LionAlert and the system workflow tells us that a large proportion of problems lies elsewhere, namely in material supply, education, and manpower. On the other hand, the lack of experience with technology produces more practical ideas rather than those we can realise just by designing an interface. Therefore, our

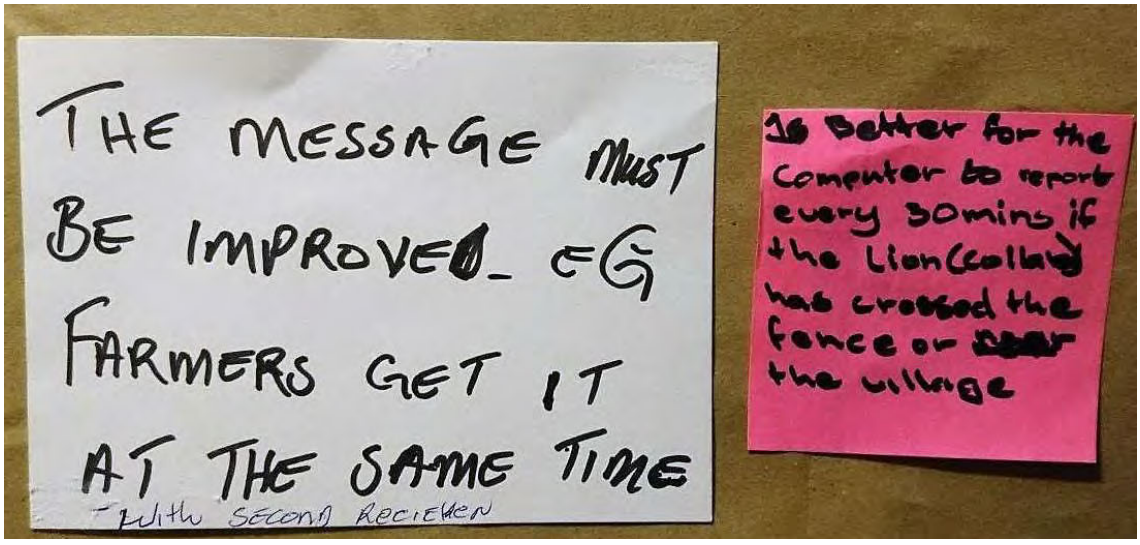

Figure 20: Technology-related suggestions to optimise LionAlert

task as HCI researchers and designers remains to develop and test these ideas, while making sure they not only appeal to users, but also provide practical support for solving their problems.

For the second workshops, to present the ideas to our participants, we organised the them on an A3 poster by assigning them to preliminary, more detailed categories (see Figure 21). We added our own summarised descriptions, and some ideas which were expressed verbally: adapting the geofence, designing the alerts for people who cannot read, spread knowledge outside the workshops, and sending more frequent and detailed alerts. During the presentation, we used a red marker to indicate those categories which we can and will address: Improving the computer system, send more useful alerts, reduce the time between the GPS sigals, increase the number of gadgets, and educate people. With a red cross, we marked those where PioP is already doing something – improving kraals, collaring more lions, making GPS signals more frequent and engaging more people in the project.

5.2.4 Conclusions for the Design

Based on our workshops and the input by other team members, we identified several implications for the second LionAlert 2.0 iteration. While we largely used the design developed before the workshops to be evaluated on-site, we sought to include all re-

Figure 21: Participants' ideas to mitigate HWC sorted and categorised by us for further presentation

quirements voiced by all types of future system users. Automisation and a near-real-

time tracking was identified as an important factor in the new system to ensure alerts reached the right people on time.

As for the interface, first, it should be translated into Setswana to make it understandable for everyone. Also, the process for registration and reporting had to be adapted. The option for indicating whether one has a kraal or not was desired to better distinguish between people's different livestock management needs.

In addition to reporting cases where one sees a lion, track sightings can also tell a lot about lion behaviour, and therefore should also be integrated into the reporting system. When reporting a lion sighting, our team members found it helpful to know if this lion was wearing a collar or not. Additionally, the option to take a picture of the lion or track could significantly facilitate the reporting process on the recipients' side. Working with USSD technology for feature phones is an option which is taking into account users' concerns about limited airtime.

As we learned from the workshops, mapping is a difficult task for many potential users of LionAlert 2.0. To avoid using concrete locations, which people might be difficult to understand on a map, we had to find a different approach. The changes we carried out in the new version of the prototype are further described in section 5.4.

5.3 Results of Field Research

Even though a major part of our field trip was dedicated to preparing and carrying out the workshops as well as analysing results and designing the LionAlert 2.0 interface, additional activities enriched our understanding of the Okavango Delta and its inhabitants, their environment and traditions, and their daily struggles and pleasures.

Describing every encounter with locals and interpreting the cultural characteristics would be very interesting, but is outside the scope of this thesis. Therefore, I will only refer to those I perceived as relevant for our project. In the following sections, I have organised the various conversations in several topics and summarised our insights on them.

5.3.1 Culture, Law, and Environment

During our stay in the field, we gained a deeper insight into the local customs on the one hand, and wildlife on the other. We could speak to the owner of our camp who once worked as a tourist guide, Pro and Flo, as well as several other people: a print shop owner in Beetsha, tuck shop salesmen, and several women whom we gave a lift while driving between the villages. There is no public transport in the area, and very often you can see people standing near the rode and waiting for a ride, because the distance be-

tween villages and cattle posts is long and they do not have a vehicle. Some even commute to places beyond the river for work, while living in and around Beetsha. Communication was sometimes difficult because of the language barrier.

During the workshops in the kgotla, we have seen many men and even more women sitting and talking for long periods. Several of them were raking the sand or removing leaves. These jobs are part of the governmental poverty eradication scheme and earn those who otherwise would be unemployed 500 pula (42 euro) per month. Every three months, the position is given to a different person. Another popular job is the police volunteer, but employment opportunities are otherwise scarce in the area where everyone is farming and managing livestock. Also, women seemed to be responsible for acquiring and carrying household material like wood and flour. Women can achieve positions in governmental institutions as well, however, female dikgosi are very rare.

Very often, we hear the phrase "the government must deliver" – related to creating jobs, improving the roads, building the bridge in Mohembo, or solving HWC. At the same time, people respect laws – rifles are not carried without a license, for example – and fight against corruption which is advertised on posters in many places.

The discrepancy between traditional and modern values was evident in several areas. Democratic principles are expressed in the kgotla, the centre of each village: Regular meetings to discuss matters demonstrate the importance and the power of the community. However, the kgosi is elected for life. Furthermore, judicative processes which take place in the kgotla work with rather traditional punishments. According to Pro, insulting someone will result in a court case and if the suspect is guilty, they will be beaten by a stick three times in the police station. One court case was taking place at the time of one of our workshops in Beetsha, which is why the beginning had to be postponed. It was about a pregnancy outside a marriage. If someone impregnates an underage girl, they will have to make a one-time payment of 8,000 pula (671 euro) to support the baby. The theft of livestock, however, is punished with imprisonment, emphasising its personal and economic significance. While people are actively practicing their traditions, as we witnessed in a healing ceremony (see Figure 22), they benefit from certain modern achievements like medicine and technology, although they only have limited access to them.

A lack of infrastructure results in some of the biggest struggles for local villagers. For water, people have to travel to the nearest borehole from which they can arduously pump it, or to the delta. Our own water supply in the camp originated from the delta and was heated in huge bowls. Also, our camp was one of the few places equipped with ele-

Figure 22: Ceremony carried out to heal a person from an illness which is thought to be caused by spirits possessing the "patient". The dancing healer on the right is supported by drummers and singers. This particular ceremony lasted for at least 12 hours overnight, while the patient can leave and thus declare it finished at any time

ctricity, while many people still do not have access to power. Even in Maun, the nearest larger city, poverty is evident in the form of slum-like currogated-iron houses as well as litter scattered across the streets.

To get an idea of the delta's structure and inhabitants, we boarded a 45-minute flight over the delta, starting from Maun. In addition to this, we undertook a 3-hour tour on a traditional mokoro boat from Jumbo Junction camp in Seronga with an instructor. We could see the high flood level in spite of the dry season, limiting the access to grassland (see Figure 23). Wildlife like elephants, hippos, crocodiles, and an abundance of birds were spotted just next to cattle and donkeys. Further away from the village, we could even see giraffes and buffalos. All throughout the villages and next to the road, we witness cattle posts with kraals, and cattle roaming the area.

The sight of the vast delta with its abundance of wildlife made it easy to grasp the fascination of this UNESCO World Heritage site. While showing us the potential as a tourist attraction, our trips provided a good insight into farming life at the border of a national park, where resources are shared and losses as well as disadvantages are taken into account.

Figure 23: View of the delta from the ground and from above. Cattle are roaming the flooded plains side by side with wildlife

5.3.2 Livestock Management and Protection

To get an idea how livestock management could look, we arranged a meeting with a herder in the afternoon. Together with Pro as a translator, we accompanied the herder while he was gathering and kraaling his herd of around 20 cattle. We met him outside in the veld across the shallow water beyond our camp fence. On our way, we saw other herders, mostly children, fetching their livestock. Our herder carried a *knobkerrie*, a stick with an axe top, as a tool, while herding his animals (see Figure 24). He called his cattle to follow him and urged those who strayed from the herd to return by throwing the knobkerrie.

Also, we learned to identify elephant tracks and their degree of freshness, which told us elephants had just recently passed this place very close to our camp. Another aspect we learned about from our research assistant were different herding practices conveyed in herder workshops: Low-stress herding was taught there which excludes shouting, as well as the importance of a grazing plan to prevent the land from degrading.

We walked for at least an hour until we reached the kraal, which was exhausting when slowed down by the unfavourable ground conditions: mud, water and sand. After the cattle have walked into the kraal on their own, the herder checked the livestock, espe-

cially the lead cow who was carrying a bell on a rope around her neck, as well as the fence (see Figure 25). Then he closed the kraal, secured the gate with branches and heavy poles, and left for the day.

Herding is a strenuous and solitary labour which requires fitness, resilience, expertise, and the readiness to face threats like wildlife in the veld. Our herder said he walked around 10 km every day to take care of cattle with improvised equipment and rather unsuitable clothes. At the same time, it pays only 500-750 pula (42-63 euro) per month and is associated with low status. Therefore, it is understandable that it is not popu- lar. Also, we understand that kraaling is not possible for everyone due to different conditions where unfavourable ground conditions and wide scattering of cattle are a barrier especially to older people or those not in good health, as well as those who simply do not have enough time between other duties.

Dogs, who could help farmers protect their livestock from predators, are mostly neglected and roam the area looking starved. We did not witness trained dogs, while they are rather treated as less than livestock and not tolerated inside or around houses. Even the dikgosi's dogs are left behind and go astray when their owner is not around.

Concerning HWC, many local people to whom we talked were very insightful and seemed to be aware of the problem:

"*We had a little chat with our hotel's desk clerk later on about the Okavango Delta and our research, and he said […] he knew how rare lions and 'how human beings are', there will always be poachers and those who profit from killing wildlife. 'Wherever we*

Figure 24: A cattle herder at work, equipped with a knobkerrie

Figure 25: Kraaling and checking up on livestock just before sunset

go, we chase away the animals from their places', he added" (Excerpt from the field notes of August 8th, 2018).

Not many of them, however, know how to deal with this situation. Lions are perceived as dangerous, but they usually avoid human beings because "*lions hate people*" (Flo; excerpt from the field notes of August 11th, 2018). Our camp owner, who had gathered experience with wildlife as a tourist guide, is especially supportive of our goal, offering his help wherever he could. Also, he is eager to share his knowledge with others:

"*We talked a bit about the human-wildlife conflict around Eretsha and [camp owner] told a story where the appearance of an elephant caused people from the village to gather around the animal and shout at it. [Camp owner] warned them that it would get 'crazy' because of that and told them to go away. Because they would not listen, he just took two sticks and slowly hit them together approaching the elephant. Apparently, this scared the animal away. He said it was the same for lions: When they see a single human around, especially making noise or even fire, they would be scared and go away immediately. So the best way to scare lions was to be around and show your presence."* (Excerpt from the field notes of August 8th, 2018).

Our observations and exchange on this topic revealed that there is still a great need for education to make HWC solutions work. In combination with people's reliance on the government in particular, as well as perceived powerlessness based on traditional hierarchy, the perception of responsibility needs to be shifted towards the community members and livestock owners themselves. At the same time, measures have to be taken to facilitate herding which can be the most effective of these solutions.

5.3.3 The Elephant Problem

One major issue which was mentioned in literature, team meetings and in the workshops were elephants. We could experience this first-hand: on the second day of staying in our camp, an elephant herd passed only a few hundred meters from our fence. Guided by Flo, we approached them for a bit to take a look. After a while, some of the animals noticed us. The mother, especially, being the herd leader, was alarmed turning her head towards us and spreading her ears. A teenaged member of the herd started coming towards us, but, as Flo predicted, quickly backed away when it noticed no one else was following. However, had we tried to come any closer, we would have been attacked by the animals in self-defence. Their eyesight is not good, but is compensated for by a highly developed hearing and sense of smell. The threat posed by the large number of elephants roaming the area was illustrated two days later, when we learned a man was killed by a herd on the road. This happened between Eretsha and Gunotsoga, when he was on his way to a cattlepost at 4am in the morning. During the dark, humans are at disadvantage and can easily walk into an elephant herd, where they are perceived as a threat. Particularly dangerous is to be caught between a mother and her child, which provokes the mother's protective instincts. Even Flo said: "*This would be a reason for me not to go outside at night*".

The man's funeral lasted a few days, which is a common practice in Botswana: A large number of tents are set up and the ceremony lasts long because some visitors need a longer time to learn what happened, and then to arrive at the site. We have seen the tents in Gunotsoga driving by. As for the elephant, Flo reported that the DWNP sends someone to investigate the kill together with him and the police. In consequence, the elephant responsible must be killed to convey the impression to the locals that something is being done, that the problem is addressed. If the culprit cannot be determined, one elephant from the herd must die anyway.

Another sign of elephant overpopulation and food scarcity are trees ripped out partly or completely and destroyed grassland next to the road. We have regularly seen animals driving by and in the Okavango Delta on our mokoro trip, heard their sounds during the night, and identified their tracks while taking an expedition outside the camp.

Further attempts to manage elephants are so-called elephant corridors, pieces of road which are reserved for the animals to cross. However, this does not solve the problem effectively. In consequence, Ecoexist has helped farmers transport poles for cluster fences, as well as established electric fences around ploughing fields, as we learned in an impressive community theatre performance arranged by the organisation in Seronga. In this piece, the fence was portrayed as an effective measure to keep elephants away from crop fields. Unfortunately, as Flo told us, even these fences can easily be de-

stroyed by strong elephant cows who sense the small fence part which does not contain any electricity. Even firing rifles does not scare elephants: the intelligent animals quickly learn these do not cause them any harm. According to him, the only effective measure would be alternating mock shots and actual electric shocks. Otherwise, the DWNP has to reduce the number of elephants by 20,000 each year to prevent overpopulation.

The dilemma between the harm humans do to elephants by poaching, and the harm elephants do to them in turn, which has also been presented in the Ecoexist theatre performance, does not make the situation any easier. Hitherto, farmers in the Okavango Delta have to live with the struggle and damage caused by these animals that almost outnumber people, while mitigation efforts have not proved to be effective.

5.4 LionAlert 2.0: Second Iteration

From experiences gained from workshops, conversations, and observations, we created the second version of our prototype. By sketching on paper and in Axure (2017), we created an interactive prototype of the interface incorporating participants' ideas as well as requirements voiced by the local researchers involved in the LionAlert project. With our team members, we determined not only the interface, but also the whole idea and structure behind the system which we presented to our participants.

Technological developments will be at the basis of this new LionAlert system. The issue of the static, single geofence will be addressed: a dynamic algorithm will ensure one or multiple warning lines can be created and are dynamically adapted based on several parameters (see Appendix E). In case of a lion overstepping the warning line, the system will then automatically determine its location and send an alert to all registered recipients in the respective area, as well as to all central warning stations. This alert system will also be supplied by community-provided data, e.g., from cattle locations and lion sightings.

Like the previous version, the prototype was adapted to three end-user devices:

- A stationary tablet at a so-called "warning station", which will be placed in central village areas called kgotla and include all functions
- A smartphone app providing similar functions to the warning station, but adapted to a different screen and personal settings
- A feature phone, which will use symbols and USSD technology instead of images and interactive menus within the borders of technological possibility.

We removed the pager from our list of devices, since these are only used by rangers and policemen. While we initially planned to include them in our workshops, the short time frame forced us to narrow down our target group to the direct users of the prototype.

In order to create a centralised contact point and increase collaboration, we presented the idea of a warning station which was received positively by our respondents. This warning station is a tablet placed in the kgotla of each village (see Figure 26). They will be ideally monitored by individuals already working at the kgotla, but who have received a special training and can instruct users on how to interact with the warning station. The warning station offers the same functions presented in the iteration. There are small changes we made to the interface. First of all, we translated it into Setswana for the most part with Pro's help. For registration, we added to option to select whether one has a kraal or not.

We further provided the possibility to report sightings of lion tracks in addition to lions themselves. If they saw a lion or tracks, users could enter additional information on lo cation, time, number of lions and whether they were wearing or collar or not. Additionally, they could now add a photo when wanting to report a sighting of a lion or tracks, a feature which is limited to smartphones. This way, a collaborative and efficient alert network is supported: This information can be reviewed by local researchers and used for an adaptation of the geofence or individual alerts.

In our workshops, the educational factor was frequently stressed. Therefore, one function which was not implemented but desired in the future for the warning station was educational material on lions, their behaviour, and how people can and should interact

Figure 26: Illustration of the warning station in a village kgotla. Made by Vicy

with them. This could be realised in the form of videos, (spoken) text, and images. PioP has video material which we could use for the start.

If a lion crosses one of the warning lines, they will then receive a fast, simple and understandable notification via text, image, sound or voice message depending on individual preferences. The message includes the number and name(s) of the lion(s) (if applicable) and their approximate location. On the alert detail screen, users will be informed about these details and also have the opportunity to display behaviour suggestions or report a sighting. Additionally, there will be an indication on a map in different color schemes depending on the warning line. In our example, we used red (village), yellow (grazing land) and green (outside the grazing land) zones. The colours should help estimate lions' distances without the need to read an actual map (see Figure 27).

Because of technical limitations, a feature phone can only offer alerts, an alert status, behaviour advice, and report as well as contact local PioP members. Reporting a sighting will be able via USSD technology, which the participants already know from the practice of topping up their phone. Also, reporting on tablet and smartphone screens has been adapted by implementing buttons and radio buttons instead of drop-down menus (see Figure 28).

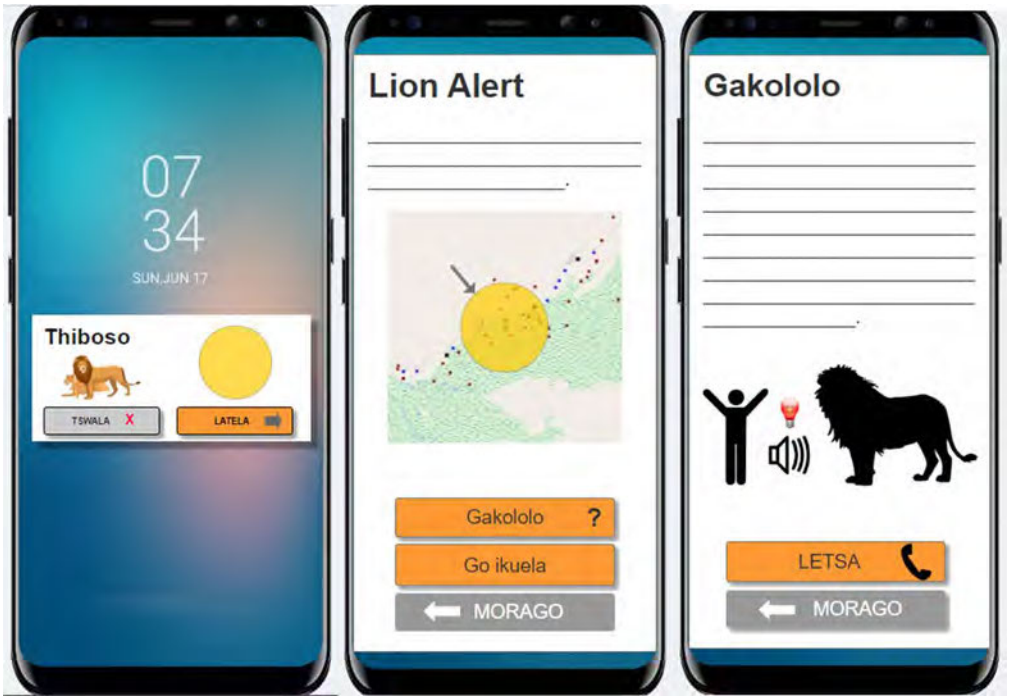

Figure 27: Screenshots of the second LionAlert 2.0 version on the smartphone: Alert push notification, alert details, and behaviour suggestion

Figure 28: Warning station as well as mobile USSD-based reporting prototypes

5.5 Evaluation Results

5.5.1 User evaluation

Before we began our evaluation, we first presented the improvement ideas from all groups who participated in the first workshop. Most ideas were encouraged in the groups, while others were highly debated. The most supported suggestions were attaching more collars to lions and employing more people for the project. One of the rather controversial one was drilling boreholes in NG11: many participants held that it would not stop lions from attacking livestock, since they are already following them. The question on smartphones also provoked discussions. Some participants requested that they be given to as many livestock owners as possible, while others perceived them as necessary only for people employed to operate LionAlert with respect to the project funds. The dikgosi especially understood our financial situation and asked to spend only as much as needed.

Regarding geographical support, broken buffalo fences were seen as a threat because lions would follow zebras coming through them. At the same time, even though translocation was a popular idea, others wondered what this would mean for tourism in the area. Firecrackers were regarded sceptically: "*[Lions] can think, like elephants. If you make noise every day, they will not be scared by it*" (VDC Chair, M, 48, Beetsha). In Gunotsoga, a lack of approaches to solve the elephant problem was criticised (including tracking their movements), and the number of suggestions that could be realised was not satisfactory to our participants. They all asked critical questions of our approach: "*Is*

that all you are going to do to help farmers?"; "How will the computer benefit me?"; "Has the system been tested before?". Herding was not seen as an option because most farmers are busy taking care of crops as well. In general, as with other conversations, we had a sense that some groups, instead of taking responsibility for their livestock, expected the project or government to solve their problems.

We further reminded our participants of the current system workflow to point out which aspects we are planning to improve. The process of automation is an important issue which produces most questions. A frequent concern was that someone will lose their job being replaced by the algorithm. Therefore, participants had to understand that the computer could only support the human members of PioP operating LionAlert. On the other hand, the algorithm's advantage over a manual process was evident to our participants: "*Improv[ing] the system so that it notifies the people automatically*" was seen as "*number one*" (kgosi, M, 48, Eretsha). To ensure the prompt arrival of alerts, participants requested that lions' position be updated real-time, but at least as often as possible.

Our concept of the warning stations was approved by our participants. They immediately asked who will be operating them and suggested employing someone from the village to monitor, maintain and assist users with operating the tablet, making sure no one steals or damages it. Some people suggested that Pro should be managing the warning stations. We had to make clear that warning stations will not replace phone alerts, but rather both versions would be extended and customised. Should one device malfunction, then there would be a backup.

After explaining the general concept of the warning station where most functions will also be integrated on smartphones and GSM phones, we proceeded with the actual evaluation on the computer (or on the paper mock-ups for the first workshop). One person was assigned or volunteered to interact with the prototype at the computer in the form of a walkthrough. Usually, it was a younger or more highly educated participant. However, as mentioned before, it was only possible for the warning station mock-up to be used because transferring a phone simulation to a laptop screen and imagining they were actually touching a phone while using a keyboard was too abstract for many participants and resulted in reluctance to interact even for digitally literate users.

By asking questions and encouraging participants to comment on the interface during the evaluation, we found significant issues and problems, as well as improvement suggestions which we later used for the second iteration. Example for accompanying questions on the design and its usability were:

What do you think about this screen? What do you like and what would you change about it?

How understandable is it for you? Would you interprete this function differently?

Where would you go or what would you do next from here? What do you expect to happen next?

In commenting on and asking questions about the interface, we could observe an increased participation by women as compared to the first workshop round. Because it was not all about livestock management with which women were mostly not concerned, but a system which eventually everyone would use, we roused their interest and desire to contribute.

Registration worked well, as the users testing the interface were literate and could understand the Setswana translation we prepared. Everyone agreed that Setswana should be the interface language, since all users in the area can understand it. However, using a computer was an unusual activity. Therefore, many of them encountered difficulties with using a touchpad, typing and clicking. Scrolling, opening drop-down menus, and pushing buttons to proceed were concepts that we had to explain to our participants. The mock-up of a feature phone was more familiar and therefore more satisfactory to our participants than other types of interface, but operating it on a computer turned out to be difficult, so we demonstrated the features using it by ourselves.

The first aspect where questions arose was the indication of the amount of livestock. Because many people share a herd within the family, they asked whether they should enter the total number or only their own cattle. Furthermore, some users have two mobile phones and proposed the option to include more than one device to receive alerts. Another aspect which produced questions was that of a user account and the according settings: several participants asked whether they would be able to change details on their phone number and number of cattle after registration.

In contrast to this, data security seemed not to be an issue or even a familiar concept to our evaluators: When asked whether they were willing to give their data to the computer, they mostly responded in a confused or positive way, and did not ask why we wanted to know these details: "*If the computer needs it, it's okay to give it*" (livestock owner, M, 30+, Eretsha). Others had not realised before that they have a choice and could influence what happens to their own data. A few participants were more conscious or skeptical about their data and wanted to ensure it is used purposefully: "*We will now give you 45% - we will give you 100% once these computers are here*" (livestock owner, M, 52, Beetsha). We further explained how their data, along with other parameters, is processed and what it is used for in the new version of LionAlert.

When asked for preferred login options, most people voted for a password, because this is what they already knew from social networks and email. Others suggested an indi-

vidual 4-digit PIN code similar to a the one used on a SIM card. After the registration, a confirmation was often required on the participants' mobile phone in form of a text message to ensure the registration has been successful.

The image of a dynamic, manually adaptable geofence helped people immensely in understanding this concept. In consequence, many were in favour of extending it, while the suggested distances ranged from three to five km. However, measuring distances with these units was unusual for participants, as they relied on other reference points. If they interpreted or entered geographical data themselves, they would prefer indicating specific landmarks familiar to them, such as trees, lakes, termite mounds, lagoons, islands, pathways or houses. At the same time, dividing the alert area into three colour zones was approved and participants claimed to understand this idea. Nevertheless, a few voiced the concern that people might want to hunt the lion if it is in the red zone instead of considering their own safety.

Concerning the alerts, automatically issued notifications should be recognisable as such, to clarify where they are coming from. Some participants thought these come from warning stations themselves instead of the server. Voice alerts appealed to most participants, and were especially popular in combination with image or text. For an instantly understandable alert, a lion roar as sound was suggested. ASCII images on a feature phone were difficult to recognise for some participants and therefore required prior familiarisation. Prior to the workshop, as a demonstration of the voice notification, we recorded an original warning message read out loud by Pro. It mostly amused our participants, but it was also apparent that a live demonstration of this feature improved their understanding of the final product.

For reporting sightings or kills, many users favoured the option to take their own photos to include in the report. This feature was preferred for phone apps instead of the warning station tablets. Another reason for this preference was that it takes less time and effort to send information via phone, and people can issue real-time, on-site reports. Reporting could be possible via calling a toll-free number, possibly with an automated speech assistant, or USSD to save users' money. More detailed descriptions for lions and their tracks, such as sex, age, size, and moving direction, were suggested. In addition to this, some locals claimed they can distinguish lions wearing the collars and recognise those they named themselves, while others stated they never saw them, neither in real life nor on pictures. However, for the option "Collar: Yes/No" they emphasised that, to preserve one's own safety, one must not approach the lion to find out if it is collared. Reporting should also be available for other predators as well as elephants.

Additional features were also desired. Especially the education aspect was endorsed, as users would like to have information on lions included on the tablets, along with the

smartphone app and memory card for the feature phone. Participants hoped it would change the attitude of those who are not in favour of predators or the project as a whole. Educational content be presented as images, videos and (spoken) text. Users suggested not to spend huge parts of the budget to create videos, so that possible material could be provided from herder workshops and other existing educational programmes. A voice option for text is essential for all those who cannot read. Here, they also approved the idea of instructions on how to behave when encountering a lion. At the same time, a presentation of, and introduction to, the new LionAlert system and interface is required. The kgosi of Eretsha even suggested including PioP in regular kgotla meetings to update the community on the project results and progress. Others supported the idea of more workshops.

Overall, our concept was widely approved. Most users were happy after they had successfully registered for LionAlert on the mock-up, experiencing a sense of personal accomplishment (see Figure 29). Attendees from Gunotsoga, initially sceptical concern ing its benefits for their situation, eventually agreed: "*If the system is going to be improved, it will be helpful*" (livestock owner, M, 59, Gunotsoga). One participant even urged us to "*bring it fast*" (livestock owner, M, 52, Beetsha) and we learned a new word in Setswana: "*Gosiame*" means "this is good". The automatic versions of alerting and receiving user reports were even regarded as more reliable than workflows operated by human workers. Being confronted with possible features in a smartphone app, a few people were encouraged to buy a smartphone. An older participant even asked us to grant him a loan so he could purchase one. "*It shouldn't end here. Come back and show*

Figure 29: LionAlert 2.0 prototype users after a successful registration. Altered to ensure anonymity

us the final thing!"; "*This will be very fantastic!*" (livestock owner, M, 52, Beetsha). "*This one is very good*".

We used the workshop breaks to ask participants to show us the phones they were using, and for which purposes they were using them. In all workshops, we collected twelve feature phones and five smartphones, Beetsha being the village with most smartphones (see Figure 30). Each of our participants had a phone, while some did not bring theirs with them, and one participant's phone had been stolen. Those using feature phones mostly needed them for calling and texting, whereas smartphones were also popular for text messaging, social networks (mostly Facebook, but also WhatsApp and Twitter), games (which were not limited to younger participants, but also played by older ones), videos, music, and even banking. At the same time, the discrepancy be

tween livestock management and ICT becomes apparent when we observe many older people taking care of cattle, but not having smartphones – an aspect which had been mentioned by other team members as well.

Once more, it becomes evident that digital literacy in our study area is still very low. Based on responses and our own observations, we can say that five of our participants (14.29 %) had a higher degree of digital literacy. Mostly, they were younger than 40 and possessed smartphones. Even though an increasing number of people are using smartphones and apps, the adaptation of a new system like LionAlert needs to be carefully guided to ensure locals use it effectively, efficiently and are satisfied with it. Our participants were quite optimistic, comparing appropriating LionAlert to getting used to

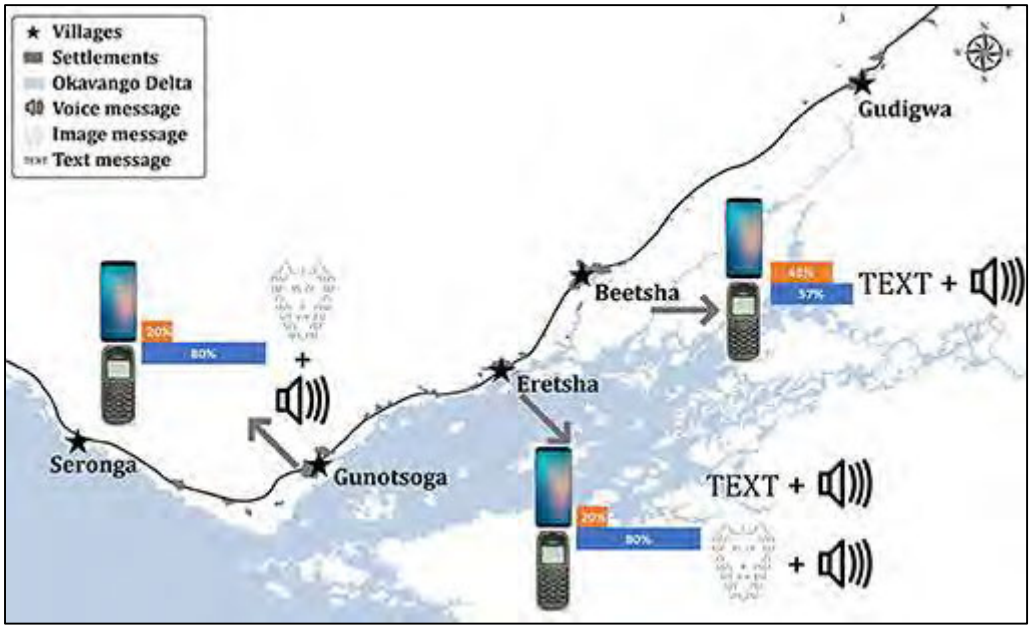

Figure 30: Relative numbers of phone users and preferred alert message types by village. From Weise et al. (2019), based on own illustration

mobile phones, and the latter are part of their daily lives now. The same could happen for LionAlert 2.0.

5.5.2 Expert evaluation

Most of the local users' opinions were supported by other members in our team. The research assistant Chris endorsed our suggestion to link the colour zones to distances in the current geofence simulation, which is 2.5, 5, 7.5, and 10 km respectively. According to him, this corresponded to the actual distances of the future geofence. We asked for the safety level for the respective distances of lions and learnt that 7.5 was far enough for people to go and collect their cattle, whereas anything under 5 km meant it was safer to stay at home. He was in favour of including the distance into the alert and linking behaviour advice to the alert zones as well.

However, this was later challenged by Flo: giving suggestions for specific behaviour was outside our responsibility and could lead to legal issues if the suggested actions resulted in people becoming injured. Because people know what they should do in case of an alert, the most to include, he argued, would be generic advice.

Another safety issue in the interface was found in the reporting feature. By asking people whether the lion had a collar, we were potentially provoking them to approach the lion. Therefore, it was argued, this question should be entirely deleted from the mock-up and replaced by the warning "Don't approach the lion" in all local languages. Similarly, the option to take a picture during a lion sighting or of a lion kill was rated as too dangerous, since the lion could be still nearby. Flo argued that in case of an attack, he would come anyway and take pictures of the carcass. In addition to being dangerous, photos, information on collar, and the lion's name provided no significant value to the recipients of this information. To minimise possible legal consequences for PioP, a legal notice, disclaimer, and data protection note also had to be included in the interface at the end of the registration, where the user would have to check that they read and understood these texts.

Furthermore, identifying the lion sex by tracks was not possible according to Flo. However, distinguishing between actual lion sightings and track sightings was crucial for him to decide whether he should arrive at the site or not. Also, the direction and number of tracks played a role in the assessment of the situation. However, it was suggested that people should only be encouraged to report attacks by lions through our application and therefore, the option to choose another predator was regarded as unnecessary.

With regard to the warning lines, not only their position, but also their number can change depending on the season. The only fixed line will be the village warning line, which is 5.74 km around every village, which corresponds to the average distance a lion

covers in an hour. This should give villagers enough time to react and seek shelter. Consequently, the colour zones should also be dynamically adaptable depending on the warning line position, and alerts should reflect these zones as well. Users should additionally be informed in the interface about what these zones signify. We will need to ask people during registration whether they have or are responsible for livestock. If yes, they will receive alerts for both the grazing land and the village warning lines; otherwise, only the latter will be displayed.

Eventually, the idea to include registration on the smartphone and feature phone was to be discarded because of the danger of incorrect entries and misuse. User accounts should instead be managed by administrators, which includes not only registration, but also changing user details like phone number and number of cattle. The person monitoring the warning station should assist users in registering for LionAlert 2.0. This person should also be contacted when users wish to change their details. Existing users could be migrated into the new database. The mandatory user data include:

- Phone number and/or email address to be notified
- Place of residence
- Are you responsible for cattle?
- Location of cattle (choosing the cattle post, later this will be realised in a map)
- Language (multiple choice)
- Mobile device (multiple choice)
- Type of alert (text, picture, voice, text and picture, voice and picture)
- Literacy

Optional data include:

- Name
- Occupation
- Are you herding?
- Do you have a kraal?

Registration should create an entry in a database with users, lions, and potentially cattle they are to be collared for the sake of gathering further geographical information. Information on users will be stored here, as well as data on the animals: for example, the number of attacks for specific lions, or location for livestock. Issued alerts, ightings of lions, lion tracks, and kills will be added as separate elements. We defined four user roles for the system: first, the administrator can make entries into the database, and can edit as well as delete them. These will be the local PioP biologists. New users can also be registered without the warning station by administrators, particularly after they have had a loss to lions which has to be investigated. The managers, i.e. research assistants, policemen, and those managing the warning stations, can enter, but not delete information. Users can only receive alerts. The administrators should have a separate user

interface, which is not included in the mock-up, but rather created by the programmer. Secured with a password, it allows access to the database. Managers can also access this interface to change user data.

Accordingly, users' mobile phones should only be able to receive alerts and send reports, narrowing down the list of functionalities offered. For smartphones, using GPS can assist users in reporting a lion sighting or attack without the need to pick a location on the map. Alert status should only be accessible via the warning station, since the phone is not linked to a user account. Displaying status alerts based on GPS position raised the issue of people potentially following lions, because they did not always remain near the location entered in their user account.

While we initially planned to include an automatic reply when the alert was received and acknowledged by users, according to Chris, this was not necessary. We also left this feature out due to technical difficulties in realising it.

As suggested by Flo, the interface should be available not only in Setswana, but also in English, Hambukushu, and Bayeyi. Alerts should contain only the lion name and the warning line crossed (village or grazing land), in the form of the colour zone. Should the lion remain in the geofence for a long time, managers will be alerted after 24 hours. It was decided not to alert users constantly, but to send a message once the lion has left the area.

5.6 Final Prototype: *Tsibosô ya ditau*

Upon evaluation of our interactive prototype, we received and incorporated our participants' suggestions as well as other stakeholders' specifications. First of all, the name was changed to *Tsibosô ya ditau*, which is the Setswana translation of "lion alert" and preferred by all participants, as it is readily understandable to. The interface content was subsequently corrected and expanded with Pro's help. Three kinds of users are planned for Tsibosô ya ditau:

- administrators who have access to all functions and can add as well as remove users (direct members of PioP and the University of Siegen project team)
- managers who can create, but not delete users, and are able to assist new users with their registration (local research assistants)
- users who cannot access the database, but all other functions.

We included registration only on the warning station in the final prototype, which can be carried out by adminstrators and managers. In the registration interface (warning station), the following changes have been made to the registration form to make it more

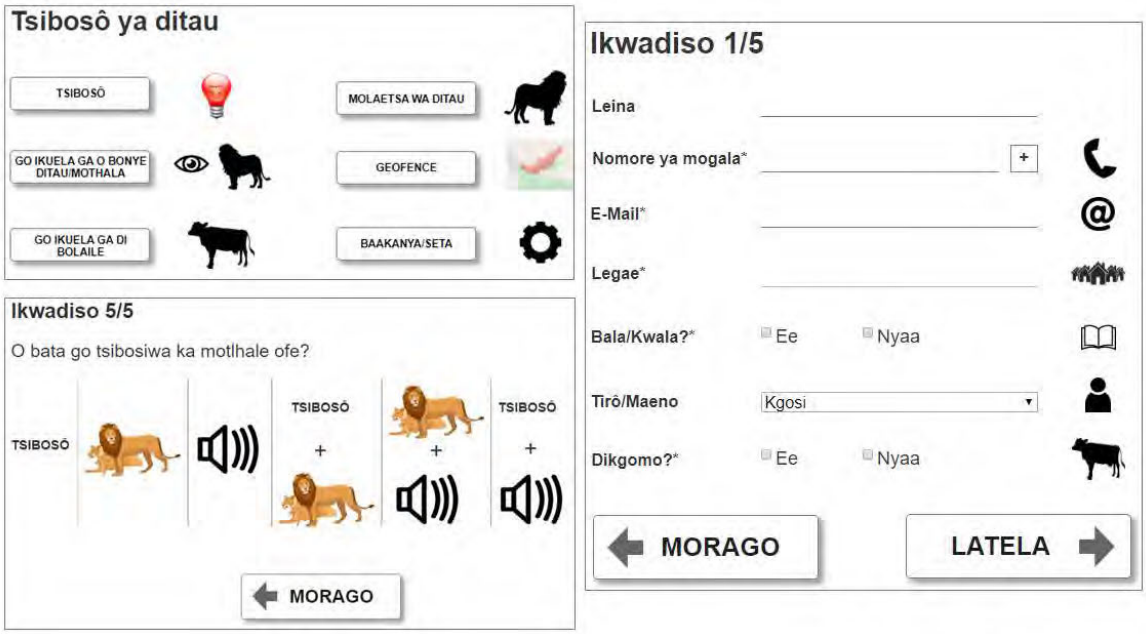

Figure 31: Registration on the warning station tablet for Tsibosô ya ditau

understandable, usable even with a low level of digital literacy, and complete (see **Fehler! Verweisquelle konnte nicht gefunden werden.**):

- Splitting the registration entry form into two screens on the warning station to avoid scrolling
- Adding a "+" to the phone number indication if users have more than one phone number
- Including the indication of literacy for a more accurate record
- Adding the option "family kraal" when indicating the number of cattle, so that the total number is recorded instead of the individual number
- Asking if the person is herding their cattle
- Adding the option to choose a language between Setswana, English, Hambukushu, and Bayeyi
- For modality, the option to choose between a combination of text, image, and voice/sound
- Resizing the confirmation page elements and geofence demonstration to fit on the screen without scrolling.

The users can also now choose if they take care of cattle or not. In the latter case, the registration screen for cattle post and kraal questions is skipped, and the user is only to be sent alerts for their village. After successful registration, the users should receive a text message on their phone welcoming them into the system. However, we excluded the settings for the user account, since it is no longer linked to the device.

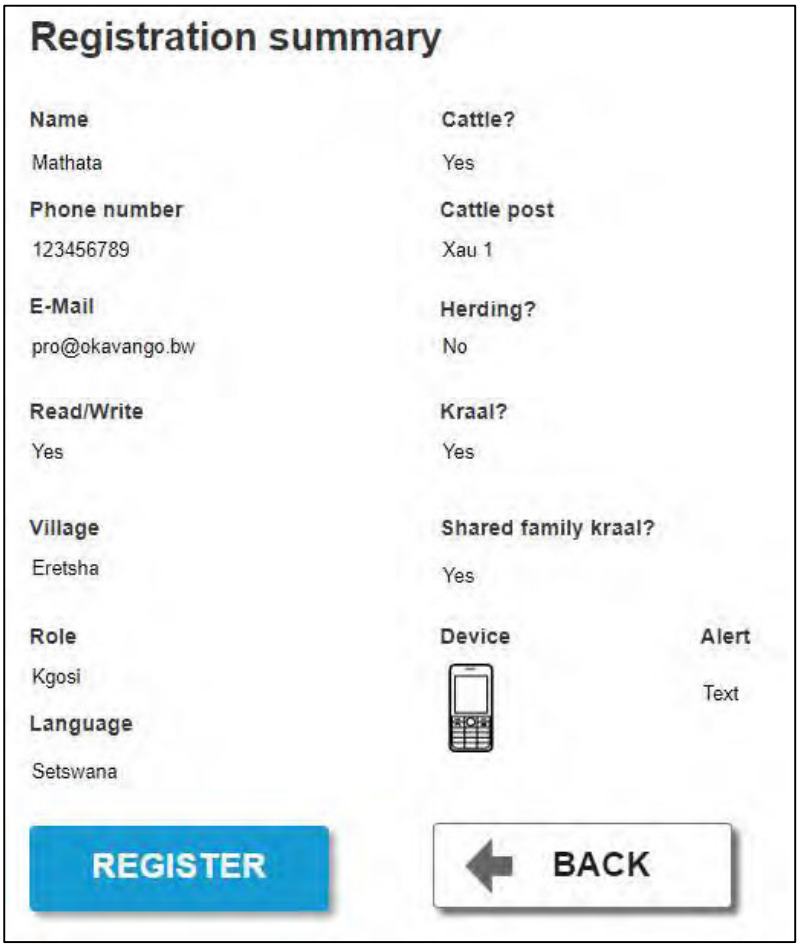

Figure 32: English version of new user data on the warning station

Because some of our administrators who will add new users are English-speaking, we also designed an English version of the warning station registration interface (see Figure 32).

Furthermore, the suggestions concerning behaviour were adapted to our colour scheme to ensure that users received the right advice depending on the distance of the lion. It was not linked to specific alerts but remained a separate menu option. We additionally added an orange colour zone to reflect different numbers and sizes of warning lines. Initially, these zones corresponded to the four exemplary geofence versions shown in the relevant screen. For red and orange zones (approximately 2.5 and 5 km away, respectively), locals were instructed to seek refuge, while yellow and green (7.5 and 10 km) meant they still had time to kraal their cattle. However, as we learnt in our work shops, these distances do not help, but rather confuse people, so landmarks should be used instead in the future. Because the warning lines are dynamic and not fixed to a certain distance, we cannot associate the colour zones with specific distances. After our final meetings, the number of zones was changed to three: red for village warning line,

yellow for grazing land warning line, and green for anything outside the warning line (see Figure 33).

The option to report a kill was also added after some participants requested this function. Here, we requested that users indicate location and time, and in case they reported from a smartphone, also their name phone number so that PioP will be able to get back to them. We also let participants choose the predator responsible for the kill between lion, hyaena, wild dog, and cheetah. After the final meeting, we omitted the type of predator for kills since the application was only meant to be used for lion attacks, and not cause more work than necessary.

Furthermore, with respect to the reporting option, we had added the lion sex and direction of tracks using the colour scheme, the name of the lion if participants recognised it, and the option to send a picture taken with the smartphone. For the collar identification, the concern was voiced by some participants that this posed a potential risk if users decided to come closer to the lion to determine this detail, which is why we initially included a third "I don't know" option. Eventually, this option was left out because it did not provide significant content for the receivers. Whether the lion was collared or not could, in any case, also be verified on the map. The lion name, behaviour, and picture option were also omitted after a discussion with Flo mentioned above. Similarly, the indication for a track sighting includes only time, number, location and direction in the third iteration. Furthermore, a legal note and disclaimer as well as a warning to not ap-

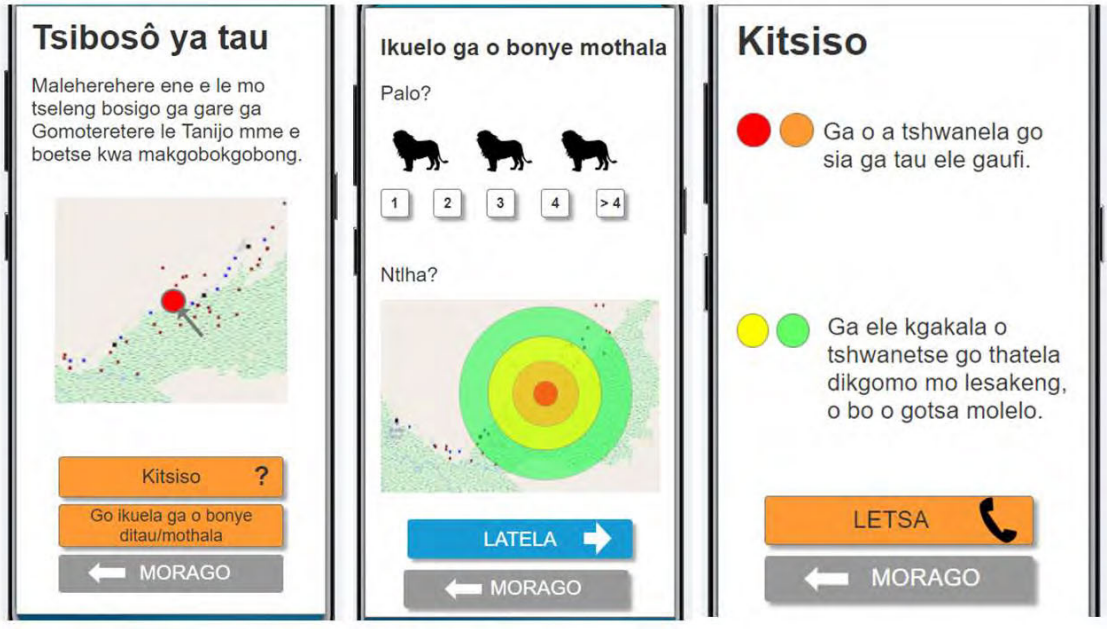

Figure 33: Smartphone alert details, lion sighting report, and behaviour suggestions screens for Tsibosô ya ditau

proach a lion in any event will be added to prevent the app from causing more harm, and relieving PioP from any legal responsibility.

We rely on diverse information from different sources on which the warning algorithm is built. At the moment, more than 25 parameters are considered for the automatic warn ing line calculation, such as season, water level, abundance of wild prey, and cattle position (see Appendix E). This algorithm is accompanied by the fact that the new collars are not preprogrammed, but only contain GPS, which makes them cheaper, lighter and longer lasting. Sending the signal more often than every two hours significantly improves the tracking reliability. Currently, the algorithm is being developed and iteratively tested.

6 Discussion

Human-wildlife conflict has been an issue in many parts of the world where people and wildlife live closely together. Such conflicts are a danger to both sides: Livestock owners and farmers lose their livelihood by wild animal behaviours, while the habitat reduction and persecution poses a threat to endangered wildlife species. Many mitigation approaches have been applied, including ICT solutions. Research has shown that approaches which include local participation, education, and prevention are most effective and have the most sustainable success.

The Okavango Delta is no exception: where cattle farmers live close to the national park border, their livestock is roaming freely and are frequently attacked by predators, above all lions. In turn, these endangered predators are persecuted because of the damage they cause to livestock owners, threatening to decrease their chances of recovery under otherwise stable conditions. Pride in our Prides, a CLAWS Conservancy project, has been addressing this issue with a notification system based on GPS collars on lions, called LionAlert. Although this system has significantly reduced fatal encounters between lions and cattle, it has several aspects which call for a second, improved version. The latter is the goal of the project described in this thesis, which is concerned with the following research question:

How can information and communication technology be used to create a sustainable solution for co-existence of people and wildlife, which maximally addresses local users' needs, fits their everyday life, and is nurtured by their support, at the example of a lion warning system in the Okavango Delta?

Together with an interdisciplinary team, we conceptualised an interactive and adaptable version lion alert system called Tsibosô ya ditau together with the local livestock owners in Botswana's Okavango Delta who are affected by HWC. For this purpose, we have conducted a Design Case Study, which includes a close look at daily practices, participant incolvement in the design process, and evaluation in the field. Based on Participatory Design, we developed a prototype which should allow for an effective and efficient long-term HWC mitigation strategy, if it is supported by education efforts and improved livestock management.

In the following, I will discuss the methodology (6.1), results (6.2) as well the limitations of our research (6.3). Furthermore, I will provide an outlook on future research (6.4), and provide a conclusion (6.5).

6.1 Methodological Discussion

We applied the method of Design Case Studies in a restricted manner. In a timeframe of three weeks, we could only conduct a context study in the form of semi-structured group interviews together with mapping and an idea collection in a creative workshop manner. The concept of DCS does not prescribe concrete methods or guidelines, therefore, the choice is left to the researcher with regard to methods appropriate to the specific target group, context, and practice. Methods used in DCS range from interviews and questionnaires, observations and action research in the context study to usability tests, focus groups and living labs in the appropriation study (Wulf et al., 2018). User participation is equally heterogenous: while in some DCS, results from the contextual study are used to design a product which is then evaluated with users, others directly involve users in a real-time mock-up design process including democratic design decisions.

To get to know our users and their practices better, a longer participatory observation and designer participation approach according to Blomberg et al. (1993) as well as Puri et al. (2004) would have been beneficial. This was not possible due to our short field stay. We therefore applied a shortened version by accompanying a herder while he was kraaling his herd of cattle. For other practices, we had to rely on our participants' statements. As we learned from the local research assistant and biologist, not all of these statements were true; for example, the fact that livestock owners kraal every day was not confirmed from their experience (for other examples, see chapter 6.2). This kind of statements fell under the phenomenon of social desirability, or the idea that our social status was perceived as higher so people said what they assumed we wanted to hear . While this generally did not disrupt the DCS approach, in some cases, this made it more difficult to determine the real factors influencing HWC and therefore more difficult to develop effective solution approaches. Developing a trustful and honest dialogue over a longer time, together with observation, could help understand the local practices, concerns and needs better. To illustrate this, some of the participants called us "teachers", which demonstrated that we had not communicated on the same level. Although we repeatedly explained that the workshop attendees are the actual teachers here and we need to learn from them, their perception of us as educators and, in general, outsiders, did not seem to change.

However, we have a wide range of sources for our context study. We obtained diverse views on the issue: observations and participation in local events and daily practices outside cattle management, group interviews, informal conversations, field notes, and meetings with other project stakeholders.

At the same time, the opportunity to co-design according to the PD principle (Schuler & Namioka, 1993) was restricted, as was the possibility of getting involved into our users'

practice to a significant extent. Because of the limitations pointed out in section 2.2, we could not apply an actual design process together *with* our potential users, because they do not perceive and imagine an interface the way we do, but we rather had to design *for* them to be able to use it without unnecessary effort and difficulties. We understand PD as an adaptable approach rather than a predefined methodology, in keeping with other studies where especially the barrier of digital literacy has hindered an actual participation in the design process (Elovaara et al., 2006; Gubbiotti et al., 1997; Hussain et al., 2012).

Additionally, many ideas our participants voiced (see chapter 5.2.3) did not have to do with technology, but mostly with other aspects like financial, material or educational factors. Nevertheless, the design study was informed by these workshops, meetings, observations and conversations recorded in field notes, video and audio recordings as well as on paper/photographs (mapping and participant ideas). Our prototype was evaluated with the same participants who took part in the context study, and revealed further problems, ideas and opinions which influenced our final design.

For our participants who have little experience with technology, it was not entirely possible to estimate possible ease of use. Another problem was that we had to display our prototype on a notebook PC instead of the actual device (tablet/smartphone/feature phone), albeit using relevant templates for this purpose. Therefore, participants had difficulty imagining what the actual program would look like as well as interacting with the prototype. As mentioned by Vitos et al. (2017), collective criticism was an unfamiliar concept for our participants, especially when it comes to something with which they are unfamiliar in their daily lives. Only by asking concrete questions could we find out how to improve the design and adapt it to our potential users.

Our appropriation study was therefore limited to evaluation sessions similar to the context study workshops. A long-term study where the new system is introduced into the usage context, including training, and evaluation is already in planning for the next stay in the Okavango Delta. Equally, insights gained from one DCS are not necessarily transferable to another, albeit similar social context (Betz & Wulf, 2018). The process should therefore be iterated and adapted in a different context of appropriation.

Our study was limited to 35 participants, while the Okavango Delta is inhabited by over 5,000 people. A small sample is not a hindrance to valid qualitative research, but we are missing valid data on phone usage, actual and digital literacy, and modality preferences. When introducing the prototype, this process needs to be accompanied by a larger-scale study where we can gain better insights into our users' characteristics, needs and issues.

We experienced some of the challenges identified by Hussain, Sanders and Steinert (2012) during a design case study in Cambodia, namely language barriers, users' possi-

ble degree of participation, time constraints, as well as cultural difference. Also, formulating technological statements from requirements and needs (Irani et al., 2010) is problematic in this context because of the mindset of participants, resulting in suggestions which are mostly not ICT-based, but tangible. What we did not yet consider – apart from small items and snacks – is the issue of rewarding participants to acknowledge their effort and contribution, and ensuring they stay motivated for further participation (Fischer, 2008; Hussain et al., 2012). The participation was mostly driven by curiosity to learn something new and trust in an effective solution for HWC which will sustainably improve our users' situation. In order to keep up cooperation, regular visits, meetings, and workshops as well as a transparent development process are necessary to show that we are determined to continue the project and constantly working on it.

Our PD workshops might be considered "bungee research" (Dearden & Tucker, 2016), where the ICT4D methodology assumes only short visits to the location where it is supposed to be used, and most of the research takes place in the "developed world". However, the continued presence of two of our team members, preliminary and constant trainings, as well as occasional project leader visits will guarantee the sustainability of Tsibosô ya ditau.

6.2 Discussion of the Results

During our workshop and evaluation sessions as well as by other observations in the field, we gathered diverse information on the categories of livestock management, HWC, Lion Alert usage, and feedback to improve the system. We could point out several issues which lead to HWC and which complicate mitigation, while we also found out possible ways to improve the situation.

An HWC solution already offered by the government is compensation, which is valuable for our users who do not have further income apart from their farming and who lose a high number of cattle, which affects them economically. From our local team members, we heard that lions are sometimes falsely claimed to have caused the attack in order to receive more compensation. For Eretsha, hyenas seem to be the most common problem and, according to them, they do not get compensation for these kills in their own words (although actually, they should receive 35% of the killed cattle's value). However, due to a limited state budget, this compensation is paid out with great delays, often after years, which renders it rather ineffective – a phenomenon also found in other countries (Madhusudan, 2003). At the same time, for many people, this is an urgent existential problem that requires a solution.

The fact that HWC is still not effectively addressed in the Okavango Delta and threatens both livestock farmers and endangered lions led to the establishment of PioP in the first place. It had already reduced attacks by 50 % (Weise et al., 2019), which is also reflected in most of our participants' attitude towards the project and our workshops, as well as towards lions themselves. They perceive them as valuable at least for the tourism industry which secures employment to future generations. While some are still sceptical about the actual benefit for themselves, others support us and hope for or even expect Tsibosô ya ditau to further improve their situation.

What we categorised as the most pressing issue is that herds are still mostly left unattended, most often because their owners lack time and resources to herd, kraal, or even build kraals. Kraaling is one of the most effective methods to prevent livestock predation (Kgathi et al., 2012; Weise et al., 2018). Therefore, PioP is already helping farmers who lack the necessary resources by building stronger and more effective kraals together with them. Meanwhile, some livestock owners are already using other strategies to make their cattle come back by themselves and avoid the strenuous process of kraaling which, as we noticed ourselves, requires a good health and a certain amount of time. Herding, as well, is seldom done anymore due to a lack of time and resources for employment. This job is only attractive to a few because of the low payment and resulting poor reputation.

An important factor, also named by our participants, is education. Alerts can only be effective if recipients understand how to react to them. Most respondents were familiar with recommended behaviours in this case. Furthermore, many of them expressed interest in learning more about lions, understanding their behaviour and life, and adapting their own behaviour and livestock management in accordance with new insights. This is a good basis for involving locals into actively and effectively mitigating HWC, which can ensure a sustainable solution (Baruch-Mordo et al., 2009; DeMotts & Hoon, 2012; Fischer, 2008; Garside, 2009; Hussain et al., 2012; Puri et al., 2004; Treves et al., 2006).

The solutions our participants offered in the workshops are mostly equivalent to earlier HWC mitigation efforts: Fences, translocation, and a better compensation (Distefano, 2005). These current approaches and ideas belong to the mitigative category of HWC solutions, but what is needed are arguably preventive approaches. Aspects like attaching more collars to cover a greater population of lions are already covered by the local project team and are outside the scope of this work. Other ideas that involve a greater budget – employing more people or supplying airtime, computers and mobile phones – cannot currently be addressed, which we explained to our participants during the second workshop.

Concerning the Lion Alert system itself, most of our participants had experiences with it, but also voiced criticism. The most important development which needs to be addressed is automation and more frequent or up-to-date alerts. The fact that users perceive the system as delayed emphasises the urgency of these aspects. To avoid them starting to question it when they do not receive alerts over a longer time, they also need an overview of past alerts as well as a current status which tells them that there is currently no collared lion near their area. Many of the suggestions mentioned by our participants have been integrated into the Tsibosô ya ditau prototype or will be realised in a later version in accordance with other stakeholders. Our design did not require significant alteration, but in accordance with their feedback led us to add valuable functions and make it more usable.

Also, the static feature of the current warning line was criticised. Lion attacks are influenced by a variety of factors, especially the season which affects the water level and therefore the movement of both livestock and wild animals. Also, areas which are affected by HWC based on our participants' estimates, are not covered by the current geofence. Implementing a dynamic geofence adaptable by this data is therefore a welcome solution. Our participants are ready to provide data from their side to help improve the algorithm calculating the warning line. Currently, they are already contributing to LionAlert effectivity by reporting lion sightings to PioP.

Local technology diffusion and infrastructure are still important factors that we need to consider in our research and development. Many users still have feature phones and do not always have access to airtime, electricity, and the network. Pro regularly had to visit a friend's house just to charge his phone. Also, to repair a phone, users would have to go as far as Maun. These results and observations are consistent with earlier research (Weld et al., 2018).

6.3 Challenges of an Interactive LionAlert Application for Inhabitants of the Okavango Delta

While our app can offer a preventive approach to mitigate HWC, it also poses many challenges to both the users and developers. First of all, users have to be trained to be able to use the app and warning station. In our prototype design, we attempted to make the interface as simple and pictoral as possible in accordance with suggestions in prior research (Medhi et al., 2006; Sherwani et al., 2009; Vitos et al., 2017). However, we could not entirely disregard text and certain interface elements and actions, such as scrolling and drop-down menus, which are new to many of the potential users. Consequently, constant training and repetition is required to make sure everyone is able to benefit from Tsibosô ya ditau, as is constant adaptation of the prototype in correspond-

ence to needs, wishes and usage. From the users' side, we have to rely on their readiness to learn and master new systems. In our workshops, we observed a willingness, but also the phenomenon that concepts are quickly forgotten if they are not repeated: for example, the notion of the geofence had to be explained once again although our local team members claimed to have already explained this in earlier meetings.

With our app, we address not only livestock owners who are targeted as primary users, but all members of the community affected by HWC and who are consequently being potential stakeholders Tsibosô ya ditau (Byrne & Sahay, 2007). Especially as we did not have a representative number of women in our study, they need to be taken into account to a higher degree since Tsibosô ya ditau will be addressing personal safety as well. Other future users in our study area are children. As these are mostly influenced by their parents whose opinion they usually take (Ertl, 2017), education from an earlier age needs to be considered as well.

When relying on a smartphone app, we found several barriers. Not everyone is familiar with or has access to a store, and many feature phones do not offer the possibility to insert SD cards. If everyone is to benefit from the system, the app needs to be available on all the devices normally used. For registration, we have found that providing everyone with a user account is rather problematic. Making everyone memorise a password can lead to mistakes and problems, so the solution was to establish a database which can only be altered by administrators and managers. Via phone, users can only receive the warnings configured for their phone number. Using GPS location would interfere with the location they entered upon registering: sending alerts for the village the user is currently in while their livestock is in another place does not make much sense. Therefore, we facilitated the whole process and shifted database maintenance to the administrators. Users can still receive alerts and report sightings on their mobile phones as well as make use of educational material, but most other functions will be limited to the warning station as there will be no user profile to which they can log in.

For our project and PioP in general, there is a tension between being transparent and protecting lions from poachers: communities have to trust PioP, but they do not receive a specific location of the lion to prevent poaching. While PioP has not recorded any evidence of lion poaching in the study area, due to the negative attitudes of some locals (Ertl, 2017) and global cases of attacks on predators (Distefano, 2005), we cannot fully exclude this possibility. However, we can see that this issue is taken seriously: when a lion is shot, there is a kgotla meeting in the village. Regardless, since the project start, five lions have been poisoned or shot by an unknown attacker. This shows that the problem still persists and we should put in more effort into preventing HWC and increase the local farmers' quality of life, eliminating the need to resort to such measures. We

need to ask the following questions in a future appropriation study: How much of a threat does the system pose for humans? Will the system lead to people relying too much on it and therefore not using other mechanisms to warn each other of approaching lions? And how much of a threat does the system pose for lions?

The expansion of all three networks is far beyond the scope of our project. As we have observed ourselves, internet access as well as electricity and cell phone network is quite unstable in the Okavango Delta (Mutula et al., 2010) and would not automatically ensure a reliable notification even excluding the human factor. While the warning station might reliably display the results from the server, it could be problematic to reach all recipients on time. Furthermore, to include notification in case of sightings and attacks, we thought of working with USSD technology. This, however, relies on the network provider. Furthermore, having enough airtime and battery for their phones poses a challenge for some users, while a broken phone is also a difficult issue (Weld et al., 2018). An opportunity for providing Tsibosô ya ditau users with power lies in the usage of solar panels to overcome the barriers of access to power due to a lack of infrastructure. Solar panels have been successfully used mostly by the rural middle class for communication and media consumption, e.g. in Kenya (Jacobson, 2007). However, they require proper maintenance and, as mentioned above, these are perceived as highly valuable and therefore are subject to theft in the Okavango Delta.

We have observed in the workshops that most local livestock owners possess feature phones. However, we need to ask the question: how sustainable is a Tsibosô ya ditau feature phone application? Smartphones are far from ubiquitous in our study area, but with the exponential growth of smartphone penetration in rural areas of Africa (Chetty & Grinter, 2007; Mutula et al., 2010), how long will people be using feature phones? Would it not make more sense to focus on a smartphone app right from the start?

As the greatest challenge, we found that an ICT solution alone is not enough to solve the problem, because of the wide range of factors that influence HWC. It can only be realised with the cooperation of its users who have to apply better livestock management such as kraaling. PioP's efforts to build kraals are limited due to budgetary and human resource constraints. Therefore, this development takes place over a longer time and cannot benefit all livestock owners at once. Furthermore, kraals can only help if their owners use them: while many claimed to do so regularly, we learned that there are many barriers which prevent farmers from kraaling and carrying out an effective livestock management. Probably due to the traditions, hierarchy of Tswana culture, and trust in authorities (Meyns, 2000; Nord, 2004), people expect and rely on these to solve their issues.

Another issue which we cannot currently solve with Tsibosô ya ditau are elephants (DeMotts & Hoon, 2012). These are destroying peoples' crop fields and making it dangerous to leave houses after dark, and even prevent people from kraaling their cattle when they are around. While we were conducting the workshops, a man was killed by an elephant, probably because he walked in between the elephant cow and its offspring in the dark. Two elephants were shot by the government on the same day to avoid retaliations by the local communities. The elephant problem is not new in Botswana, and not limited to our study area: In Chobe national park, they have been maintaining an exceedingly high population for a long time and elephants have caused similar destructions to the local flora to what we witnessed in the Okavango Delta (Spinage, 1990).

6.4 Implications for Future Research and Development

So far, Tsibosô ya ditau has been developed as a prototype, but has yet to be fully implemented including many other changes and extensions. For a schematic overview of the functionality, see Figure 34. The algorithm calculating the warning lines and the user database are currently under construction and will most likely be further iterated. In future versions of Tsibosô ya ditau, livestock owners should be able to find their cattle on a map, provided it is equipped with a GPS sensor. The warning station will include Google Earth as well as several other educational apps, videos, and texts. Part of the educational material should be profiles for collared lions, presenting the animals in detail and thus enhancing the feeling of ownership or belonging. It should be manageable remotely from Siegen so as to include new content and edit the databases. In addition to the stationary tablet, the local PioP members should get one as well to be able to maintain the app even remotely.

The whole app should be later available in the local languages of Setswana, Hambukushu, and Bayeyi. The automatic alerts will be predefined as text, and recorded in all languages to be able to automatically put together the necessary information: lion name and location (warning line). As a signal tone, we can also use a lion roar or a similar recognisable sound to alert people efficiently. For using the system itself, people need to be trained and informed as well. For this purpose, we plan to create posters and brochures which contain information about Tsibosô ya ditau, the warning stations, as well as contact details of project members for further information. In addition, we will offer introductory sessions to explain the usage and clarify questions. As we have seen that those not receiving the alerts will be informed orally by those around them. We would like to bringe this gap by utilising further alert systems such as sirens and lights at the kgotla.

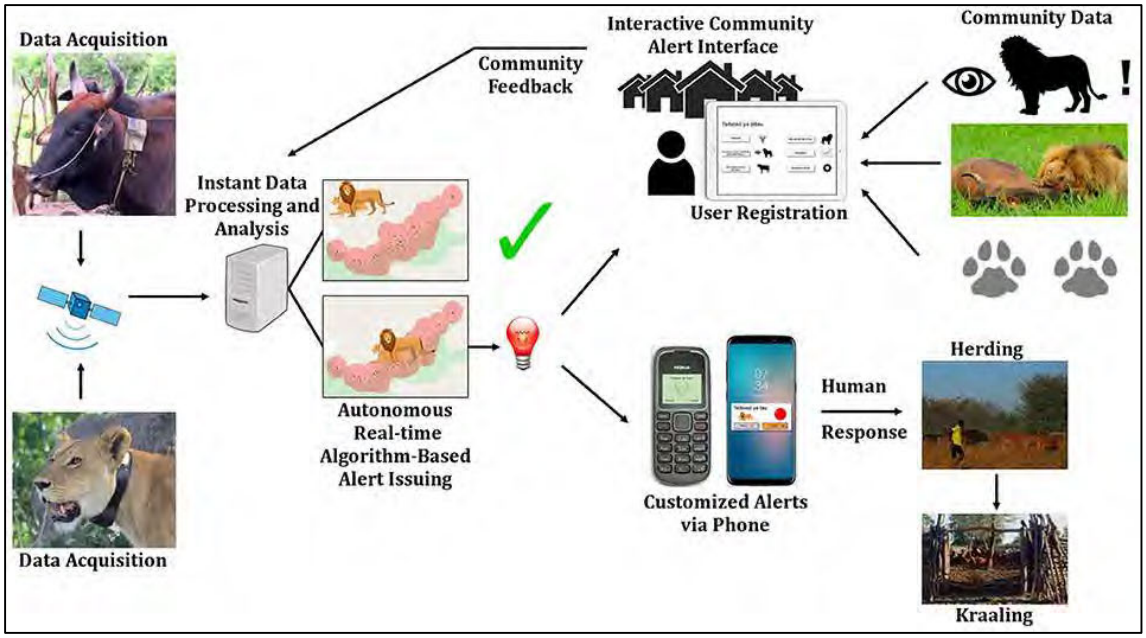

Figure 34: Visualisation of LionAlert 2.0. From Weise et al. (2019), based on own illustration

The warning lines, which so far are pre-programmed in the lions' collars, will be dynamically calculated by an algorithm on the server side that takes into account over 25 additional factors, such as wildlife movements, wildlife pace, season, water level and community feedback (see Appendix E). Mapping training is a prerequisite for some of that feedback as well as the overall usability of the system. Based on future collaborative participatory mapping (Mascarenhas, 1991), exercises which utilise the local communities' landmarks – such as lagoons and islands, big trees, rock formations or termite mounds – will be undertaken. The dynamic geofences will be visualised as green, yellow and red alert zones in the smartphone and tablet app. Users will also be able to report lion sightings, learn about lions and get an overview of old alerts using either the tablet or the phone version of the app. To be able to offer these and a range of other functions, warning stations will be installed at all the dikgotla- These will offer the chance to register for the system, report lion sightings and check the current alert zones on a tablet. The warning stations will be operated by specifically trained members of the community to ensure sustainability and ownership (Dearden & Tucker, 2016; Garside, 2009). Maintenance and iteration of Tsibosô ya ditau could be an opportunity for CBOs: their characteristics are involving locals and adhering to local requirements and expectations, growing quickly, distributing their benefits fairly, as well as acting sustainably (Arntzen et al., 2003). As many locals are struggling with poverty, there is an employment opportunity. To solve the compensation problem and enable farmers' livelihood, farmers could further be supported by the local lodges and a trade for agricultural products could be established. This way, they can employ herders and sustain their business

while species diversity is secured, which, in turn, supports the tourism industry the lodges are part of.

Reporting sightings or attacks will be also possible via USSD or calling PioP; later, reporting a lion roar with direction information will be included. If no one can answer the call, an automatic answering machine will ask questions (in Setswana, Hambukushu, and Bayeyi) about location, time, number of lions as well as name and phone number of the calling person. For illiterate users, here, we could include the option of automated voice menus inside the frame of USSD. Sightings should not generate an automatic alert, but first be examined by PioP, because there have been previous cases of false alerts. For attacks, however, there should be an automatic alert for the particular area with a status update for users.

To find out in what way we can deploy the warning station and ensure that it can function reliably under all conditions, we require more data on the local infrastructure. For now, we have only glimpses of what network and internet connection look like in the Okavango Delta, but to plan the deployment of Tsibosô ya ditau, we need to learn more about historical data as well as the current area development plan. For further development, we have identified several opportunities to enhance the system, such as utilising the warning stations as bases for public WiFi and cellular networks

Apart from implications for our system, the workshops brought to light further aspects of HWC mitigation beyond the programmable technological part of the system – and partly also beyond the scope of this thesis. In terms of material support, the local PiOP team are already building kraals and attaching more collars to cover a greater population of lions. In December 2018, six new lions have been equipped with collars. Ideas around personal support such as employing more people or supplying airtime, computers and mobile phones cannot currently be addressed within the project's budget, which we explained to our participants during the second workshop.

An issue that needs to be further addressed is herding and associated education: "*In an optimistic scenario, education and training would promote commitment towards conservation, raise awareness on the essential role of wildlife in the ecosystem functioning and its ethical and economic value, as well as its recreational and aesthetic importance.*" (Distefano, 2005, p. 23). This is especially important since we realised that Tsibosô ya ditau alone is not a complete solution to HWC in the Okavango Delta, but rather a part which can support a more holistic approach. As stated by Hussain, Sanders and Steinert (2012), ICT4D projects should be oriented towards enabling local development instead of producing a tangible solution. No technology can solve a social problem on its own (Oelschlaeger, 1979; Toyama, 2015), and hence improved and communal herding is an important part of a possible solution to the Human-Wildlife Conflict.

Only very few people want to work as a herder, due to low pay and reputation. Herding is still widely regarded as a duty of young boys, despite the introduction of compulsory schooling several decades ago. As a result, herding became a profession, but herders are not considered professionals – not even by themselves. Educational programs such as PiOP's herder workshops not only impart knowledge to herders, but also raise the local reputation of herders, which can significantly help reduce the killings of cattle by predators in the long run, which was also highlighted by Gusset et al. (2009). Also, communal herding – combining a village's herds together where herding is done by one or more employees – could solve the problem. Well-trained communal herders who also use Tsibosô ya ditau to manage the grazing direction and area in combination with kraaling by night could contribute significantly to solving the conflict between lions and humans (Gusset et al., 2009; Weise et al., 2018). This approach, according to the local team members, could help prevent killings by establishing larger and thus more defensible herds. While social conflict might hinder its success, communal herding might also set an example to other communities which will be more likely to follow once they have experienced the result. From March 2019, PioP has started a communal herd in Eretsha and Gunotsoga with six young herders, and are planning to further develop this approach.

To expand the scope and impact of our project, we need to involve more stakeholders – also those who are not direct users of the systems (Byrne & Sahay, 2007). As initially planned, interviews with members of the DWNP, the local government, police, rangers and teachers could help to get a better idea of the current situation. Furthermore, we would increase the trust level and ensure a wide cooperation and support, where we could apply aspects such as education and input (e.g., lion behaviour) for Tsibosô ya ditau.

Our warning station is meant to support the education aspect more extensively in the future by offering material on agriculture and wildlife in the forms of text, audio and video. One herder participant said he is familiar with farming apps. Such apps, which specifically address farmers, often currently with a low level of digital literacy, offer promise for the future. For example, iCow sends text messages with suggestions and knowledge around farming, along with providing automatic SMS-based tools which allow to specifically find the information they need to optimise their farming (Green Dreams TECH Ltd, 2016). Similarly, Kurima Mari (Welthungerhilfe, 2019) provides a large database of information on different crops and livestock types, displays current weather conditions, provides finance management, and helps farmers get in contact with others as well as sell their products. For the financial aspect, M-farm, who have also launched a mobile app, supports farmers with an overview of seasonal crop prices and therefore facilitates the decision of planting management (Wambua, 2012). Learning

from these apps could help choose the right content and improve the way of conveying it. This educational part should further be explored from the point of view of e-learning (Bhuasiri, Xaymoungkhoun, Zo, Rho, & Ciganek, 2012).

Since we would like to allow our users to automatically report lion sightings and kills, we need to apply collaborative mapping. As has been already done by several others (Elovaara et al., 2006; Mepedza, Wright, & Fawcett, 2003; Vitos et al., 2017), it will help build a system which is validated and expanded by local users. In our workshops, we have learned that conventional maps pose a challenge to many livestock owners in the Okavango Delta. Similar to the study by Medhi et al. (2006), orientation is mostly based on landmarks: trees, lagoons, termite holes, etc. It is therefore not necessary nor is it efficient to stick to conventional maps. For example, Elovaara et al. (2006) used paper and imagery to create a workspace map with symbols which represented certain elements which are familiar and adequately represent the given location to the users. Collective mapping in the Okavango Delta is already being addressed in herder workshops where grazing plans are established. Therefore, there is an opportunity to build on this knowledge. Mapping can also be applied to other problems. As Pro told us, there have been leaks in water pipes in the area which could not be located. Tracking down these leaks could be made possible by collective effort.

Eventually, this project should also be regarded from the viewpoint of transferability (G. Stevens et al., 2018). Since CLAWS Conservancy focuses not only on Botswana, we would like to allow for Tsibosô ya ditau to work for other countries, animals, and contexts. However, this can also pose a challenge since usage of interfaces differs to a high degree depending on the culture (Crabtree et al., 2013; Dray et al., 2003; Irani et al., 2010; Sherwani et al., 2009; Vitos et al., 2017). According to Dell and Kumar (2016), HCI4D should explore the ways to use multimodal and multi-language interfaces, trying to approach a more universal use. Therefore, the goal for a further iteration would include designing a more general interface, which can be flexibly customised for specific needs. To be able to do this, Design Case Studies in these contexts could help point out the differences, similarities, and opportunities for transferal, as has been done by previous studies (Aal et al., 2009; Elovaara et al., 2006; Yerousis et al., 2015).

6.5 Conclusion and Outlook

By applying a Design Case Study together with Participatory Design, in my thesis, I, together with our interdisciplinary team, aimed to address the following question:

How can information and communication technology be used to create a sustainable solution for co-existence of people and wildlife, which maximally addresses local users'

needs, fits their everyday life, and is nurtured by their support, at the example of a lion warning system in the Okavango Delta?

This question has several dimensions. First, we needed to understand why previous approaches did not work: they were mostly focused on short-term and mitigative instead of preventive strategies and developed externally, without involving users' opinions and seldom producing sustainable, effective solutions. ICT4D projects in this area are rare butgenerated promising results, while ICT4D in general bears the risk of being largely technology-focused. This is why we initially sought to involve our users and their context into the process as much as possible and gather data from them all throughout the development and iteration. HWC prevention by ICT can only work when affected people contribute to this. It is tailored and adaptable to its target group as much as possible and it is supported by other measures such as education and livestock management.

Too often, development projects – both technology development and economic development – are well-intentioned, but do not only have positive impacts (Dearden & Kleine, 2019). To mitigate negative impacts as much as possible, we follow the paradigm of DCS and PD to a degree which is realisable in a limited time frame, relying on ethnographic pre-studies and evaluation workshops. We can conclude that our approach, involving user participation, can work well in this regard. In our project, we were able to show that the approach helped involve as many stakeholders as possible and let a variety of different perspective on the need for an ICT solution be explored. This led to a better understanding of the current system and helped to identify more features needed in the upcoming system.

We have identified several improvements for LionAlert and conceptualised them with Tsibosô ya ditau. The future version will solve many shortcomings that LionAlert currently demonstrates. However, there remain several limitations which can hinder the deployment. Apart from the system, we need to address further issues which contribute to HWC such as training and behaviour. At the same time, Tsibosô ya ditau is powerless against factors such as elephants – an issue which poses a further threat to people's livelihood results in many other problems that, in turn, complicate the prevention of human-lion conflict by proper livestock management. Therefore, the question arises whether we are currently addressing the root of the problem or if it lies elsewhere.

We can only find out with a long-term appropriation study once Tsibosô ya ditau is released. By constantly working together with the local community, we can observe the real-time results of the system implementation as thus avoid limiting our project to bungee research (Dearden & Tucker, 2016). Together with further workshops and iterations, we hope to make Tsibosô ya ditau even more effective, efficient, and sustainable. Among others, we can also address the questions if the system can even worsen HWC

instead of reducing it. We hope that PiOP's activities can really inspire feelings of pride and ownership of the lions in the people.

With the idea of the warning station, we can lay the foundation for a technical infrastructure where users can actively co-design the ICT artefact (Fischer, 2008): by entering lion sightings, for instance, they improve the warning accuracy. Furthermore, our hope is that through our workshops, users will be encouraged to openly criticise and suggest improvements for Tsibosô ya ditau. The biggest opportunity we see is fostering digital literacy and out-of-the-box thinking through the establishment of a local educational ICT intervention, possibly as a mobile solution so it can be deployed in different villages at different times. Making users into collaborators can set the path for establishing "*social structures that enable groups of people to share knowledge and resources in support of collaborative design*" (Fischer, 2008, p. 8). As expressed by Distefano (2005), this way, we could establish the ideal context for preventing human-wildlife conflict:

"*The best scenario would imply integrated community development and wildlife conservation promoted by national park managers and supported by local populations. Community-based conservation should give indigenous people the right to limited and sustainable use of natural resources while promoting tolerance towards wildlife, responsible interaction with their natural environment and the recognition the value of natural heritages*" (p. 27).

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Appendix A: Declaration of Consent

Project: Lion Alert
Declaration of consent for sound, image and video recordings

I, _____, have been informed orally by Victoria Wenzelmann / Margarita Grinko that sound, image and video recordings of me will be made as part of the above project.

The recordings serve exclusively to view and analyze the evaluation again. They are recorded with a recording device and then potentially written down by the staff of the research project.

There is a chance I am recognizable in the footage. For this reason, all persons involved in the evaluation are subject to absolute confidentiality. The recordings will not be passed on to third parties.

I am aware that my statements in scientific papers are quoted in excerpts, and I was assured that they will be treated anonymously. Image extracts, on which I am shown, are anonymized before a possible publication. All information that could lead to the identification of my person will be changed or removed from the text.

Since I can potentially be recognized in the recordings, I have the right to have these recordings deleted at any time without any disadvantages. To get recordings of me deleted, I contact the researchers.

The declaration of consent for sound, image and video recordings is voluntary. I can revoke this declaration at any time. In the event of rejection or withdrawal, I will not incur no costs or other disadvantages; however, participation in the study will then not be possible.

Personal contact data are stored separately from interview data and are inaccessible to third parties. After completion of the research project, I have been assured that my

contact data will be automatically deleted, unless I expressly agree to further storage for the contact option for topic-related research projects. I can object to longer storage at any time.

Participation in the research is voluntary. I may at any time cancel an interview, refuse further participation and withdraw my consent to a recording and transcript without any disadvantage to me.

I agree to take part in an interview/several interviews, workshops, and focus groups as part of the research project mentioned above.

☐ Yes ☐ No

I agree to be contacted for future related research projects. For this my contact details about the end of the research project remain stored.

☐ Yes ☐ No

I have received a copy of this declaration of consent.

☐ Yes ☐ No

For questions or other concerns I can contact the following persons:

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Place, Date & Signature of Participant

Name of Participant in Block Letters

Place, Date & Signature of Researcher

Name of Researcher in Block Letters

Appendix B: Use Cases and User Stories for LionAlert 2.0

These use cases are based on my understanding of the current system and the situation in Botswana. They have to and will be adapted based on expert knowledge and interviews with local people.

USE CASE 1: GETTING AND REACTING TO AN ALERT

A farmer in the Okavango Delta with a herd of ten cows has got a feature phone able to display text messages. She is not literate, so she chooses to receive a sound, picture and voice message in Setswana should a lion be close to her location.

One early morning around 5am, she gets an alert that a pair of lions have been detected in her village. She does not know how far away they are, but she has already lost a few cows to lion attacks before and knows that they can be dangerous in his area. As she does not have a kraal, she lights a small fire outside and stays up, carefully watching out of the window. Also, she prepares a pan and a large spoon to make noise should the lions come into sight[3]. Luckily, two hours later, there is no more alert, which means the lions are no longer in the area, so she can carry on with her evening undisturbed.

USE CASE 2: REPORTING A SIGHTING

A farmer is working late in the evening when he gets an alert on his feature phone that a lion has been detected near his location. Because he can read, he receives a text message along with an ASCII code. His large herd is already inside the kraal so he enters his house to be safe in case the lion approaches.

About half an hour later, from inside, he can see the lion so she uses the number provided by LionAlert to report a sighting by leaving a voice message. As his cattle is inside the kraal, everything stays peaceful and they are not approached by the lion.

[3] Comment in original document: Find out how people actually react in this situation/what would be the correct reaction

USE CASE 3: ENTERING LION CHARACTERISTICS

A biologist has come to a village in the Okavango Delta to study the local wildlife. He sees in LionAlert that a few attacks and even more sightings took place there, so he marks the area as especially endangered in a map provided in LionAlert. Based on the sightings and his observation, he can enter details on the local lions: Their group size, meal times and the fact that they are not afraid of humans.

Based on these details, the geofence is further optimised and attack risk is calculated. When the lions approach this area, the system alert is issued earlier and with the message that an attack is possible[4].

USE CASE 4: ENTERING A NEW USER

A kgosi of a small village has recently been using LionAlert on his smartphone. He can see an overview of members in his village that will get a notification in case of an approaching lion, but not all of them are included. A few farmers are missing in his list. He does not have their numbers, so he sends a secretary to gather information on them. Once he got it, he uses a web interface to enter the new LionAlert users. He enters their name, phone number and occupation.

The farmers get a message on their phones where they confirm that they get informed about LionAlert and confirm that they would like to use it. They indicate if they are literate or not, what language they prefer the system to use and which kind of alert they would like to receive.

USER STORIES:

Farmer/Livestock owner

As a farmer, I want to enter personal information such as education and literacy, language and alert type so that I can get the type of notification I prefer.

As a farmer, I want to get timely and understandable notifications of an approaching lion so that I can kraal my cattle or hide before an attack happens.

As a farmer, I want to enter the location of my cattle so that the geofence is optimised and I can be better notified if my herd is in danger of getting attacked.

[4] Comment in the original document: Question: Does the attack probability influence the warning to this extent?

As a farmer, I want to report lion sightings and attacks so that they can support location, geofencing and possible compensation in case of an attack.

Kgosi (partly overlaps with cattle owner)

As a kgosi, I want to enter my village location, size and characteristicts, as well as choose the type of notification I prefer to receive.

As a kgosi, I want to get timely and understandable notifications of an approaching lion so that I can kraal my cattle or hide and notify others before an attack happens.

As a kgosi, I want to enter new villages, cattle posts and users so that they will be notified as well.

As a kgosi, I want to enter the location of my cattle so that the geofence is optimised and I can be better notified if my herd is in danger of getting attacked.

As a kgosi, I want to enter lion sightings and attacks so that they can support location, geofencing and possible compensation in case of an attack.

Biologist/Ranger/Field guide

As a biologist, I want to enter my location or area of responsibility as well as the type of notification I prefer to receive.

As a biologist, I want to get timely and understandable notifications of an approaching lion so that I can better understand and enter information on their behaviour.

As a biologist, I want to enter new villages, cattle posts and users so that they will be notified as well.

As a biologist, I want to mark locations on a map with different lion attack probabilities so that the risk can be better calculated.

As a biologist, I want to enter individual information on the lions so that the attack risk can be better calculated.

As a biologist, I want to enter lion sightings and attacks so that they can support location, geofencing and possible compensation in case of an attack.

As a biologist, I want to have an overview of lion sightings and attacks in my area to make better judgments of their character and behavior as well as help predict future attacks.

Appendix C: Final Workshop Guidelines

PARTICIPATORY DESIGN IN BOTSWANA: FIRST WORKSHOP GUIDELINE

- Meet at the village Kgotla areas, pick people up if necessary and bring them back home
- Ideally: One workshop at 9 – 11am in the morning, second 2 – 4pm in the afternoon
- Around 2 hours (consider relative time!)
- Two groups of six people per village (authorities (kgosi, VDC chair, farmers' committee) and farmers/herders from different cattle posts), two workshops for each group (before – after the design)
  - → 12 workshops
- Buy cold drinks and magunyas (in ant-safe containers); bring glasses for the participants
- Workshop leaders: Rita, Vicy, Pro

Workshop 1: Structure

1. Introduction round: 20 minutes
   a. Open prayer (2 minutes)
   b. Greet everyone present and introduce ourselves personally (6 minutes)
      i. We are working together with Flo and Pro: They are biologists, we are here for the technical part
      ii. Helmut, Konstantin and Tanja were here to help develop first version
      iii. "We want to improve the system for you, therefore we ask for your input. We help you build the system that you need." → We want to learn from *you*!
   c. Let participants introduce themselves (6 minutes)
      i. Name
      ii. Age
      iii. Role/occupation
      iv. Location
   d. [Greeting by kgosi (2 minutes)]
   e. Explain the workshop structure (2 minutes)
   f. Ask people for recording consent (2 minutes)
2. Interview part: 30 minutes
   Ask open question to the group: Please tell me about your typical day as a farmer
   a. How many cows they have
   b. How many losses they have and at which locations
   c. How many alerts they received before (directly or indirectly) and at which times of the day

d. Which phone they are using
e. If they can read and write
f. Do you often see lions or other predators? Do you feel personally threatened by them?
g. Before the system, did you know a lion was coming? What did you do then?
h. With the new system, what do you do if an alert comes in?
i. Do you think LionAlert improved the situation? Do you have less attacks now than before? Do you personally feel safer?

3. Discussion of status quo: 30 minutes
    a. Mark attack spots on a map
        i. People tell the locations to Pro
        ii. Pro marks them on the map
    b. Ask about understanding of the current system
        i. Let people explain the system in their own words
        ii. Use illustrations to visualise them on the poster
        iii. Complete the picture if necessary so that everyone understands how LionAlert works at the moment (if noone talks, ask Pro to explain it)
    c. Ask if they have questions, check with Pro everything is alright
    d. What do you think about the system in general? Are you satisfied with how it works?
    e. What are you unhappy with in the system? What would you improve?
4. Creative part: 15 minutes
    a. Task: Please draw or write how you would imagine an improved LionAlert system: How would you protect your cattle from lions and prevent kills? What measures and materials would you use?
    What should the new system have what it doesn't have so far? What would you like to be able do with it?
    You don't have to draw well!
    b. Divide the group into three pairs
    c. Give everyone a piece of paper and pens/pencils to draw or write
    d. 10 minutes of time, maybe more, depending on the results

--- BREAK ---

5. Discussion part: 20 minutes
    a. Let every pair present their ideas (10 minutes)
    b. Go through each idea and let everyone comment on it and discuss, what they like and do not like (10 minutes)
    c. If the ideas are very different: Find a consensus together by combining parts of the ideas
6. Thank you and see you next time! 10 minutes
    a. Ask what participants think of the workshop
    b. Explain next workshop → try to find a date
    c. Exchange numbers and advise to call if they have questions, concerns or new ideas

PARTICIPATORY DESIGN IN BOTSWANA: SECOND (EVALUATION) WORKSHOP

Aspects omitted in the second version of this guideline are marked in grey.

PROCEDURE

1. Reminder part

- Prayer and welcome
    - Stress the point that they are at any time welcome to ask questions, make statements, add information – just co-design the system ;)
- Show which ideas were brought up in first workshops
- Ask if they have additional ideas for the existing system after the first workshop
- Lay out the illustrations of the system on the table
- Replace the people in image 3 and 4 with computers to illustrate the automatisation
- Say that because of the automatisation, they can decide themselves how they would like to receive the alerts
- But first, the system needs some information from them
- Explain the database and why we need the data from users
    - Use example parameters: Movement of lions, kraal location and herd size

2. Warning Station: Registration

- Show Warning Station image, explain concept of Warning Station at kgotla → stress importance of chief, if chief is present
- Go through registration process on paper/computer by registering a mock user together
    - Observe interaction: Technical shyness? Problems?
    - Ask for comments and questions as well as improvement suggestions
    - Stress that the system is still in development and any improvement is possible and welcome
    - Encourage people to move and draw on the pictures: prepare paper and pens
- Ask which kind of information/data the people would like to give us
    - Touch the topics of age and literacy: Ask those where we still need this information
    - (Digital literacy? Awareness of privacy / security…?)
- Ask each of them what kind of alert they would prefer:
    - Modality
    - Content
    - Language
    - Frequency

3. Warning Station: Functionalities

- Once a mock user is registered, show log in
    - Encourage people to interact with the system
- Explain functionalities and ask if they would like to have more
    - Show alert status
    - Show example alert

    - Show geofence simulation
- Explain map and ask people to name landmarks using the Open Street Map (idea for next workshop as it takes too much time and there is no sufficient internet connection for Open Street Map)
- Show sighting report and let someone go through the interaction

--- BREAK ---

4. Presentation of phone app

- Ask them what kind of phone they are using, which apps they like and how they get apps/software for GSM phones → photo of all phones on table
- Show alert on GSM phone first
- Go through process on the PC and observe interaction
- Show alert on smartphone
- Go through smartphone process (reporting) on the PC and observe interaction

5. Conclusion

- Ask for further questions, comments and suggestions

Thank you and prayer

Appendix D: Workshop Participant Lists

Village Time, *Location*	**Group 1** **Role, gender, village/cattle post, age**	**Group 2** **Role, gender, village/cattle post, age**
Eretsha Group 1: 17/08, 9am Group 2: 15/08, 9am *Kgotla*	Kgosi, M, Eretsha, 48	VDC Vice Chair, M, Eretsha, 40+
	VDC Chair, M, Eretsha, 32	Farmer, F, Katapa, 40+
	Farmer, F, Eretsha, 46 representing Farmers' Committee Chair	Farmer, M, Miyagogo, 30+
	Farmer, M, Twaimango, 21	Herder, M, Eretsha, 40+
	Farmer, M, Kwaga, 24	Farmer, F, Kachirachira, 30+
	Farmer and Village Health Committee Chair, M, Eretsha, 30+	Farmer, M, Kwaga
Beetsha Group 1: 17/08, 2pm Group 2: 16/08, 9am *Kgotla*	Kgosi, M, Beetsha, 50+	VDC Vice Chair, F, Beetsha, 40
	VDC Chair, M, Beetsha, 48	Farmer, M, Matswii 2, 52
	Farmers' Committee Chair, M, Beetsha, 83	Farmer, F, Zambia 2, 36
	Farmer, M, Samogo, 48	Farmer, F, Beetsha, 41
	Farmer, F, Matswii 1, 40+	Farmer, M, Matswii 1, 29
	Farmer, F, Beetsha, 30+	Farmer, M, Gomoteretere, 35
Gunotsoga Group 1: 23/08, 9am Group 2: 23/08, 2pm *Kgotla*	Kgosi, M, Gunotsoga, 70	Farmer, M, Ndorotsha, 46
	VDC Chair, M, Gunotsoga, 76	Farmer, M, Gunotsoga, 80+
	Farmers' Committee Chair, M, Gunotsoga, 53	Farmer, M, Samoti, 64 representing VDC Vice Chair
	Farmer, M, Gunotsoga, 59	Farmer, M, Ndorotsha, 41
	Farmer, M, Samoti, 35	Farmer, M, Gunotsoga, 65
	Farmer, M, Xau 2, 24	Farmer, M, Gunotsoga

Workshop 1 participant list. Participants marked in grey did not attend the workshop. The age was estimated for those who could not or did not want to indicate their age.

Village Time, *Location*	**Group 1** **Role, gender, village/cattle post, age**	**Group 2** **Role, gender, village/cattle post, age**
Eretsha Group 1: 27/08, 2pm Group 2: 27/08, 9am *Our camp*	Kgosi, M, Eretsha, 48	Farmer, F, Katapa, 40+
	Farmer, M, Kwaga, 24	Farmer, M, Miyagogo, 30+
		Farmer, F, Kachirachira, 30+
		Herder, M, Eretsha, 40+
Beetsha Group 1: 29/08, 9am Group 2: 28/08, 9am *Kgotla*	VDC Chair, M, Beetsha, 48	VDC Vice Chair, F, Beetsha, 40
	Farmer, M, Samogo, 48	Farmer, M, Matswii 2, 52
	Farmer, F, Matswii 1, 40+	Farmer, F, Zambia 2, 36
	Farmer, F, Beetsha, 30+	Farmer, F, Beetsha, 41
		Farmer, M, Matswii 1, 29
		Farmer, M, Gomoteretere, 35
Gunotsoga Group 1: 30/08, 9am Group 2: 30/08, 2pm *Kgotla*	Kgosi, M, Gunotsoga, 70	*Combined with Group 1 due to low participation*
	Junior Kgosi, M, Gunotsoga, 80+	
	Farmer, M, Samoti, 35 representing VDC Chair	
	Farmer, M, Gunotsoga, 65	
	Farmer, M, Gunotsoga, 59	
	Farmer, M, Gunotsoga, 80+	

Workshop 2 participant list. Participants marked in grey did not attend the workshop, those marked in bold are only introduced in the second workshop. The age was estimated for those who could not or did not want to indicate their age.

Appendix E: Preliminary List of Parameters Included in the Warning Line Algorithm Calculation

Updated by PioP on February 11th, 2018

No.	Variable/Parameter	Rationale
1	Core lion home range	more likely to interact with cattle if they live close by
2	Cattle herd size	bigger herds are easier for predators to detect
3	Time of day	lions being crepuscular
4	Size of cattle	middle of the preferred prey weight range? likely to be preferentially preyed upon
5	Presence of herder/guard dog	protection vs no protection
6	Kraaling	protection during night hours vs free-roaming when lions are most active
7	Micro-habitat	proximity to cover for stalking
8	Cattle distance from 'home'	more likely to interact with lions further away from 'home'
9	Surface water availability	influencing cattle & zebra & lion movements
10	Season	seasonality of lion movements and conflict intensity
11	Zebra movements	Mainstay prey moving seasonally influencing lion movements
12	Abundance wild prey	prefer wild prey cf livestock if the abundance of both are considered
13	Habitat (macro)	conflict may be pronounced in specific vegetation classes due to cattle grazing
14	Lion behaviour	lion movements (speed and direction) differ by behavioural state
15	Moon phase	lion activity differs with lunar cycle
16	Lion ID and group size	different individuals may be more prone to kill livestock (habitual raiders?)
17	Time since last kill	lions likely to be more conflict-prone as time from last meal increases
18	Presence of cubs	females energy-stressed during rearing of cubs

Affidavit

Hereby I assure that I have written the work at hand by myself and and have used none other than the indicated sources and means. I have duly noted the sections of the valid examination regulation concerning any fraud attempts. I agree that my Master thesis be saved for the sake of plagiarism assessment. I assure that the electronic version has the same content as the printed version.

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Hiermit versichere ich, dass ich die vorliegende Arbeit selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe, insbesondere keine anderen als die angegebenen Informationen aus dem Internet. Diejenigen Paragraphen der gültigen Prüfungsordnung, welche etwaige Betrugsversuche betreffen, habe ich zur Kenntnis genommen. Der Speicherung meiner Masterarbeit zum Zweck der Plagiatsprüfung stimme ich zu. Ich versichere, dass die elektronische Version mit der gedruckten Version inhaltlich übereinstimmt.

Ort, Datum

Margarita Grinko