Human-Crocodile Conflict (Nile crocodile: *Crocodylus niloticus*) in the Okavango Delta, Botswana

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature:

Date: 27-11-2006

Abstract

Human-Crocodile Conflict (HCC) is becoming an increasingly social, and conservation problem in most African countries, as many predator species are under threat due to conflict situations where predation of livestock and humans is occurring. However, very little is known about this multidimensional issue, which affects social, political, economic, cultural and biological aspects of life in regions throughout the world.

The extent and severity of HCC in the Okavango Delta, Botswana, was investigated through completing questionnaires with the aid of translators in 35 villages surrounding this unique inland delta in the Ngamiland District of Botswana (N=482). Perceptions towards crocodiles, the degree of utilization of river resources and traditional beliefs of the local people were also investigated. A high incidence of attacks was expected to occur where human and livestock populations were high, with an increasing number of attacks over time. Half of the people interviewed fear crocodiles and remarked that the brain is poisonous when consumed. Most human attacks occurred when people were fishing, swimming or collecting water. Total human population was positively correlated with total attacks on humans and total livestock attacks. The rate of attack on humans and livestock is increasing linearly with time, which is very concerning as people are dependant on farming (livestock and crops) for about 50% of their income. A comparison of recorded attacks with the DWNP (Department of Wildlife and National Parks) records, revealed that the number of livestock attacks by crocodiles is minor compared to attacks by lion and leopard in the Ngamiland District. However, combined with external influences, such as HIV/AIDS, the impact of HCC will potentially greatly undermine people's livelihoods in the future.

Mitigation measures combining both prevention and reactive techniques are provided for policy amendments and for communities for the long term resolution of HCC. The gradual phasing-out of monetary compensation (which is currently practiced in Botswana), together with regulations restricting use of open access water of the Okavango Delta is recommended. Policy instruments and various incentives (for communities) will aid in policy implementation and thus facilitate the future coexistence of man and crocodile in the Okavango Delta, Botswana.

Uittreksel

Mens-Krokodil-Konflik (MKK) is 'n toenemende sosiale, en bewaringsprobleem in die meeste Afrika-lande. Die rede hiervoor is dat al meer roofdiere onder druk is weens konfliksituasies waar predasie van vee en mense voorkom. Baie min is egter bekend rondom hierdie multi-dimensionele kwessie wat die sosiale, politiese, ekonomiese, kulturele en biologiese aspekte van lewe regoor die wêreld affekteer.

Die aard en omvang van MKK in die Okavango-delta, Botswana is ondersoek deur die voltooiing van vraelyste (N=482), met behulp van vertalers, onder 35 van die nedersettings wat hierdie unieke binnelandse delta in die Ngamilanddistrik van Botswana omring. Persepsies jeens krokodille, die mate waartoe die river as hulpbron gebruik word, en die tradisionele geloof van die plaaslike mense, is ondersoek. 'n Hoë voorkoms van aanvalle is verwag om plaas te vind waar mens- en veepopulasies baie is, asook 'n verwagte, verhoogde toename oor tyd. Die helfde van die mense waarmee 'n onderhoud gevoer is, is bang vir krokodille en het genoem dat die brein van die krokodil giftig is om te eet. Die meeste aanvalle op mense het plaasgevind terwyl mense visgevang, geswem of water geskep het. Daar was 'n positiewe korrelasie tussen die totale menslike bevolking en die totale aantal aanvalle op mense en totale aanvalle op vee. Die tempo van aanvalle op mense en vee is toenemend lineêr oor tyd. Dit is kommerwekkend, aangesien die meeste mense aangewese is op boerdery (vee en gewasse) vir omtrent 50% van hulle inkomste. 'n Vergelyking met aanvalle opgeteken deur die Departement van Wildlewe en Nasionale Parke, toon aan dat die aantal aanvalle op vee deur krokodille veel minder is as aanvalle op vee deur leeus en luiperde in die Ngamilanddistrik. Die impak van MKK, gekombineer met eksterne invloede, soos MIV/VIGS, het egter die potensiaal om mense se bestaan in die toekoms te ondermyn.

Maätreels wat beide voorkomende en reagerende tegnieke kombineer, word voorgestel vir beleidswysigings en vir 'n lantermyn-oplossing van MKK in gemeenskappe. Die geleidelike uitfasering van geldelike kompensasie, soos wat tans die gebruik in Botswana is, tesame met regulasies wat die gebruik van vrye-toegang water beheer, word vir die Okavango-delta aanbeveel. Beleids-instrumente en verskeie prestasielone (vir gemeenskappe) sal hulp verleen in beleidsimplementasie en so die toekomstige mede-bestaan van die mens en krokodil in die Okavango-delta, Botswana meehelp.

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Table of Contents

CHAPTER 2

GENERAL ATTITUDES OF THE BATSWANAN PEOPLE TOWARDS CROCODILES & THEIR UTILIZATION OF THE OKAVANGO RIVER AND ITS RESOURCES

CHAPTER 3

INVESTIGATING THE EXTENT OF HUMAN - CROCODILE CONFLICT IN THE OKAVANGO RIVER SYSTEM, BOTSWANA WITH REFERENCE TO HUMANS, AND THEIR LIVESTOCK

CHAPTER 4

ASSESSING THE SPATIO-TEMPORAL DISTRIBUTION OF HUMAN CROCODILE CONFLICT WITH REFERENCE TO HUMAN POPULATION DEMOGRAPHICS AND LIVESTOCK DISTRIBUTION

CHAPTER 5

RECOMMENDATIONS FOR HUMAN-CROCODILE CONFLICT MITIGATION

CHAPTER 6

DISCUSSION & CONCLUSSION

List of Figures

Page

List of Tables

Page

CHAPTER 1

INTRODUCTION

1. The interaction between man and wildlife: Human-Wildlife Conflict

The relationship between man and wildlife is multifaceted and has changed over time (Morris 2000). It has been described as antagonistic (Osborn & Anstey 2002; Weladji & Tchamba 2003 and Morris 2000) with people hunting animals for food, animals eating crops and attacking livestock and people (Osborn & Anstey 2002). Neutral relationships between wild animals and humans are 'exceptional' and are usually due to cultural or religious reasons (Lanhupuy 1987). There are only a few examples of coexistence between wildlife and humans that are living within close proximity to each other, as nearly all wild animals are potential competitors for natural resources that humans utilize (e.g. water and food)[Mungai 2003 and Tjibae 2001]. The relationship between man and animals has changed drastically in recent years due to pressurized circumstances, for example: increasing land scarcity and degradation, hunting limitations, high human population density and fragmented wildlife populations. Human-Wildlife Conflict (HWC) has become a serious issue within the world today, due to the above mentioned factors (Holmern et al. 2004). Recent trends show that HWC is increasing in both frequency and severity throughout the world and will likely continue to escalate (Madden 2004a).

Human-wildlife conflict has been described as an 'age-old problem' (Fall & Jackson 2002), is said to have existed for decades (Holmern et al. 2004) and is one of the key threats to conservation in Africa (Tchamba 1996 and Naughton-Treves 1997). HWC is heightened when the species' survival is threatened, while it's presence in an area poses a threat to human welfare (Saberwal et al. 1994). For example: wild tiger populations in Asia have been drastically lowered to less than 7000 individuals and their long term survival is threatened by retaliatory killings due to depredation on livestock by the predators (WWF 2005).

HWC can come at a significant cost to countries; In the United States the annual losses related to wildlife is nearly $3000 million and an average of 75000 people are injured or contract an illness from wildlife (Conover et al. 1995). Rodents are having a significant effect on crop production and on the livelihoods of farmers in Indonesia where 36 million tonnes of rice are lost to rodents

annually, which is enough to feed the whole population of Indonesia (215million people) for a year (Singleton et al. 2004). The management of HWC in the USA is termed 'wildlife damage management' which broadly describes actions that are taken to reduce financial loss to agriculture and livestock caused by wildlife (Messmer 2000). With current pressures from state wildlife legislation and regulations, which are designed to protect or conserve wildlife, these laws are seen as restrictions on public benefits and individual property rights and may result in conflict.

At the IUCN World Parks Congress (RAMSAR 2005) it was stated that there is currently no existing international forum to address matters of HWC across taxonomic disciplines, groups and geographic regions, with the aim to develop and share lessons and strategies to prevent and resolve the various economic, environmental and social costs of human-wildlife conflicts. The reasons that were given for this apparent lack of co-ordination is that HWC is strongly site and species specific, thus preventing managers in mitigation or resolution of their own HWC problems. Other reasons are a lack of resources for local stakeholders and those that have the expertise often lack time and energy to share their experiences with those struggling with similar situations (Madden 2004a). HWC has indeed become an advancing area of social science that needs considerable attention, especially in Africa and other developing regions where HWC is greatly affecting people's livelihoods.

Before we look into the dynamics of the relationship between humans and wildlife, we need to fully understand the concept of HWC and to identify the main aspects that shape its definition. In Messmer (2000) human-wildlife conflict management is "being applied to situations that involve any negative interactions between humans and wildlife. Where conflict can be real or perceived, economic or aesthetic, social or political". This also includes damages to individuals as a result of any state or wildlife legislation, regulation or policies that are designed to protect public benefits, individual rights and also wildlife conservation. Another definition states that HWC occurs when the needs and behaviour of wildlife impact harmfully on the goals of humans or when the goals of humans harmfully impact the needs of wildlife (Madden 2004a and 2004b). These conflicts can result in crop damage, security threats, injuries and fatalities of humans and livestock. The inclusion of the harmful effects on wildlife due to the interaction between human and wildlife shows that it is equally important to consider both sides of a conflict situation.

HWC is said to escalate when local people feel that the needs of wildlife are given priority over their own needs, or when local authorities and people are insufficiently empowered to deal with the conflict (Madden 2004a). It is also stated that without properly addressing HWC issues, conservation efforts will lose stability and momentum, together with support from local communities. Analysis of worldwide HWC cases show that many share similar causes and effects as well as challenges and trends (Madden 2004a). Therefore, it is important to look at the general causes of HWC, because only once you have understood the origin of the conflict, you then can manage it properly and attempt to resolve or mitigate the problem.

Biological & ecological dimensions of HWC

Messmer (2000) states that HWC is closely linked with status of species, i.e.: whether they are indigenous or foreign species. Native species (indigenous to a specific area) are generally better equipped to biologically co-exist with natural predators, other competitors and transmitted diseases as they have 'co-evolved' or adapted with their natural surroundings. Many foreign species do not have the ability to develop an adaptive coexistence with organisms already in the ecosystem. Therefore, through human intervention, where natural habitats are altered together with the introduction of new species, the balance or stability of natural communities is altered (Nyhus & Tilson 2004).

The instability of the ecosystem can result in conflict between humans and native species. For example: introduced domestic cattle do not have the adequate resistance (immunity and reduced escape ability) to native predators and diseases to sustain themselves at acceptable economic levels without human assistance (Mishra 1997 and Messmer 2000).

Other biological factors relating to HWC are the biology and behavioural traits of the problem species or animals (Weladji & Tchamba 2003 and Fall & Jackson 2002). Biological information that is relevant to HWC that should be considered for the species is: anatomy, physiology, geographic variation, biomechanics and individual variation (Fall & Jackson 2002). Behavioural aspects to HWC are described in Holmern et al. (2004) where wildlife is said to know no boundaries and tend to roam freely, which affects the damage management of problem animals, as this involves: barrier technology, surveillance, capture techniques and behaviour dependent technology (Fall & Jackson 2002).

Conflicts that result from human introductions and altered environments are usually controlled through the regulation in density of the offending species. Depending on the social value of the species, it is usually the native species' numbers or density that is affected (Mishra 1997 and Fall & Jackson 2002). Madden (2004a) states that biological science alone cannot provide a complete understanding into HWC issues when mitigating HWC in a social setting, and thus the social dimensions in HWC will be investigated.

Social dimensions in HWC

The importance of considering the social aspects to HWC is highlighted by Manfredo & Dayer (2004) where they remarked that despite the diversity of situations and species in HWC globally, "the thoughts and actions of humans ultimately determine the course and resolution of the conflict". They focused on concepts for exploring the social aspects of HWC in a global context and proposed a micro – macro level model, which helps to explain the behaviour of individuals in specific HWC situations and gives a structure for examining HWC situations within a cross-cultural context. However, it does not explain the entirety of social dimensions in HWC which has multiple factors at different scales and all of which need to be investigated, as they relate to the diverse global nature of HWC.

The social dimensions of HWC that relate to the impacts caused by wildlife on society are health and safety, cultural and psychological factors (Decker et al. 2002). One of the most concrete social effects of HWC is observed in human fatalities and injuries caused by wildlife. Fatalities caused by wild animals are frequently publicised and tend to be sensationalized by the public. It is difficult to quantify the extent of wildlife damage or conflict in multiple regions, as there is no universal methodology in reporting cases and in many instances data is not easily available. Information on attacks also tends to be species specific and limited to a small area.

Cultural dimensions, beliefs and values influence how people react in different situations (Boyden 1992). McGregor (2005) states that 'actions of culturally embellished animals are fearfully entangled in understandings of social relations'. This means that due to the cultural linkage or value placed on a specific animal or species, people may condemn or label harmful actions against it as 'criminal or immoral'. In Malawi mammals are closely liked in the social life of people, as they are weaved into their culture, ethics and daily living. Some larger animals such

as elephant are so important to them that killing one is seen as committing homicide (Morris 2000).

Ethics are associated with morality (Babbie & Mouton 1998) and are usually agreed upon by a group of people and are associated with specific codes of conduct or norms. Ethical issues relate to the duties or obligations of man to animals and ecological systems as well as science and the general public (Minteer & Collins 2005). Ethical dimensions in environmental research are particularly important to HWC, as people have to deal with a volatile situation that involves the relationship between people and wildlife. A culture tends to have some shared ethics and is broadly defined as 'systems of shared meanings' (Mc Ewan 2001), therefore the way a certain group of people act or conduct themselves towards a certain situation (e.g. depredation on livestock by a wild predator) is influenced by their culture and shared ethics. However, groups of people are diverse and there is a misperception that communities act as whole units (O'Connell-Rodwell 2000).

The diversity within groups is seen in ranging attitudes to specific wildlife damage situations (Decker et al. 2002). Variation in attitudes towards predators is said to partially depend on the degree that the species conflict with human interests and the prejudices of people (seen in misconceptions about certain reptile species) [Lindsey et al. 2005]. Self-identity is potentially an important social-psychological dimension within HWC, as it is the composition of multiple identities or relations within a group of people (relating to family, religion, occupation, gender, race and the natural world) which affect the interaction between man and wildlife. In a larger context of social relations, it can easily become highly complicated in analyzing the social dynamics of HWC. However, reactions and attitudes to conflict situations can be gauged by a person's tolerance levels to a potentially harmful situation.

Tolerance of wildlife depends partly on how people perceive risks associated with HWC (Knuth et al. 1992 in: Decker et al. 2002) and this influences how they react or respond towards a certain conflict situation, as it is linked with fear and dread of a harmful event. For example: subsistence agriculturalists in Malawi are highly dependent on their crops and climatic variables (such as rain) for their livelihoods, while wild animals are seen as a liability and are a constant source of anxiety and concern for them (Morris 2000). During harvest time people guard their crops several weeks at a time in order to ward off baboons, as they have a low tolerance for these agricultural

'pests'. Predictors for tolerance were developed through surveys in Wisconsin, USA, where similar attitudes to wolves by humans were strongly linked to individual's social identity or occupation and education level (Naughton-Treves et al. 2003). The perception of risk by people is influenced by the degree of severity of consequences (Decker et al. 2002), for example: people camping in a wilderness area may be extremely afraid of bear attacks (perceived risk); however, the reality of it occurring is not very likely (actual risk).

Economic dimensions of HWC

Economic dimensions of HWC can greatly influence the success of conservation measures, where financial and other incentives (eg. education, access to services and employment) can influence communities' willingness and capacity to conserve wildlife or a natural resource (Emerton 2000). Mishra et al. (2003) state that there are few tangible economic returns (eg. compensation) to local communities who are living with wildlife and therefore they are unwilling and often unable to adopt conservation-friendly practices. Economic risks associated with HWC situations are seldom accurately assessed (Decker et al. 2002) and a cost-benefit analysis can provide a clearer view of the economic effects felt by communities resulting from HWC (Holmern et al. 2004).

Escalating land-use conversion from wilderness areas toward human-based activities can be seen as one of the major causes of HWC worldwide (Rao et al. 2002; Lindsey et al. 2005 and Mishra et al. 2003). This is also coupled with contraction of wildlife's habitat range (Patterson et al. 2004). As human activity continues to intensify in and around protected areas, wildlife is bound to threaten economic security and people's livelihoods. Conflict is expected to escalate because of man's development (modification of habitat) and when protected areas and authorities fail to deal with the conflicts adequately, local support for conservation declines (RAMSAR 2005).

Political dimensions in HWC

The political dimensions of HWC, which is seen in the regulations that relate to the protection of a problem species, is highly controversial, as it is these laws that restrict people from taking matters into their own hands. Conflict situations between wildlife and rural communities are often seen in the political and administrative arena, where it is suggested by Fergusson (2002),

that issues should rather be treated as a wildlife management or ecological problem. However, the political setting is important in shaping conservation regulations that relate to HWC. In Africa, the past colonial politics (that tends to exclude local people from protected areas) have had a great influence on conservation laws in the past. Various social and land use problems resulted together in conflicts between locals and wildlife authorities (Rao et al. 2002).

Political values also have an effect on people's attitudes towards wildlife (Naughton-Treves et al. 2003), such as in the case of native wolf species in Wisconsin, USA where the animals are seen as a negative symbol of federal intervention. Therefore, the wildlife managers bear the brunt of frustrations felt by the public who are opposed to the restrictive laws that are conflicting with their own individual rights. Carnivore conservation in Treves & Karanth (2003) is said to depend greatly on the socio-political setting of a region. Carnivore management is said to have changed from mostly economic goals to adaptive management that includes a better understanding of the environment, which is seen as a result of shifting political attitudes and views of policy makers and the public.

Other dimensions in HWC

Geographical (e.g. location of communities near wilderness areas), institutional and historic features as well as demography and livestock management techniques (e.g. herding techniques and protective measures) are other factors that are known to have an influence on HWC, especially in Africa.

Two factors that are particularly relevant to this study are human demographics and livestock management practices. Demography is an important aspect to consider when faced with predictions of HWC over time. Increasing human populations are a major cause of HWC (Fall & Jackson 2002) and as human populations expand, the interface between man and wildlife becomes larger, thus creating a higher chance for HWC to occur. Livestock management practices also have a great influence on the degree of wildlife- predator conflict experienced in rural regions. For example: in Botswana the management of livestock is minimal and losses via predators are high (Ogada 2001). Predators are attracted to prey on people's livestock which in turn damages the economy of rural communities. This can be a major stumbling bock when trying to promote conservation of a predator species.

Site specificity of HWC is common trend across the world, as issues are mostly linked to localised circumstances. The People and Wildlife Initiative [partnership between WildCRU (Oxford University's Wildlife Conservation Research Unit) and Born Free Foundation] (WildCRU 2005) suggest that HWC problems should be dealt with on a case-by-case basis fitted to a unique set of circumstances (social, cultural, economic and ecological). There is no "universal placenta" for HWC, even though similar principles apply to most problems.
With the above statement in mind, the principles and themes will be investigated with reference to human-crocodilian conflict worldwide.

2. The interaction between man and crocodile: Human-Crocodilian Conflict

Human-Crocodilian Conflict (HCC) is defined as any interaction between man and crocodile "which results in negative effects on human social, economic or cultural life, on conservation of the species or on the environment" (Fergusson 2002). There are eight species of Crocodilians in the world that are capable of attacking humans and their livestock (Fergusson 2004).

The interaction between Nile crocodiles (*Crocodylus niloticus*) and humans was recorded as early as 3000BC in ancient Egypt and also in 100 BC by ancient Greeks and Romans (Grenard 1991). Crocodilians are important symbols to many cultures, such as the Australian Aborigines, ethnic groups in Madagascar, Zimbabwe, some West African countries and New Guinea have described them as sacred and treat them with great respect (Lanhupuy 1987 and O Behra 1992). And the most extreme form of religious beliefs is seen in ancient Egypt, where the first King, Menes founded a city called Crocodilopolis after supposedly being saved by a crocodile that offered him a ride on his back. This ancient civilization worshiped the crocodile god, Sobek and mothers felt honoured when their children were eaten by a crocodile (Graham & Beard 1973).

However, most people have a loathing attitude towards crocodiles and regard them as 'pests' (Hutton et al. 2001) where crocodiles are described by Uganda's first game warden, Mr. C Pitman as "a foul beast (which) is typically a bully and a great coward" Graham & Beard (1973). For 17 years he waged a campaign to exterminate crocodiles in the country. Crocodiles are often seen as evil symbols and are even called the 'devil's mafia' and 'murderers'. The feelings generated are primarily sourced from the crocodile's nature which is described as violent. However, there are far more destructive predators in Africa such as lions, which are not seen to

be as evil as crocodiles (Graham & Beard 1973). Crocodiles were often depicted in Egyptian hieroglyphics as 'savage' creatures and were associated with mad men. In many cases the fear of being eaten by an animal is much greater than being killed by it. Symbolism of this fear is seen in the following statement: "To be eaten by a croc(odile) is to be consumed forever *by evil*" (Graham & Beard 1973). Another symbolic aspect of the crocodile is linked to their amphibious nature, which is to be ambiguous, unpredictable, obscure and therefore dangerous. Crocodiles are elusive creatures as they tend to spend most of their time out of sight and are usually only active at night.

Crocodilians, less than 100 years ago, occurred in vast numbers throughout the warmer regions of the world (Bellairs 1987). In more recent times the crocodile has become threatened due to the discovery of the commercial worth of their hides as prized leather. The demand for crocodilian skins is generated by the leather industry, where crocodilian leather products are prized as the costliest and most fashionable leather in many first- world countries (Ayensu et al. 1983). Due to the high demand of these luxury products, which greatly exceeded the supply, this resulted in a vast global exploitation of crocodilians and a resulting detrimental effect on the populations (Satiapillai & de Silva 2001).

In the late 19th century, 60 000 American alligators, *Alligator mississippiensis* were harvested from the wild annually and trade escalated into the 1940's when 120 000 Nile crocodile skins were exported annually from Madagascar alone (Hutton et al. 2001). From 1950-1960, 60 000 Nile crocodile skins were exported from East Africa annually and by the late 1960's nearly all wild populations of commercially important species of crocodilians were being exploited to some extent. Extensive hunting has had a devastating effect on wild crocodilian populations, as breeding adults were removed from the population.

However, economic incentives can work in favour of crocodilian conservation if certain laws are put in place to regulate the trade of skins. Hutton et al. (2001) stress that the economic importance of crocodilians has often resulted in stronger institutional planning for their conservation and ongoing management. The effective conservation of crocodilians often depends on the economic value that is given to a wild population, therefore providing tangible incentives for their long term sustainable management. The strongest factor affecting their survival today is said to be the quality of habitat rather than the level of exploitation or economic utilization of

crocodilian species. Economic interests and conservation often have conflicting interests if illegal trade isn't controlled (Hutton et al. 2001).

By 1975, CITES had listed most Crocodilians on either Appendix I or II in 1975 (CITES 1973 and Luxmore 1992). Appendix I listing states that no utilization of the species can occur and Appendix II allows for some restricted utilization to occur (with a limit on exports). In 1985 the Nile crocodile and some other species' listings changed from Appendix I to II within most countries, followed by Botswana (*C. niloticus*) and Congo (*C. cataphractus* and *Osteolaemus tetraspis*) in 1987. Following protection under CITES listings, many crocodile populations made a come back, e.g.) in Zimbabwe Nile crocodiles have become a serious threat to humans and their livestock due to increasing population sizes (Hutton et al. 2001).

In some areas human-crocodile conflicts have become a major problem, and this is one of the driving forces behind the implementation of sustainable management programs (Fergusson 2002). Human-crocodile conflict has been reported in 17 different African Countries, with the most HCC allegedly occurring in Kenya, Uganda, Zambia, Malawi and Mozambique. Other countries where the extent of HCC still needs to be investigated are Botswana, Rwanda, Ethiopia, Sudan, Democratic Republic of Congo and Tanzania. The crocodilian dimension in HWC is of immediate concern to crocodilian biologists, but it is largely been ignored by the larger conservation community (Fergusson 2002). This shows that there is an evident need to clarify and fully explain the dimensions of and need for research within this specific human-wildlife interaction.

In the United States and Australia crocodilians are seen as dangerous and undesirable creatures with economic consequences of HCC being a minor factor and focus has shifted to public education as a management solution (Butler 1987). In Africa, people have a higher economic and social dependence on the resources where crocodiles live and therefore the presence of crocodiles is felt more severely through financial and social costs. In Madagascar there was no motivation towards the protection of crocodiles, as the communities living in proximity to the crocodiles did not derive any benefit from them in the past and therefore they were considered a nuisance and were readily exterminated by locals (O Behra 1992). Since the development of a sustainable use program on Nile crocodiles, whereby crocodile eggs can be collected by locals from the wild, there has been a minor attitude shift from destructive views to those of coexistence with crocodiles.

Swanepoel (1996) states that the crocodile, together with hippopotamus, are responsible for the most human wildlife fatalities in Africa. However, this is only speculative as the status of many Nile crocodile populations and the incidents of attacks are mostly unrecorded in many African countries. Wildlife authorities in many countries are generally poorly equipped and ill-trained in assessment and alleviation of wildlife-human conflicts. There is also very little up to date information regarding wild crocodilian populations in most African Countries, where they are distributed and the status or health of the population (Fergusson 2002). The Nile crocodile is the largest Crocodilian species in Africa and is of great ecological and economic importance (Fergusson 2002) and is therefore highly worthwhile to investigate.

A lack of knowledge about specific crocodilian species within communities in a local dimension, can fuel the negative attitude that people have of this animal and can potentially aggravate conflict situations. The understanding of the ecology and behaviour of the different crocodilian species is of significant importance to long term HCC resolution. Crocodilians are generally seen as opportunistic or generalist feeders (Pooley 1982; Magnusson et al. 1985), which means that their diet is determined by the availability and vulnerability of prey. Crocodilian species' diet changes according to the availability of different prey species found in specific habitats (Magnusson et al. 1985). The crocodile is said not to make any differentiation between animal and human prey (Swanepoel 1996). Most attacks on humans recorded by Fergusson (2004) are seen as a result of crocodiles seeking food, and a few were a result of female crocodiles defending their nesting sites. However, susceptibility to attack is related both to crocodile and human behaviour, where human behaviour is seen in the activity of the person within the crocodile's habitat.

Water is an essential resource in rural Africa and many land-uses in rural developing countries involve the collection of water from natural and man-made water bodies. Other activities such as fishing and watering of livestock occur where crocodiles are likely to be present and thus the threat of attack increases (Fergusson 2002). The social dimensions of HCC are important, as they affect issues such as poverty alleviation and rural development (Fergusson 2002). Therefore, the effects of HCC become more detrimental to communities that have a lower economic status and derive their livelihoods from natural resources that are found in areas that coincide with the crocodile's habitat.

3. (i) Study area: The Okavango Delta, Botswana

The Okavango River System flows through three different countries: Angola (the source), Namibia (Caprivi Strip) and ends in Botswana in an inland delta (NRP 2001). The Okavango River originates in the highlands of Angola and flows some 1300km before entering Botswana. In Botswana the Okavango River System covers a total area of 20000km^2 during maximum flood and 16000km^2 otherwise. The Okavango River System in Botswana only covers 3% of the countries land area, yet an estimated 121,000 people live in 32 communities within the area surrounding the Okavango River (Mendelsohn & el Obied 2004). The urban population is 26% of the total population, with approximately 40,000 people living in immediate vicinity to, and have a direct relationship with the river for their livelihoods (Block 1993).

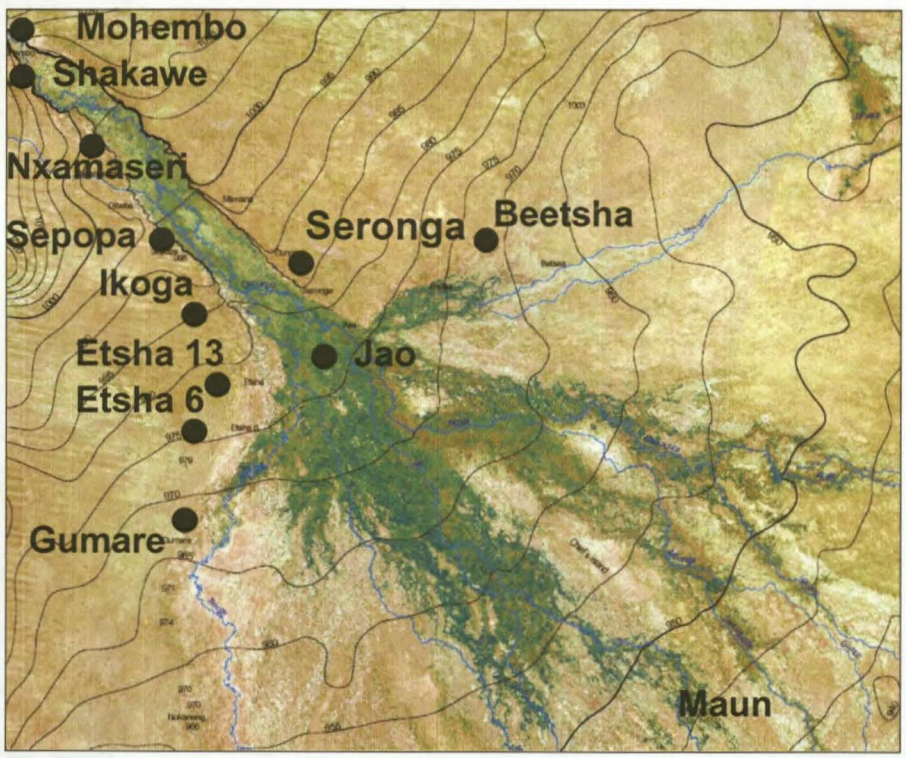

Figure 1.1: The study area, the Okavango Delta in Botswana (NRP 2001).

The Panhandle is a narrow stretch of river that is approximately 95km long, between 10 -15km wide (NRP 2001) and extends from the Namibian border at Mohembo in the north to below the village of Seronga in the south. It gradually widens and fans out into the flood plain which is a mosaic of open water, wetlands and grasslands and is extremely rich in natural resources (Kgathi 2001). The diversity in natural resources has somewhat contributed to the expansion of human

settlements within close proximity to the Okavango River and Delta. The population in Ngamiland (the district where the Okavango River System is situated) is very unevenly distributed with large areas being unpopulated, with a higher concentration of people in villages or towns following the main road from Maun (the district centre) to Mohembo in the northwest (Kgathi 2001).

Rural activities such as fishing, livestock grazing, collection of reeds and other building materials, fuel, production of crafts and hunting are important aspects in the rural economy. The development of agriculture in the region is limited by the soils and climate which mostly results in production at a subsistence level (Mendelsohn & el Obied 2004). Agricultural activities are usually isolated to a narrow strip near the banks of the Okavango River.

Apart from the value of the Okavango River System derived from the rural subsistence and agricultural population, the system is identified as an area of high ecological importance. There are numerous bird species, unique large mammals and over 160 species of reptiles have been identified, including the Nile crocodile (*C. niloticus*). Most large mammals are found in the western region of Botswana, with a greater diversity in the north-west (Okavango Delta Region) compared to the eastern region of the country, where there has been a decline in wildlife due to displacement by human settlement and other related activities (Government of Botswana 1998).

The dynamic flow regime of the Okavango River has a profound effect on the ecological processes such as water distribution and sedimentation of the different river channels. The annual flow of the river ranges between 7000-15000 million m^3 and 97% of the water that flows into Botswana is lost to evaporation, the remainder (3%) seeps into the ground water which flows south towards the Makgadikgadi Pans (Ramsar 2000 and Mendelsohn & el Obied 2004).

The majority of the land-use is for conservation with 7% of the Okavango Delta falling within Moremi Game Reserve under the National Parks Act of 1992 and 65% of the Okavango River System is protected as a Wildlife Management Area under the same Act. This Act allows for the non-consumptive and consumptive use of wildlife (NRP 2001). With the remaining 28% of the area allows for agricultural and residential development (Ramsar 2000).

(ii) Study animal: *Crocodylus niloticus*, with reference to the Okavango Delta, Botswana

The Nile crocodile, *C. niloticus* belongs to the class Reptilia and its natural distribution covers 42 countries in Africa and varying degrees of HCC has been reported in most of these countries (Fergusson 2002). Its geographic range stretches from below the Saharan Desert southwards into South Africa, excluding the southwestern and central region of the country (Grenard 1991). The species is also found in Madagascar and historically was abundant in Egypt and Israel, however is now only found in the far southern region of the Nile River, in Lake Nasser.

Habitat preferences of the Nile crocodile are freshwater wetlands, including lakes, rivers, coastal and brackish swamps (Grenard 1991). They are capable of swimming a fair distance out to sea, as indicated by their presence in Madagascar. They are remarkable creatures as they have not changed in body form for over 200 million years, which shows that their form is extremely effective in coping with the changing environment that it lives in (Butler 1987). Dietary aspects of the Nile crocodiles are most notably influenced by temperature, as crocodilians stop feeding at extreme temperatures and their optimal foraging temperature is between 25-35°C (Grenard 1991). Nile crocodiles eat a great variety of prey types and their diet changes with age or size class and also varies between habitats (Blomberg 1976 and Pooley & Gans 1976).

Behavioural aspects relating to prey capture and location are dependant on the role of senses of the Nile crocodile. Vision, smell and hearing are all well developed in crocodilians and this enables them to make precise judgments when locating and seizing prey. The Nile crocodile is primarily a nocturnal aquatic feeder (Graham 1968) and predatory activity usually peaks in the early evening. However, they are known to feed freely during the daytime as well (Cloudsley-Thompson 1964 in Pooley 1982). Prey capture depends on the availability of the prey species, rather than the time of day or night (Pooley 1982).

The Nile crocodile is a keystone species in the Okavango Delta (Leslie 2003) as it has an influence over many trophic levels and is therefore an integral part of the whole ecosystem. Even though crocodile management and conservation policies were documented by Simbotwe (1988) and nest monitoring programs developed by Graham (1976), there is currently no management plan that is being implemented for the Okavango Nile crocodile population. The Nile crocodile is listed under CITES II (Convention on International Trade in Endangered Species of Wild Fauna and Flora) (1973) in Botswana as *Crocodylus niloticus* **-110. This stipulates that although this

species is not currently threatened with extinction, it may become so in the future if trade is not subject to strict enforcement and regulation. It also states that this population is geographically separated and is subjected to annual export quotas from ranching and crocodile farming.

The current status of the Nile crocodile population within Botswana is easily affected by the negative influence of man on its habitat and the direct removal of animals and eggs from the Okavango River System. Recent studies (unpublished research by Dr A Leslie 2004) show that 99% of the crocodile nests in the Okavango River System occur close to the deep-water channels of the northern Panhandle. This area is under increasing pressure from livestock farmers and rural communities who depend upon the river for numerous purposes. The alteration of the natural habitat of the Okavango River is noted by the burning of papyrus and *Phragmitis* reeds which increase palatable fodder for livestock along the river (Cassidy 2003). The survival of crocodile species in Africa is greatly dependant on the quality of its habitat (Swanepoel 1996) and therefore the situation in the Okavango River System is particularly concerning.

(iii) The people of the Okavango Delta, Botswana and their land use practices

The Okavango Peoples consist of five ethnic groups, who are distinguished by their unique language and culture. They are the Bugakwe, Hambukushu, Dxerike, Wayeyi and Xanekwe, each of which has various sub-groups (Block 1993). The Hambukushu, Dxerike and Wayeyi are Bantus that are involved in mixed economies of agriculture, fishing and pastoralism, while the Bugakwe and the Xanekwe are Bushmen that are traditionally hunter gatherers. The Batwana people are not included as they are traditionally savanna pastoralists and live in areas surrounding the Okavango River System. Smaller ethnic groups such as the Ovaherero, Ovambanderu and other Bushmen groups also live in the region of the Okavango, but intermarriage is becoming increasingly more common within these groups.

Over the last 150 years the Hambukushu, Dxerike and Bugakwe people have inhabited the Panhandle and the north eastern region of the Okavango Delta. The Xanekwe live in the Panhandle region and also near the Boro and the Boteti Rivers in the extreme south of the Delta. These people are nomadic and have traditionally moved away from the delta during the summer months when there is an availability of resources away from the river and return to the river in the dry season. This seasonal movement promoted the sustainable use of resources in the delta, as it allowed for recovery and regeneration of plants in the times when they were absent from the

area (Kgathi 2001). The Wayeyi, whose ancestral home is in the Caprivi Strip of Namibia, are now located primarily around Seronga and in the southern Delta near Maun. However, in the early 1970's over 4,000 Hambukushu refugees from Angola immigrated to the western region near Etsha and within the last 20 years there has been a vast migration of people in the Okavango Region to the district centre of Maun in the south of the Delta.

Many ethnic groups, like the BaYei, the BaTawana, the HaMbukushu, the OvaHerero and the River San, who have different perceptions on land and natural resource utilization, are presently living mainly along the fringes of the Okavango Delta and are involved in these rural activities (Ramsar 2000).

(iv) Human-crocodile (Nile crocodile: *Crocodylus niloticus*) conflict in the Okavango Delta, Botswana

The Nile crocodile exists in the few perennial wetland ecosystems in Botswana, which include the Chobe/ Linyanti and Kwando Systems and the Okavango River and the Okavango Delta (Thorbjarnarson 1992). The estimated Nile crocodile population size in the Okavango River System is 5,704 - 6,608 (Simbotwe 1990 in: Thorbjarnarson 1992). It is important to note that this information is outdated and may not accurately describe the situation in the Okavango Delta at present, as it is more of a broad estimate determined by aerial and nesting surveys conducted from 1973-1979. The status of the Nile crocodile in Botswana is said to be depleted or vulnerable (Thorbjarnarson 1992) and is affected by human activities that influence crocodile nesting habitat (Shacks unpublished).

Reports regarding crocodile attacks on humans and livestock are available from the Problem Animal Control Unit of the Department of Wildlife and National Parks (DWNP) who are responsible for managing HWC problems within the district of Ngamiland. Conflict resolution is undertaken through various means by the DWNP: Management practices include: (1) monetary compensation for livestock killed by various predators and (2) the control of dangerous wildlife that may threaten people's livelihood. The wildlife authorities generally lack adequately trained staff (Government of Botswana, 1998) and resources to initiate an effective assessment of the Nile crocodile population, let alone investigating the extent of HCC within the Okavango River System. The management of various wildlife species by the DWNP is therefore based on inaccurate wildlife population censuses and other outdated data sources and this may result in

well intentioned but ill-informed decisions on the alleviation of human-wildlife conflicts (Fergusson 2002).

In order for HWC to be accurately applied to a specific species it is important to refer back to the definition of HWC (in section 1). RAMSAR (2005) stated that "HWC occurs when the needs and behaviour of wildlife impact harmfully on the goals of humans or when the goals of humans harmfully impact the needs of wildlife". Therefore one must look at (1) aspects of the Nile crocodile's behaviour, biology and needs that can harmfully affect the local community *and* (2) aspects of local communities' goals or actions that harmfully affect the Nile crocodile.

It is expected that the Nile crocodile's behaviour in Botswana should be similar to other Nile crocodiles in Africa; however, behaviour is shaped by local conditions as seen by the opportunistic and unpredictable nature of crocodiles in different habitats. Some generalizations are made by Fergusson (2004) where adult crocodiles which are blamed for most attacks, however their diet primarily consists of fish and they are adaptive, intelligent animals that can become accustomed to human disturbance such as utilization of the river and noise. This behavioural trait of the Nile crocodile is only a perceived cause of human attacks. Generally wild crocodiles are expected to move away from a threat (e.g. hunting, motor boats and fire) and into areas that are more pristine with less anthropogenic disturbances.

Behavioural aspects of Nile crocodiles relate to a larger understanding of predation and also more specifically to HCC. The Nile crocodile is an elusive creature and there are very few studies have been undertaken on crocodilian behaviour in the wild. One can only attempt to make inferences on behavioural predatory aspects that relate to HCC through studies into broader topics such as: predator-prey relationships, optimal foraging behaviour, feeding and dietary requirements. Field observations from other studies can also be used to try and draw out the patterns and causes of attacks on humans and their livestock. Pooley (1982) states that it is not possible to conclude if Nile crocodiles are selective in their prey type with reference to other available species. However, the nature of prey species (i.e. if they are domesticated or wild) does have an effect on susceptibility to predation, as domesticated animals lack caution and are more vulnerable to attack than are wild animals.

Harmful effects on the Nile crocodile by humans can be seen through the history of hunting for crocodile skins. Exploitation of the Nile crocodile in Botswana by hide hunters and crocodile

farmers has occurred ever since 1957 and three distinct periods of exploitation were noted. In the period 1957-1969 some 50 000 crocodiles were removed from the Okavango River and Delta (Pooley 1982). During this time annual quotas of 2000 crocodiles were given to two hunting concessionaries by the Department of Wildlife and National Parks (DWNP). By 1969 organised hunting of crocodiles was stopped supposedly due to depressed population numbers.

In 1973 hide hunting was resumed by the Botswana Game Industries which were allocated an annual quota of 500 crocodiles, but in the following year the quota was not filled. This was consequently due to low crocodile densities which suppressed the economic viability of crocodile hunting. From 1983 to 1988 after a decade of supposable recovery, crocodile farmers removed 1053 live adults and 14 000 crocodile eggs from the Okavango River. By 1987 nesting surveys showed that this harvesting period caused a 50% reduction in the breeding population of the Nile crocodile. Presently an annual quota of 2000 eggs, together with small scale hunting quotas of adult crocodiles is legally permitted by the DWNP in Botswana.

Crocodile farming and ranching is a highly lucrative business, where the total world trade of 80,000 Nile crocodile skins was recorded in 1993. The majority of skins which were legally traded came from Zimbabwe (54%) and South Africa (15%) (Fergusson 2002). More recently CITES has developed a sustainable yields program which emphasizes crocodile ranching as a preferred means in obtaining conservation benefits through the utilisation of the Nile crocodile. Long established ranching programs in Botswana, Zimbabwe, Zambia, Malawi and Mozambique were permitted under CITES ranching criteria with no limit on exports. In Botswana crocodile farming/ranching operations started in the early 1980's and farms have actively collected eggs from the wild which they breed in captivity.

The measure of tolerance (and attitudes) towards the Nile crocodiles in Botswana can be broadly predicted through the generalized attitude in Africa of most reptiles as "the only good snake is a dead snake" (Fergusson 2002) which could be a major obstacle in effective conservation of the Nile crocodile population in the Okavango Delta. One cannot broadly predict attitudes in communities, as they may be diverse and it is therefore worthwhile to directly investigate the range of attitudes towards these creatures in a local setting.

Investigating the trends in HCC in the Okavango Delta, Botswana will help to provide a clearer view on the different factors that play a role in HWC of this notorious predator and will help in

assessing the overall extent of HCC in Africa. One of the main hypothesis' that is expected is that a high occurrence of conflict should occur where the human population density is high together with a high livestock density in proximity to the river's edge.

(v) Introduction to the research problem

The extent or status of human-crocodile conflict in Botswana is virtually unknown and no research has yet been attempted to assess this problem and the impacts it has on the local community. The only information available relating to HCC is through reports of attacks on livestock and humans that are gathered by the Department of Wildlife and National Parks in Botswana and even these records are incomplete. Fergusson (2002) stresses that attention should not only focus on the number of human fatalities and livestock attacks that are caused by crocodiles, as this fails to capture the entirety or diversity of HCC impacts. A more in depth approach that looks into multiple dimensions of HCC, needs to be undertaken in order to properly assess the extent of HCC in the region surrounding the Okavango Delta, Botswana.

(vi) Aims and Objectives

The aim of this study is to determine the extent and severity of human-crocodile conflict in the Okavango Delta, Botswana and to provide mitigation measures that can be adopted by local communities to prevent attacks and to make poli cy recommendations to the Department of Wildlife and National Parks.

Primary Objectives:

1. To investigate the extent of human-crocodile conflict in the Okavango River System, Botswana with reference to humans and their livestock.
2. To assess the spatial and temporal distribution of human-crocodile conflict in reference to external factors, such as human population demographics and livestock density.
3. To provide practical recommendations that can be used by local communities and DWNP officers for the mitigation of human-crocodile conflicts in the Okavango River System, Botswana.
4. To provide recommendations for policy in mitigating human-crocodile conflict.

4. Methodology and Report Layout

4.1 Research Methodology

Various information resources will be used to generate a complete overview of the extent of HCC in the Okavango River System, Botswana. The following quantitative resources will be used: interviews from various people in close proximity to the Okavango River; population census statistics (2001) for the various communities within the study area; records of the provision of water taps to communities from the Water Unit (a section of the Department of Local Government and Development) and records on livestock and human attacks by various predators from the Department of Wildlife and National Parks (DWNP). Additionally the division of Problem Animal Control, hospitals and clinics will be visited as well as the police and Botswana Defence Force (BDF). The qualitative sources of information will be gathered from community discussion groups and key informants including interviews with chiefs or headmen of major villages and available literature resources will be reviewed.

Secondary objectives investigated:

1. The number of attacks by the Nile crocodile on humans and livestock and its distribution over various categories.
2. Investigating the attitudes, perceptions and traditional beliefs of the Nile crocodile within the region of the Okavango River System, Botswana
3. General factors relating to HCC: land use practices, human and livestock population density, degree and type of utilization of river resources and ecology of the Okavango Delta.
4. HCC factors that are potentially compromising people's livelihoods. Looking at human population dynamics and other relating trends, rural livelihoods in reference to the cost or burden of living in the vicinity of the Nile crocodile.
5. Mitigation techniques for the resolution of HCC relating to local factors: prevention and incentive based techniques, education, community participation and consultation.
6. Obstacles that hinder the long term resolution of HCC within the context of local factors in the study region.
7. Policy measures that relate to HCC in Botswana: CITES Appendix II listing, problem animal control, compensation strategies for wildlife damage, crocodile ranching/ farming regulations (Department of Wildlife & National Parks, Botswana) and water use regulations.

Interviews

The need for a standard reporting procedure within the larger HCC issue in Africa is necessary for the collaborative effort needed throughout African countries in addressing HWC resolution in a rural context. Therefore, Crocodile Specialists who are involved in research projects within Africa, together with a sociologist, were consulted in the procedure and formatting of the questionnaire that will form a large component of this study. The interviews were conducted over a three month period between June 2004 and July 2005.

Interviews were conducted with the aid of an interpreter following a certain format and methodology. The researcher and translator introduced themselves to the interviewee and provided background information on the entire study (ie: the Okavango Crocodile Research project). The specific aim of this portion of the project, namely HCC, was then explained. People were given the option to decline the interview. With each interview the name of the interviewee was requested (optional) and a reference number was recorded, so as to prevent replication. The questionnaire was comprised of three main sections: general remarks and comments, livestock attacks and human attacks. The researcher would ask the questions and the translator would translate into the language best understood by the interviewee. The response from the interviewee was translated back into English and recorded directly onto the questionnaire.

Other information sources

Dates of the placement of water taps in the various villages were obtained from the Water Unit (Department of Water Affairs) and provided information on the utilization of the river's water supply by communities. Population statistics were obtained from the population census in 2001 for Ngamiland District at the Department of Home Affairs and other data sources were derived from Mendelsohn & el Obeid (2004) and Harry Oppenheimer Okavango Research Centre, University of Botswana (pers. comm.). This helped to determine the relationship between attacks and demographic characteristics of the human population. DWNP records of attacks and compensation payments from 1999-2005 for attacks by crocodiles and other problem animals were compared to data gathered from the interviews.

Community workshops on current HCC issues took place in selected villages where the perceived conflict was high. This helped to inform people of the HCC situation and allowed people to participate in providing practical recommendations and share their views between the community

members. Key informants, conservation experts and people directly involved in HWC in Botswana were consulted/ interviewed on their insight into HCC in the Okavango Delta Region. This includes Ms. K Alexander (CARACAL: Centre for Conservation of African Resources: Animals, Communities and Land Use), Dr R. Fergusson (Crocodile Specialist Group), Dr. G Webb (Crocodile Specialist Group) and Prof. M Manfredo (Colorado State University).

Unless otherwise indicated, all data provided in this study was obtained from the interviews held in 2004 and 2005.

4.2 Analysis

Analysis was performed using the Statistica for windows 7.0 programme (StatSoft inc., USA) and Microsoft XP professional. The questionnaire was analysed to derive Regression analyses, Chi-square tests, tables and figures. Not all questions from the surveys were used in the analysis, as they are qualitative and cannot provide specific quantifiable results. However, these questions were used to draw out further issues and used to understand attitudes that relate to the situation. For each question that was used in the data analysis, the various answers by the interviewees were divided into different categories and frequency distributions to highlight certain trends within the database. Mapping of the spatial data relating to attacks on humans and livestock by crocodiles was performed using Arcview Version 3.1.

4.3 Report Layout

There are six chapters in total and each focuses on various aspects of HCC in the Okavango Delta, Botswana. Chapter two investigates the general attitudes of the Batswanan people towards crocodiles and also their utilization of the Okavango River and its resources. Chapter three investigates the extent of HWC in the Okavango River System with reference to humans and their livestock, which is the first objective of this study stated previously. Chapter four assesses the spatio-temporal distribution of HCC in reference to external factors, such as human population demographics and livestock distribution (which is objective two). Chapter five provides recommendations for local communities and policy recommendations (which is objective four) that are relevant to the government sector in mitigating HCC. Chapter six is the

discussion and conclusion of all the above mentioned chapters and includes management implications of HCC in the Okavango Delta.

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CHAPTER 2

GENERAL ATTITUDES OF THE BATSWANAN PEOPLE TOWARDS CROCODILES & THEIR UTILIZATION OF THE OKAVANGO RIVER AND ITS RESOURCES

1. INTRODUCTION

The investigation of HCC in the Okavango Delta, Botswana, requires an examination of the local people's degree and type of utilization of the river's resources, traditional beliefs, attitudes and other factors that directly relate to the interaction between crocodiles and humans (e.g. frequency of crocodile sightings). Gauging the attitudes of local communities towards crocodiles will help to provide a sociological background and tolerance levels can then be estimated (see Chapter 1). This means that the reaction of people towards crocodiles can be gauged and can provide insight into potential obstacles faced when mitigating conflict.

Since the Okavango River System is perceived as a 'life force' to both crocodiles and humans in terms of ecological and economic value of its resources, it is therefore important to assess the level of dependency that the local people have on the surrounding resources and how this may affect the Nile crocodile population. Local people's degree of utilization of the river and its resources affects their level of exposure to crocodiles and the possibility of attack can be gauged in relation this. Naughton- Treves et al. (2003) state that tolerance levels are possibly linked to occupation or social identity of affected people and therefore a person's activity (e.g. fishing) in the river could be linked to their attitude towards crocodiles.

The main land-use practices in the Panhandle Region are livestock farming and agriculture (Bock 1993 and Mendelsohn & el Obied 2004). The majority of farmers keep small herds of cattle or goats (the dominant livestock type in Ngamiland) and only a small proportion of people own a large number of animals. Agricultural activities only generate less than one fifth of all rural income in the Okavango Region of Botswana. These crops are grown on sandy soils that are generally poor in nutrients and yields are low per hectare (100-160 kg/Ha produced per year) (Mendelsohn & el Obied 2004). The predominant crops that are grown are millet, maize and sorghum. Most fields are situated close to the owner's households and seasonally flooded areas

are not generally used for crops. Most farmers in the region rely on seasonal rainfall to grow crops such as millet, maize and sorghum; however other crops, such as vegetables require irrigation.

Other rural activities include the collection of natural food products (e.g. water-lily roots, berries, nuts and fruits), cutting of reeds and papyrus, fishing, collecting of wood products (e.g. thatching grass and poles) and making of crafts (e.g. baskets and wood carvings). An estimated 3,200 people are known to fish in the river and there are two commercial fishing operations (funded by local government grant schemes) with the remaining 99% being small scale subsistence fishermen/women (Mendelsohn & el Obied 2004). Most of the fishing activity occurs within the Panhandle as there is ready access to permanent water and generally larger fish stocks.

There has been a collapse in the fishing industry within the last eight years, due to a decline in fish stocks and this has potential detrimental economic and ecological impacts on the Okavango River System (Mendelsohn & el Obied 2004). The decrease in fish population could be attributed to the use of gill and mosquito nets in recent years and an estimated average of 400 tonnes of fish are removed from the river each year (270 tones via subsistence)(Mosepele 2002). The importance of fish as an essential food resource for both humans and crocodiles can be a possible cause of conflict within the Okavango River System.

Sample size and composition

In a study by Bauer (2003), on local perceptions of Waza National Park in northern Cameroon, sociological questionnaires were conducted in 10 out of 25 villages surrounding the National park. They interviewed approximately 10% of the population by visiting every tenth household and a total sample size (N=236) was sufficient for statistical testing and gave significant results. They did state that in order to achieve a sufficient sample size, the interviews were limited in length and covered only a specific topic. Decker et al. (2002) suggested that a sample of 500 people should be adequate on a 'state-wide' or regional scale for the assessment of farmer's acceptance levels of the indigenous deer population. In other HWC studies, sociological questionnaires were conducted where 13 villages surrounding a sanctuary were sampled and this consisted of 19% of the population affected by HWC (Mishra 1997). They interviewed at least one person from each household and questions mainly focused on losses of livestock to wild predators. In Naughton-Treves et al. (2003) a mail-back survey/questionnaire was used to assess

the tolerance of 535 people towards wolves in rural areas of Wisconsin (U.S.A). The sample composition was a mixture of non-random and randomly sampled people from four different groups with varying sample sizes. They focused their sampling on individuals that were suspected to have elevated probability of damage caused by wolves (such as livestock owners and hunters). Focusing of the survey on HWC affected individuals aided in understanding of tolerance levels and compensation payments (together with other factors) had on the management of 'problem' wolves.

2. METHODOLOGY

A three part sociological based questionnaire was used to assess the extent of HCC in the Okavango Delta. The first section (the focus of this chapter) provides basic information regarding the interviewee [location of report, age, name (optional) and gender] and contains questions that are used to assess people's attitudes towards crocodiles and their utilization of the river. Traditional beliefs and whether crocodile eggs or meat are consumed are also included in this section. The other two sections of the questionnaire relating to human and livestock attacks are reported in Chapters 3 and 4.

Sample size was restricted to less than 10% of the population, due to sampling restriction and logistics, and a very large population within the Ngamiland District (total of 88 000 people). Villages within the study site were selected based on total population size and relative proximity to the Okavango River. The area was divided into three regions: Western Region, Eastern Region and the Southern Region. Interviewee sample size per village was based on population size (Table 2.1).

Table 2.1: Interviewee sample size with reference to total village population for the study region of the Okavango Delta, Botswana.

Village population size	**Average sample size (number of persons)**
0- 499	5- 10
500-999	10
1,000- 1,999	15
>2,000	20+

An attempt was made to interview one person per family household so as to prevent replication of the number of attacks by crocodiles on livestock and humans. The questionnaires were conducted in such a way as to provide general representation of the population in all age groups including children older than 13 years, adults (18 - 64 years) and elderly people (>65 years). Random sampling and confidentiality were maintained.

Data was analysed according to:

1. Distribution of sample size according to the following categories: gender, age classes, villages and regions.
2. General trends of feelings/attitudes towards crocodiles, utilization of river resources, frequency of crocodile sightings and traditional beliefs.
3. Cross comparisons were conducted to show possible trends giving a more concise view of the HCC situation in the Okavango Delta, Botswana.

3. RESULTS

3.1 Sample distribution

Sample distribution within various villages, regions and together with population size (Population census 2001) is shown in Table 2.2. Sampling within villages was not uniform due to the availability of interviewees (many people were not at home when sampling occurred), distance from river, time and resource constraints. Sampling in Tsao village was abandoned when it was discovered that the river's course had changed since the early 1980's and was no longer in close proximity to the river.

Table 2.2: Sample stratification of interviews within various villages. The area was divided into three regions (West, East, South & Delta), together with the population size of villages in 2001 (Population Statistics 2001). [Village* were sampled in 2004. n/a: population statistics not available for village.]

Reference number	Village	Region	Sample size	Population size (2001)
1	Shakawe *	WEST	24	7,874
2	Mohembo West *		15	1,726
3	Ikoga *		39	1,414
4	Etsha 1 *		8	614
5	Etsha 4 *		10	276
6	Etsha 6 *		22	5,613
7	Etsha 13		21	1,975
8	Nxamasere* & Samoro		18	1,466
12	Samochima* & Ukusi		24	847
13	Xhauga *		5	390
14	Gumare *		22	7,478
15	Sepopa *		20	2,308
16	Kavxwi *	EAST	11	1,631
17	Xakao *		15	1,777
18	Sekondomboro *		10	655
19	Ngarange *		12	1,987
20	Mogotlho *		5	n/a
21	Badiba *		5	63
22	Mohembo East* & Garoxwo		21	580

23	Dungu cattle post	EAST	10	82
24	Seronga *		21	3,043
25	Shaowe		10	557
26	Eretsha		10	616
27	Gonutsuga		10	556
28	Beetsha		10	2,832
29	Jao	DELTA & SOUTH	20	234
30	Tsao		1	304
31	Tabazimbi/ Gunns		14	212
32	Oddballs/ Nxhaga		16	n/a
33	Xaxaba		13	79
34	Maun		40	49,822

Table 2.3 provides a summary of sampling for the various regions. The variation in distribution of sampling throughout the regions is due to the uneven spatial distribution of the rural population. Village density is highest closest to the main transport route in the western region of the Okavango Delta. There are very few villages in the delta and they are isolated and difficult to reach. For example: access to Xaxaba, Oddballs camp/Nxhaga and Tabazimbi/ Gunns camps was gained via light aircraft due to high flood waters at this time.

Table 2.3: The three sampled regions, the number of villages sampled per region and the total number of individuals interviewed per region.

Regions	Total number of villages sampled (no. of villages)	Total sample size (no. of persons)
East	13	150
West	12	228
South & Delta	6	104
Total	**31**	**482**

Sampling took place in June and July 2004 (N=241) and in June and July 2005 (N=241). The total population within the villages sampled was 97 011 people and the percentage of the population sampled within study site was 0.497% (Population Statistics 2001). The average number of people recorded per household was six (S.D = 4.3; Range: 1-26). The sample size was extended to include the whole household; therefore the total sample size was 2892 people, which is 2.981% of the population sampled within the study site.

The majority of people interviewed were adults (83%) followed by the elderly (14%) and only 3% of the interviewees were children (Figure 2.1). The adult majority within the sample was due to the fact that the head of each household was usually interviewed. The distribution of interviewees by gender was 55% female and 45% male. The majority of sampling was focused within five kilometres of the main channel of the Okavango River.

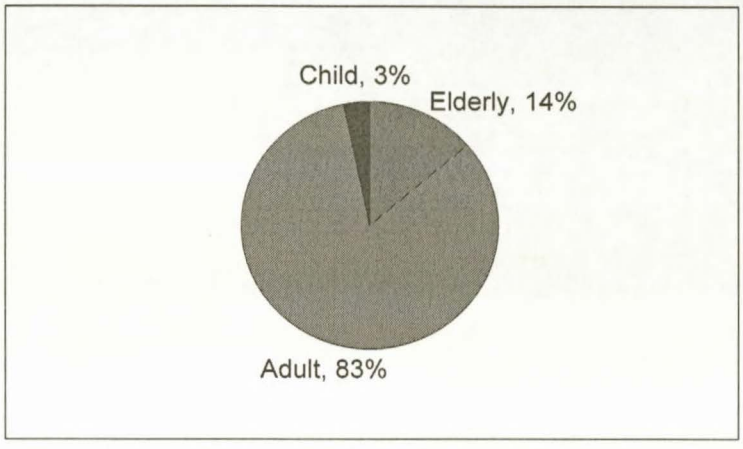

Figure 2.1: A pie chart showing the percentage of interviewees in the three specified age categories (child: 13-17 years, adult: 18-64 years, elderly: >65 years).

3.2 Utilisation of the river and its resources

Figure 2.2 shows the cycle of different annual processes in the Panhandle Region of the Okavango River, Botswana, such as rainfall, fire regimes and water levels (NRP 2001). The utilisation of resources is linked to biotic factors; such as reed collecting, which occurs in October/November when the water is low and access to the reeds is easier. Grazing is focused near the river's edge in the dry season (September-December) when there is little grazing further away from the river due to low rainfall.

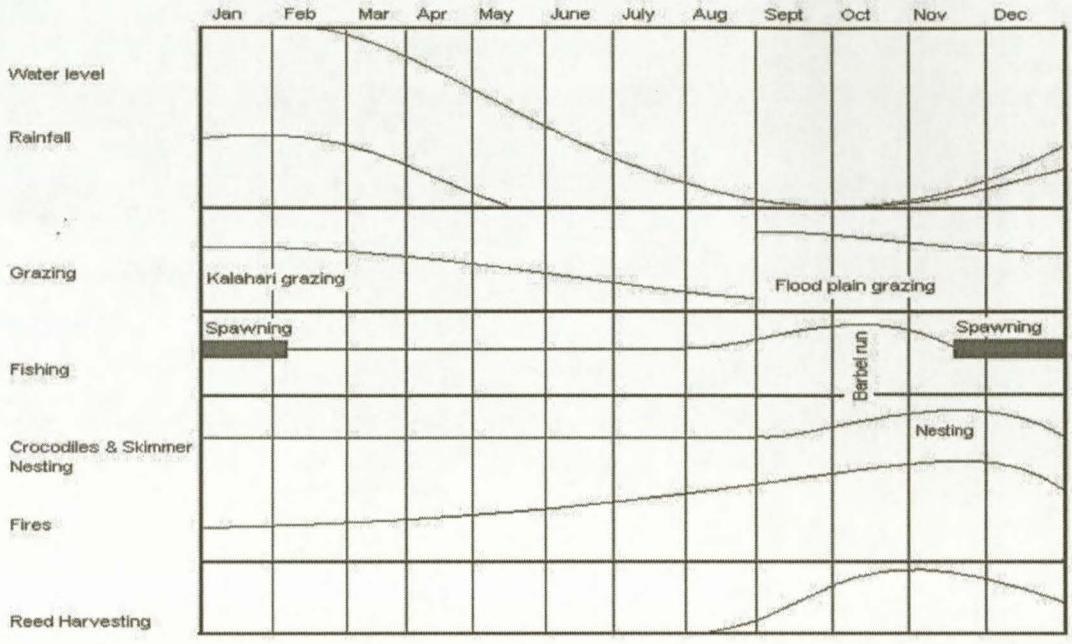

Figure 2.2: T he relative intensity of different factors and annual activities occurring in the panhandle of the Okavango Delta, Botswana (NRP 2001).

There was a high utilization of the Okavango River resources by the interviewees (89% utilize the river for various purposes). The majority of the interviewees use the river for only one activity (28%, Figure 2.3), but a large percentage of people also utilize the river for two or more activities.

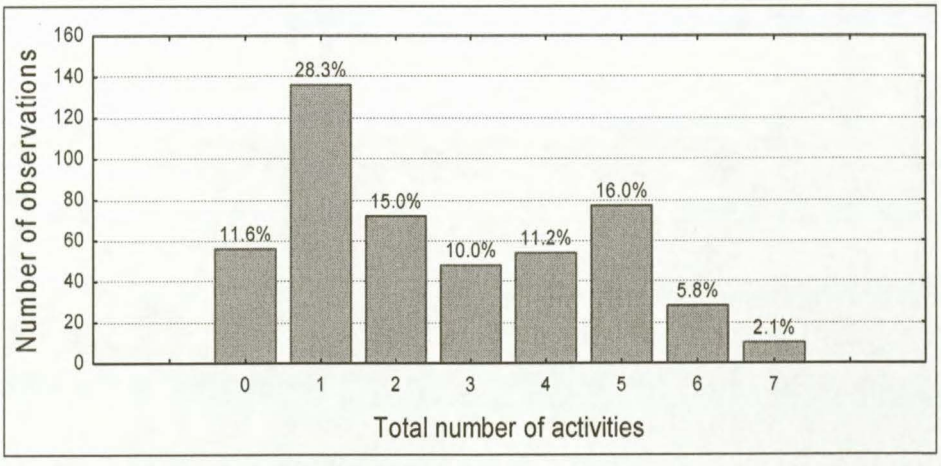

Figure 2.3 Histogram showing the percentage of interviewees within the total number of activities that they perform at the Okavango River, Botswana.

Table 2.4 shows the percentage of interviewees that utilise the Okavango River for specific activities/purposes.

Table 2.4 The percentage of interviewees that perform various activities near or in the Okavango River versus the percentage of people that do not perform these activities.

Activity	Percentage of interviewees within the sample that perform this activity	Percentage of interviewees within the sample that do not perform this activity
Collecting drinking water	42%	58%
Drinking water for livestock	7%	93%
Washing	41%	59%
Reed cutting	74%	26%
Recreation	5%	95%
Fishing	43%	57%
Swimming	26%	74%
Collecting water lily roots	19%	81%
Guiding clients	5%	95%
Irrigation	2%	98%

The percentage of interviewees that use the river for drinking water, washing and fishing were similar, namely 42%, 41% and 43%, respectively. These were seen as the most common activities performed by local people (pers. observation). The percentage of interviewees that collect reeds was very high (74%). Recreational uses of the river (5%) are primarily related to tourism activities such as boating, bird watching and scenic tours. Guiding of clients (5%) is a tourism-based activity that is conducted through the use of 'mekoros' or wooden canoes. This activity can be potentially dangerous, as tourists seek out wildlife such as hippopotamus, crocodiles and other large animals and canoes are unstable. Water lily roots are a minor food source for the local people and are seen as a delicacy and since it is not part of the local people's staple diet, the low percentage of people who utilize this resource is expected. See Addendum 2.1 for examples of people fishing in mekoros and women collecting water lily roots.

Less than half of the people interviewed utilize the river for drinking water and very few said they use the river for watering their livestock. However, this may be misleading as this category of utilisation was only included in the questionnaire at a later stage and this is therefore not a true representation of the degree of utilization of the river for this purpose. Interviewees also tended to group domestic drinking water together with drinking water for livestock, even though the

watering points may be separate. This may have resulted in fewer people saying that they utilize the river for watering livestock than anticipated. Water for domestic purposes is supposed to be fenced to keep livestock away from the communal water taps (see Addendum 2.1 for an example).

3.3 Frequency of sighting crocodiles

The frequency of seeing a crocodile is linked to the amount of time a person spends in crocodile territory and the abundance of crocodiles in the region. Figure 2.5 shows the percentage of people that have never seen a crocodile (23.5%), those who see them now and then (7.5-18.5%) those that see them daily (26.6%). The 'daily' category may have been misinterpreted, as some people said they saw crocodiles daily when they were undertaking a certain activity. However, it was later discovered that these activities do not necessarily take place on a daily basis per se, so the results could possibly be an over-estimate.

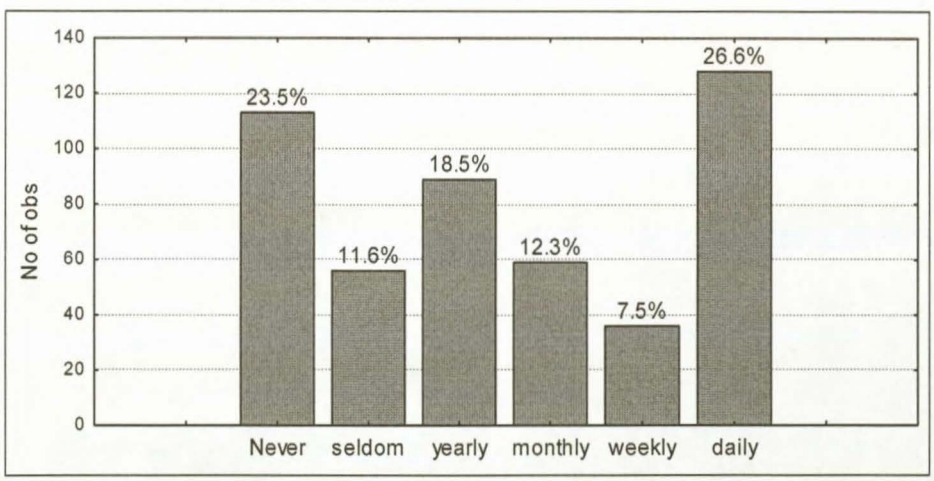

Figure 2.4: A histogram showing the percentage and number of interviewees within different time categories of when they see crocodiles.

3.4 Feelings and attitudes towards crocodiles

Nearly half (49.9%) of all respondents fear crocodiles, followed by feelings of dislike (26.0%), like (11.4%), hate (10.4%) and respect (1.5%) (Figure 2.5). Figure 2.6 shows the proportion of the total sample (N=119), where interviewees had a family member(s) attacked by a crocodile(s) and their attitudes towards crocodiles. This is of particular importance when assessing whether a person's attitude is influenced by the degree of conflict directly experienced through crocodile attacks.

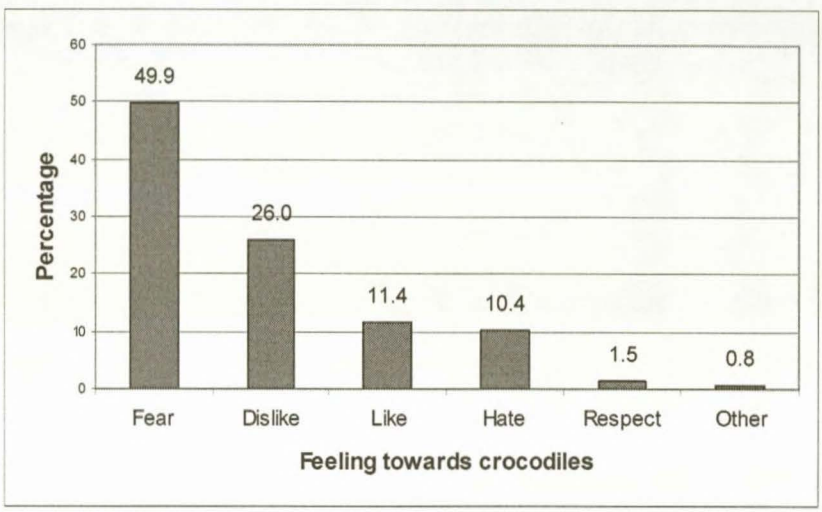

Figure 2.5: Percentage of interviewees within categories of their feelings or attitudes towards crocodiles.

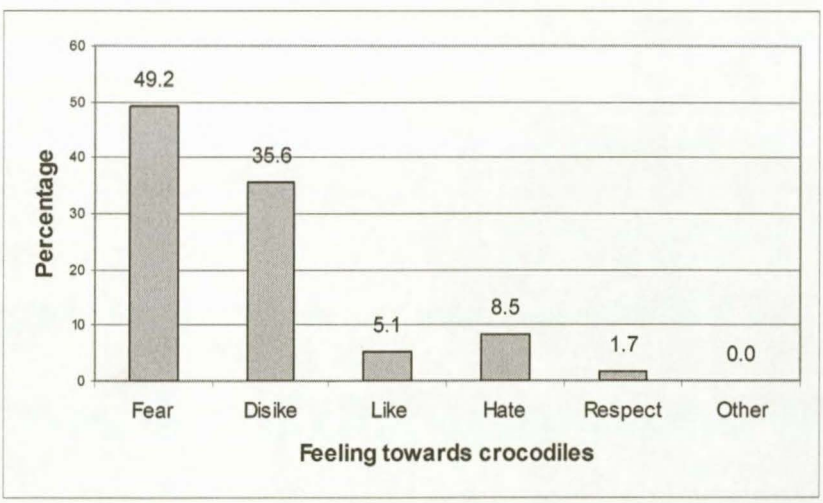

Figure 2.6: The percentage of interviewees that have had a family member(s), relative(s) or friend attacked by a crocodile within the category of their feelings towards crocodiles.

When comparing Figures 2.5 and 2.6 we see that the percentage of interviewees that like crocodiles decreases by more than half (11.4% to 5.1%) and the percentage that dislike crocodiles increases by approximately 10% (26.0% to 35.6%). Surprisingly, the percentage of interviewees that hate crocodiles, decreases by 2% (10.4 to 8.5%) and the percentage that respect crocodiles remains fairly constant (1.5% to 1.7%). As one would expect the tolerance levels would be lower (with more negative attitudes) in Figure 2.6 than Figure 2.5.

When comparing feelings of interviewees towards crocodiles with their degree of utilisation of the Okavango River and its resources, a strong correlation between the variables was observed. Feelings of hate, like and respect were associated with a higher degree of utilization (3-4 activities) compared to fear and dislike (under 3 activities).

3.5 Reaction towards crocodiles

The reaction of an individual towards crocodiles was gauged by asking the question: "If you saw a crocodile on a river bank, what would you do? (1) flee, (2) observe it, (3) kill it or (4) hurt it. The majority of respondents said that they would flee from a crocodile (68.4%), which could be linked with feelings of fear. Very few people would kill or hurt a crocodile (6.24%), which is important when considering the long term survival of crocodiles with reference to retaliatory killings (Figure 2.7). The combined percentage of interviewees (that have experienced some form of conflict) that they would kill or hurt a crocodile was 7.6% (Figure 2.8), which is a 1.4% increase from Figure 2.7. The percentage of interviewees that would merely watch the crocodile, decreased by 7.6% (25.4% to 17.8%) and those that would flee from the crocodile increased by 6.2% (68.4% to 74.6%).

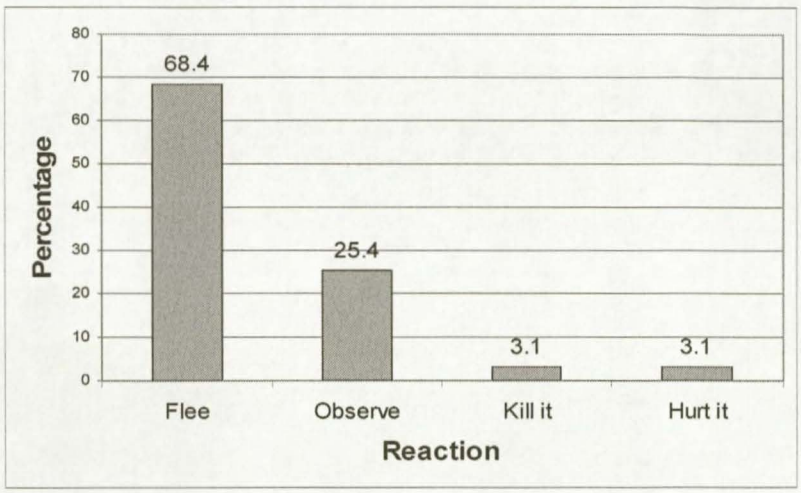

Figure 2.7: Histogram showing the percentage and number of interviewees and their reaction to a crocodile on a river bank.

Figure 2.8 shows a portion of the total sample (N=119) and consists of respondents that have had a family member(s) or relative(s) attacked by a crocodile.

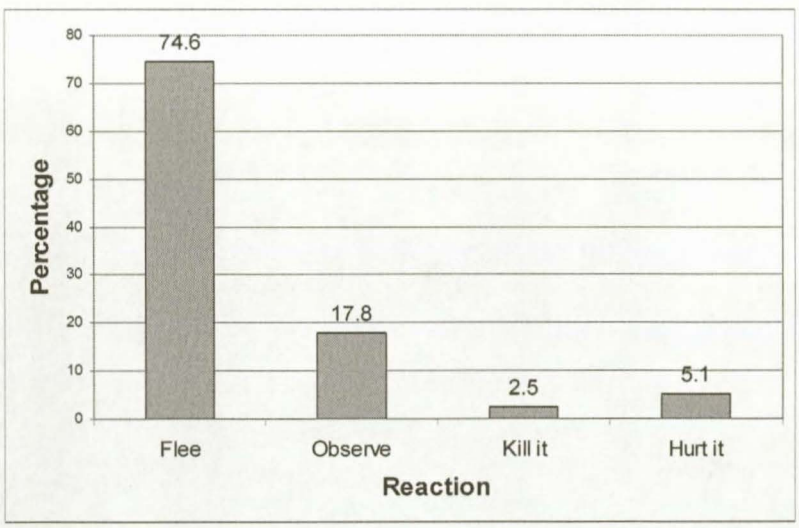

Figure 2.8: Histogram showing the percentage of interviewees that have had a family relative attacked by a crocodile, within the categories of their reaction towards a crocodile on a river bank.

When comparing interviewees reaction towards crocodiles vs. sighting frequency of crocodiles, the interviewees that remarked that they would hurt or kill a crocodile see crocodiles frequently (daily and weekly). Twenty seven percent of the interviewees that see crocodiles daily said that

they would flee from a crocodile, but 25% of the interviewees from the same sighting frequency category said that they have never seen a crocodile and 21% said that they saw crocodiles yearly. This shows that there is no clear relationship between reaction towards crocodiles and sighting frequencies.

3.6 Eating of crocodile meat

Very few people said they consumed crocodile meat (1.1%). The crocodile meat was obtained in various ways, i.e: given, received from a crocodile farm, distributed by the elders of a village when a problem crocodile was killed, or captured.

3.7 Cross comparisons of general attitudes, reactions and utilization

A comparative analysis of factors relating to interviewees' attitudes, reactions towards crocodiles and utilization of the river resources was used to further explore possible trends. These trends will help to provide more insight into the sociological dimension of HCC in the Okavango Delta.

a) Utilisation of resources vs. gender and age

i) Drinking water

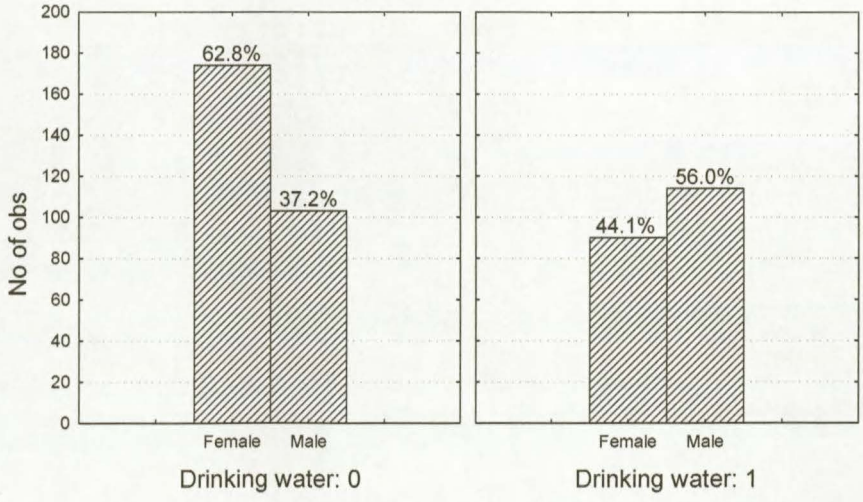

Figure 2.9: A comparison of the distribution of interviewees (number and percentage) by gender, that utilize the Okavango River for collecting drinking water (0=no, 1=yes) $p<0.001$.

In Figure 2.9 the distribution of interviewees of those that collect drinking water (drinking water: 1) within gender, is 56.0% male and 44.1% female. The majority of those that do not collect drinking water at the river are females (62.8%). There is a significant difference ($p<0.001$) in gender distribution between drinking water: 0 (interviewees that don't use the river for collecting drinking water) and drinking water: 1.

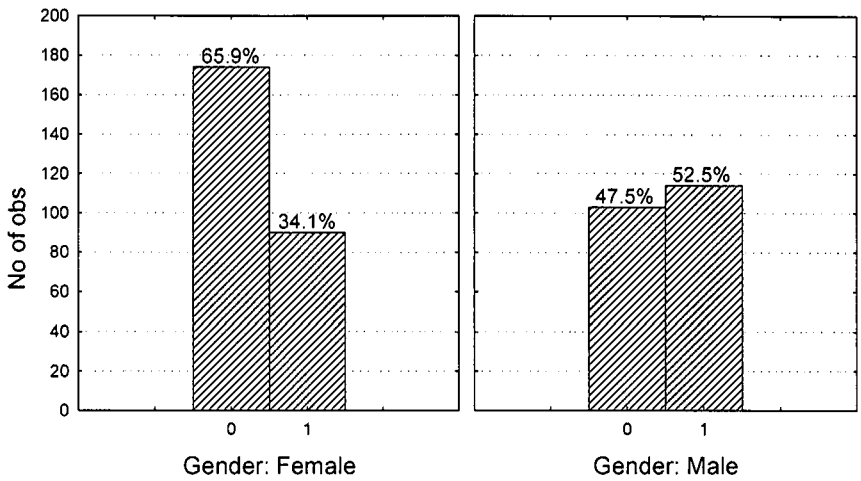

Figure 2.10: A comparison of the distribution of interviewees (in percentage and number) within two categories of utilization of the Okavango River for collecting drinking water, divided into different genders (utilization categories: 0=no, 1=yes for this activity) $p<0.001$.

Figure 2.10 shows that 65.9% of women do not collect water from the river, but rather from other water sources (i.e. communal water taps provided per village). Half of the males interviewed (52.5%) said that they use water from the river for drinking. However, this may be a misinterpretation, as tap water is derived from the river through abstraction by means of a pump and they did not specify if they collect the water themselves from the river. It is noted that mostly the women and children collect water for the household using buckets (pers. observation).

ii) Drinking water for livestock

Water for livestock is obtained from boreholes, taps and directly from the river. Boreholes are generally located some distance from the river. Livestock are kept fairly close to the river, in bomas and are released in the morning to drink water from the river. It is also common for livestock to drink water directly from the river in the evening before they return to the boma for

the night. Watering of livestock depends on guarding or herding techniques, which can be highly varied.

A low percentage of interviewees were involved in this activity with 12.4% of males interviewed and 3.4% of females interviewed performing this activity. Of those that utilize the river for drinking water for livestock, 75.0% of them are male.

iii) Reed cutting

Reeds are used by local people for the building of walls and roofs and for making baskets and ropes. Reed cutting takes place when the river is at its lowest, so that reeds can be easily accessed. Reeds are also sold and are an important source of income for some households. There was no significant difference in distribution of interviewees by gender, between those that cut reeds and those that did not. Similarly, there was no significant difference between genders for the activity of reed cutting, with 75.0% of females and 73.3% of males performing the activity. The gender distribution for interviewees that undertake this activity is 55.5% females and 44.5% males. There is a significant difference in the distribution of interviewees within age categories for this activity, as seen in Figure 2.11.

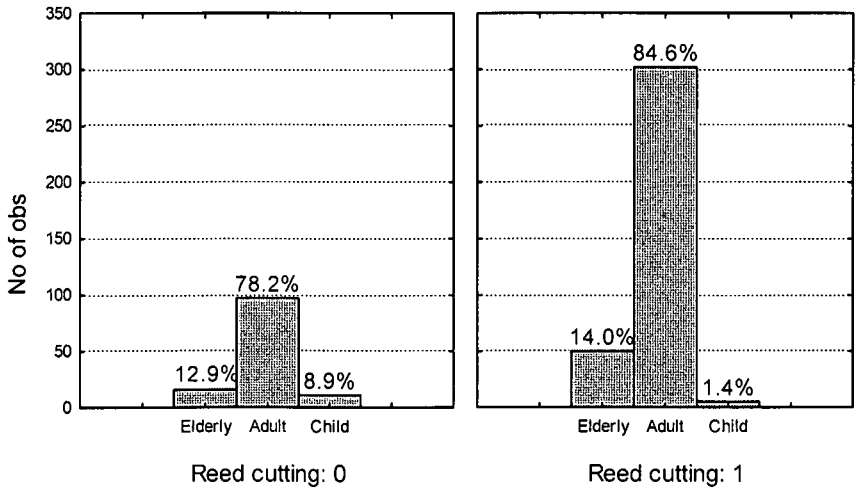

Figure 2.11: A comparison of the distribution of interviewees (percentage and number) within different age categories, that utilize the Okavango River for reed cutting (age categories: elderly: >65 years, adult: 18-64 years, child: 13-17 years and utilization categories: 0=no, 1=yes for this activity) $p<0.005$.

iv) Fishing

Fishing is an activity primarily undertaken by males (70.2%), as seen in Figure 2.12. Figure 2.13 shows that only a small percentage (23.1%) of all the females interviewed fish in the river, compared to 66.4% of all males interviewed. There is no significant difference in composition of interviewees within age structure for this activity.

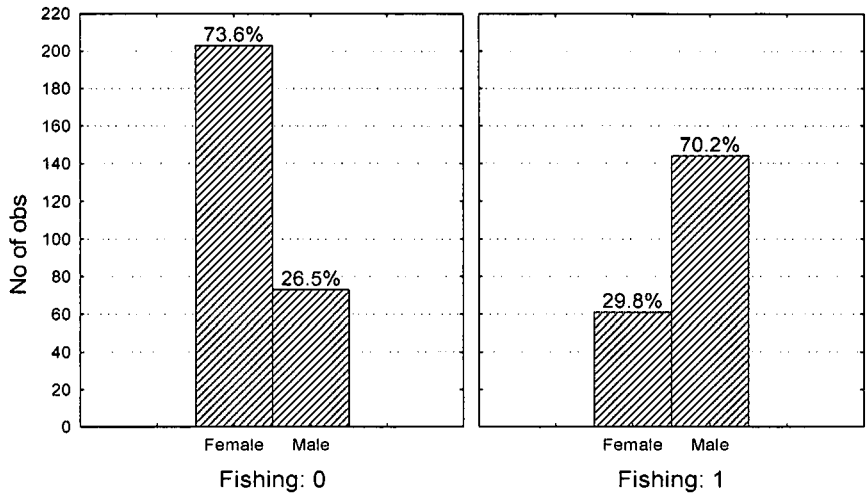

Figure 2.12: A comparison of the distribution of interviewees (percentage and number) within different genders, for the utilization of the Okavango River, Botswana for fishing (utilization categories: 0=no, 1=yes for this activity) $p<0.0001$.

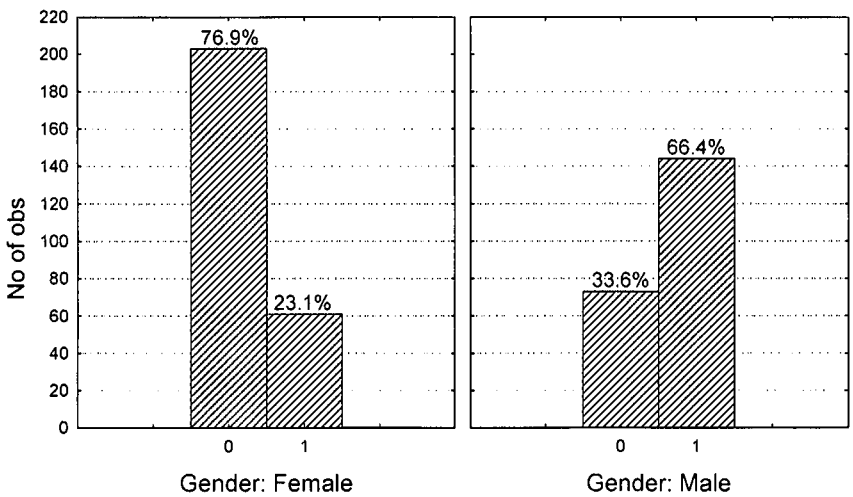

Figure 2.13: A comparison of the distribution of interviewees (percentage and number) for the utilization of the Okavango River for fishing (utilization categories: 0=no, 1=yes for this activity), by gender ($p<0.0001$).

v) Swimming

Figure 2.14 shows a significant difference in the gender composition of interviewees for the activity of swimming. The majority of those that swim in the river are men (66.7%), while only 15.5% of females interviewed swim in the river, compared to 37.8% of all the males interviewed (Figure 2.15). Females are possibly more conservative or cautious with regards to swimming in the river and the possible dangers thereof. There was no significant difference in age structure of the interviewees of those that perform this activity.

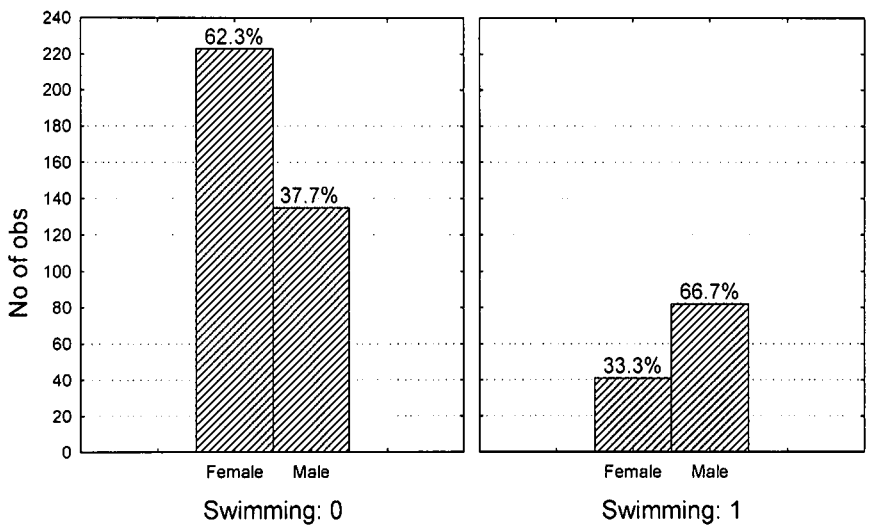

Figure 2.14: A comparison of the distribution of interviewees (percentage and number) within different genders that utilize the Okavango River for swimming (utilization categories: 0=no, 1=yes for this activity) $p<0.001$.

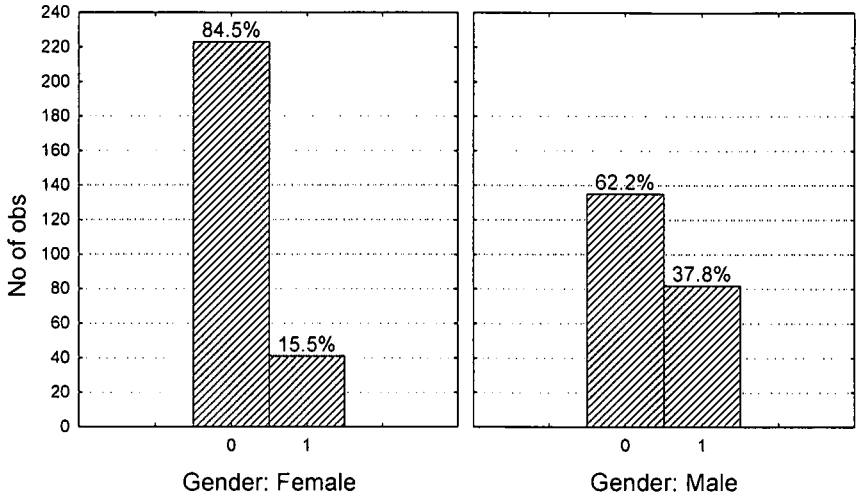

Figure 2.15: A comparison of the distribution of interviewees (percentage and number) within two categories of utilisation of the Okavango River for the activity of swimming, divided into different genders (utilization categories: 0=no, 1=yes for this activity) $p<0.001$.

vi) Washing clothes

Washing of clothes was observed to be carried out by women and children at communal water taps within the villages, rather than at the river's edge. However, the majority of those that utilize the river for washing clothes were male (56.6%) (Washing: 1 in Figure 2.16). And just over half (51.2%) of all the males interviewed said that washing of clothes was performed at the river (Washing: 1 in Figure 2.17). There is no significant difference in age categories between those that undertake this activity and those that do not, with a similar distribution in Figure 2.1.

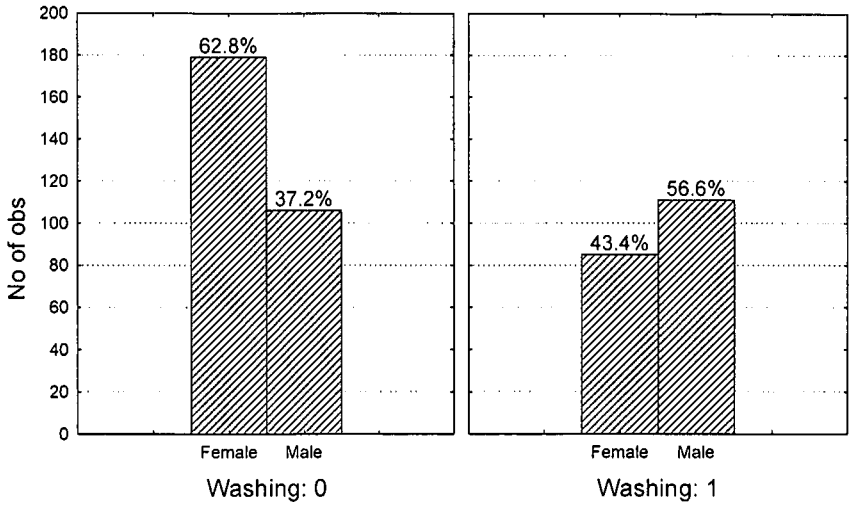

Figure 2.16: A comparison of the distribution of interviewees (percentage and number) between different genders that utilize the Okavango River for washing of clothes (utilization categories: 0=no, 1=yes for the activity) $p<0.001$.

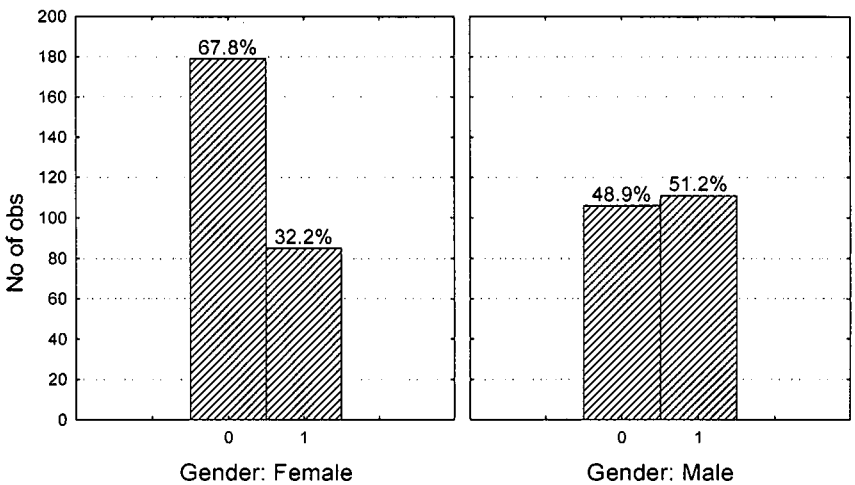

Figure 2.17: A comparison of the distribution of interviewees (percentage and number) within two categories for the activity of washing, between the two genders (utilisation categories: 0=no, 1=yes for performing this activity) $p<0.001$.

vii) Collecting water lily roots

Water lily roots are a traditional food source in the Okavango Region. Root collection involves wading into the shallow waters of the river. Figure 2.18 shows that <25% of all interviewees collect water lily roots and it is mostly females that do the collecting (62%). The age distributions of those that perform this activity 4% are elderly, 93% are adults and 2% are children (Figure 2.19).

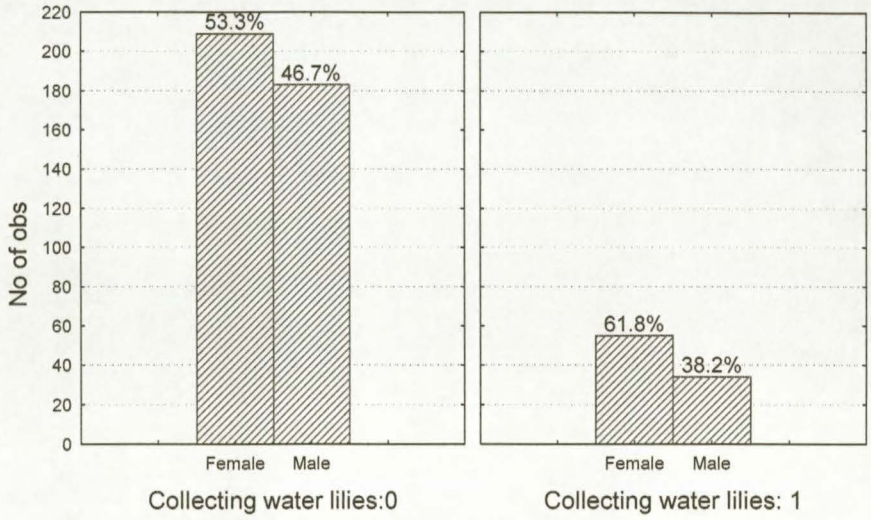

Figure 2.18: A comparison of the distribution of interviewees (percentage and number) between different genders for the utilisation of the Okavango River for collecting water lilies (utilization categories: 0=no, 1=yes for the activity) $p>0.05$.

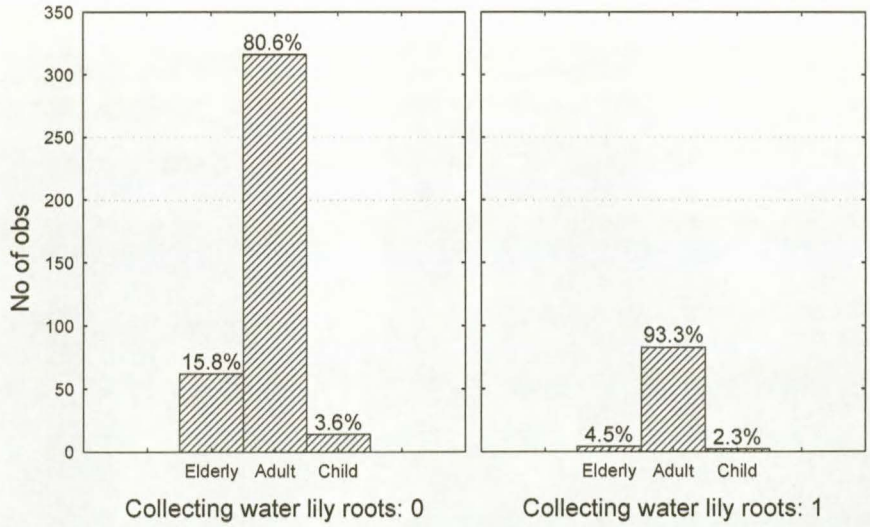

Figure 2.19: A comparison of the distribution of interviewees (percentage and number) within different age categories, utilize the Okavango River for collecting water lily roots (age categories: elderly: >65 years, adult: 18-64 years, child: 13-17 years and utilization categories: 0=no, 1=yes for this activity) $p<0.05$.

viii) Guiding clients

By law, safari companies can only employ qualified wildlife guides. In the flood plains, wildlife guides use "mekoros" as a means of transport. Guides often come into contact with potentially dangerous wildlife but they are better educated with regards to wildlife conflict and are able to avoid potentially dangerous. Figure 2.21 shows that only 11.1% of all the males interviewed said that they guide clients in or near the Okavango River. This activity is mostly undertaken by males (Guiding clients: 1 in Figure 2.20) and most of them are adults (95.8%) and a few are elderly (4.2%).

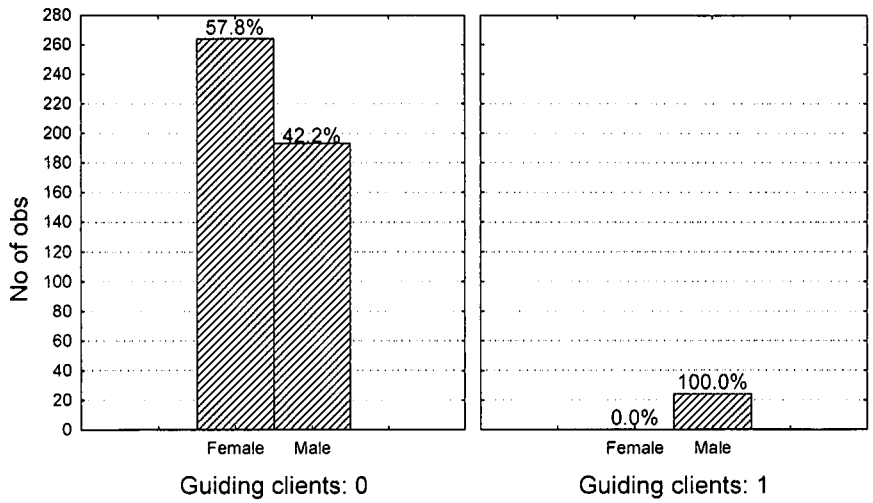

Figure 2.20: A comparison of the distribution of interviewees (percentage and number) within different genders for the utilization of the Okavango River for guiding clients (in a safari company) (utilisation categories: 0=no, 1=yes for this activity).

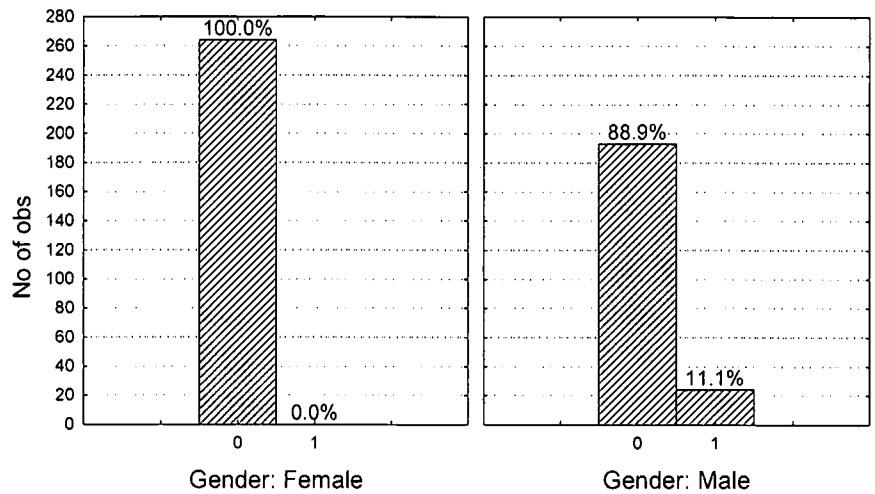

Figure 2.21: A comparison of the distribution of interviewees (percentage and number) within two categories of utilization of the Okavango River for guiding clients (in a safari company), divided into different genders (utilization categories: 0=no, 1=yes for this activity).

ix) Irrigation

The purpose of irrigation is primarily for agriculture, which occurs adjacent to the Okavango River, as water abstraction is required and is undertaken through water pumps driven either by electricity or petrol/ gas. There are very few people within the sample that utilize the Okavango River for this purpose and the age structure is: 9.1% are elderly, 72.7% are adults and 18.2% are children. The gender distribution of people that perform this activity is 72.7% female and 27.3% male. There is no significant difference ($p>0.05$) in the distribution of interviewees by gender and age for the utilization of the Okavango River for irrigation.

b. Utilisation of the Okavango River within different age groups and gender

Figure 2.22 shows that even though there is high utilization of the Okavango River within both genders, there is a significant difference ($p<0.01$) between the two, as females utilize the river more than males.

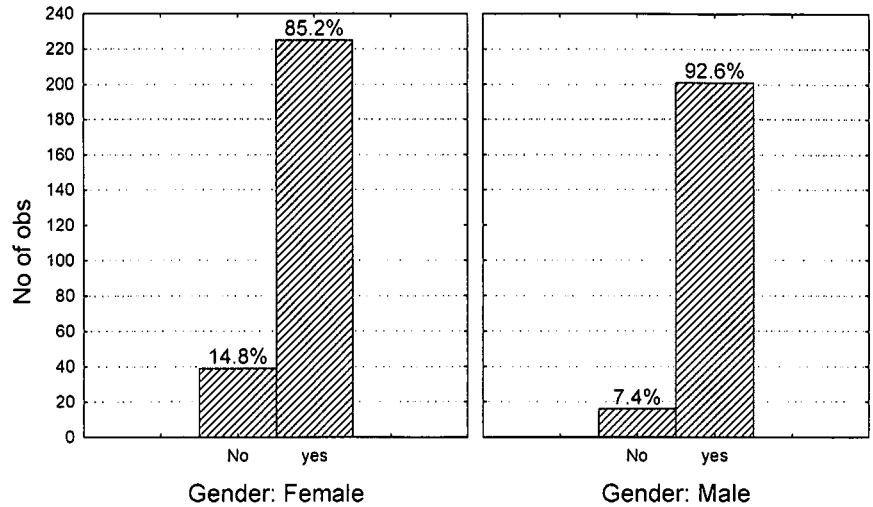

Figure 2.22: A comparison of the distribution of interviewees (percentage and number) within the utilisation of the Okavango River for different genders, $p<0.01$.

There was no significant difference ($p>0.05$) in the distribution of interviewees in utilization of the river, between different age groups. This indicates a generally high utilization of the river throughout all age groups [utilisation: yes for elderly (>65 years) =84.9%, adults (18-64 years) =89.7%, child (13-17 years) =75.0%].

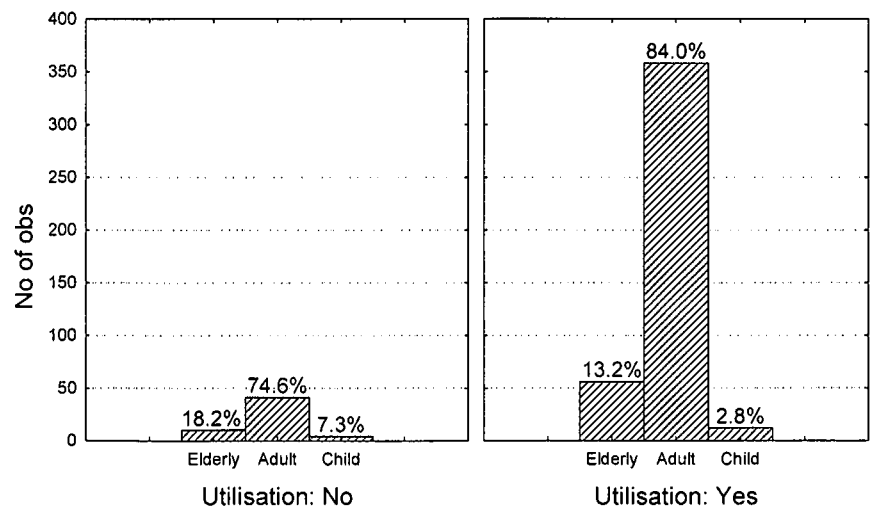

Figure 2.23: A comparison of the distribution of interviewees (percentage and number) within different age categories (elderly: >65 years, adult 18-64 years, child 13-17 years) that either utilize (utilisation: yes) or do not utilize (utilisation: no) the Okavango River.

There was no significant difference ($p>0.05$) in the distribution of interviewees within different age categories for the utilization of the river, as there is a bias towards adults in the utilization of the river and its resources. This is possibly due to the age structure of the sample.

c. Total activities per interviewee vs. sighting occurrence of crocodiles

Figure 2.24 reveals that there is a strong relationship ($p<0.01$) between the visual sighting of crocodiles and the total number of utilization activities performed per interviewee. In other words, as the number of activities per person performs at the river increases, so to does the frequency of visual sightings of crocodiles increase. For example: people that never see crocodiles perform the least number of activities at the river, while those that utilize the river the most (total number of activities at the river: 3-4) see crocodiles most frequently (monthly, weekly and daily).

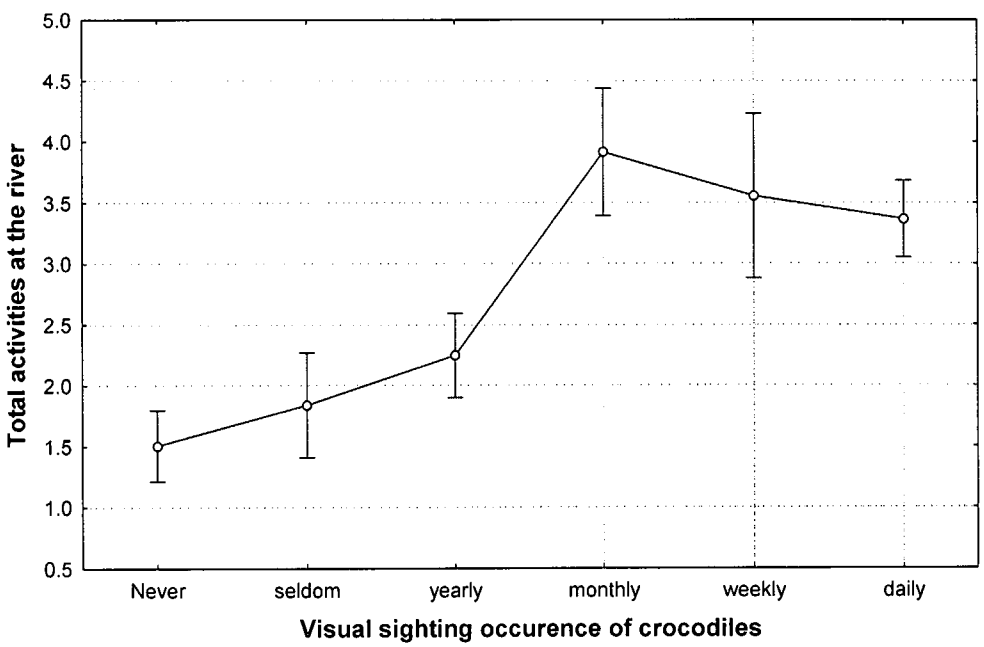

Figure 2.24: A scatter plot comparing the total utilization per person, activities performed at the river compared to the number of sightings of crocodiles (vertical bars denotation 0.95 confidence intervals). Current effect: F (5, 475) =25.711, p=<0.01 Kruskal-Wallis p<0.01, "visual"; Weighted Means

d. Utilisation of the Okavango River per village and distance from the river

There is a highly significant difference among villages when comparing utilization of the Okavango River and its resources ($p<0.001$). Table 2.5 gives a summary of a number of villages sampled (distributed widely across the study area) and provides an example of how the percentage utilization greatly varies among villages. There were generally a very high percentage of people that utilise the Okavango River with the villages following villages having the highest percentage: Samochima, Oddballs, Jao, Seronga, Dungu, Sepopa, Mohembo West and Shakawe. The villages with the lowest percentage utilization are Gumare, Maun and Etsha 6, which are larger, more developed villages in comparison to the other villages.

Table 2.5: A comparison of the percentage of interviewees that utilize the Okavango River and its resources, within a sample of villages and the number of people interviewed within each village.

Village	Number of people interviewed per village	Percentage of people utilizing the river
Shakawe	24	87.5%
Samochima	22	100.0%
Sepopa	20	95.0%
Gumare	22	54.6%
Oddballs	15	100.0%
Maun	40	72.5%
Jao	20	100.0%
Seronga	21	100.0%
Etsha 6	22	77.3%
Mohembo W	15	93.3%
Dungu	10	100.0%

There is no significant difference in the distance from the river of interviewees that utilize the river and those that do not. This suggests that the river's value or relative importance to the interviewees is not linked to the distance that the interviewees live from the river.

f. Frequency of sightings of crocodiles in the Okavango River compared within different age, gender and utilisation categories

There is a significant difference ($p<0.01$, Chi-squared test) in the variation of sighting frequency within different age groups. This suggests that there is no clear pattern of sighting frequency within the different age groups. This observed pattern may be influenced by the age distribution of the sample, which were predominately adults.

There is a highly significant difference ($p<0.0001$, Chi-square test) in the distribution of interviewees within gender for different sighting frequency of crocodiles in the Okavango River. Males tend to see crocodiles more often [within the daily (60.2%), weekly (55.6%) and monthly (67.8%) categories] than females and females more often tend to see crocodiles in the categories of yearly (59.6%), seldom (51.8%) and never (85.0%). It is very interesting to note that there are a high number and percentage of females that have never seen a crocodile.

Although there is a high significant difference ($p<0.05$) of sighting frequency within different age categories, there is no clear trends for the adult and elderly age category, except for the children which tend to see crocodiles less often [never (43.7% of all children interviewed) and monthly (25.0% of all children interviewed)].

The majority of those that do not utilise the Okavango River and its resources said that they never see crocodiles (60%), with the remaining distributed: 18% yearly, 16% seldom, 4% monthly and 2% daily. For those that utilise the Okavango River, they saw crocodiles: daily (30%), never (19%), yearly (19%), monthly (13%), seldom (11%) and weekly (8%). The general trend shows that as sighting frequency of crocodiles increases (from never to daily), the percentage of those that do not utilize the river tends to decrease.

g. Traditional beliefs

General traditional beliefs

Figure 2.25 shows that the majority of the people interviewed have one or more traditional beliefs with regards to crocodiles. The categories are: (i) that the brain is poisonous when ingested, (ii) that a crocodile bite can kill, (iii) that the teeth are poisonous referring to a crocodile bite that may become infected, (iv) the liver is poisonous when ingested and (v) other: crocodile flesh is poisonous when eaten, the presence of flowers on certain trees means that crocodiles are more likely to attack you and that you can find diamonds inside a crocodile's stomach.

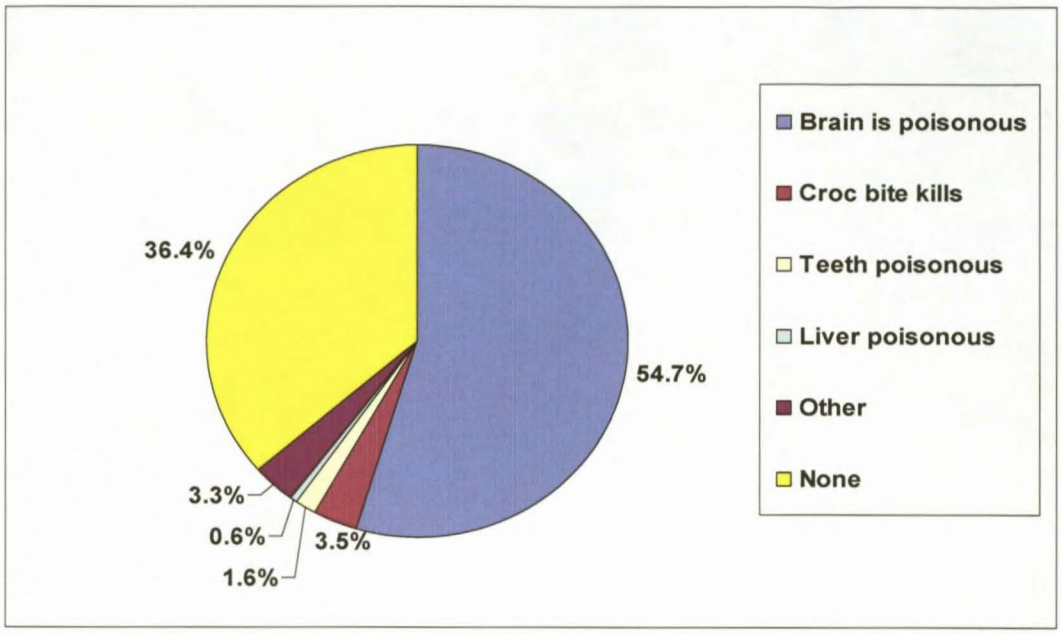

Figure 2.25: Pie chart showing the percentage of interviewees within different traditional beliefs with regards to crocodiles.

Traditional beliefs compared within various villages

Results show that there is a significant amount of variation among all villages regarding traditional beliefs. Sepopa is comparatively large village (population: 2,308 people in 2001) and the majority of the interviewees believe that the crocodile brain is poisonous (80%). Compared to other villages or towns, such as Oddballs (100.0%), Dungu (70.0%), Gunutsonga (60.0%), Eretsha (60.0%), Beetsha (60.0%), Samochima (52.6%), Mohembo West (50.0%) and Maun (52.5%) where the majority of the interviewees within these villages do not believe that the brain is poisonous, together with a high percentage of interviewees that have no traditional beliefs about crocodiles. There does not seem to be any link of traditional belief to the size of the population of a particular village, as Maun is the largest town in the study region (approx. 49,000 people) and Dungu, Eretsha and Gunutsonga have <1000 people living there, even though they have a very similar percentage of interviewees that believe that the brain is poisonous. However, villages that are located in close proximity to one another tend to have similar traditional beliefs: Eretsha, Gunutsonga and Beetsha are relatively close to one another and 60.0% of the interviewees in each village do not have any traditional beliefs. Mohembo East and Mohembo West, although they are separated by the Okavango River, have a similar distribution of interviewees that believe that the brain is poisonous (approx. 40.0%). These villages are linked by means of a ferry that transports people and motor vehicles across the river.

The other traditional beliefs that were recorded (N=43 individuals) were recorded in Shakawe (16.3%), Nxamasere (14.0%), Mohembo West (11.6%), Samochima (11.6%) and Maun (9.3%). With the remaining dispersed across various villages in the study region. The traditional belief that a crocodile bite can kill and that crocodile teeth are poisonous occurred in villages that were mostly situated in the Panhandle Region of the Okavango Delta.

4. DISCUSSION

The water of the Okavango Delta is seen as 'life blood' to many creatures and humans that depend upon it for their survival. In many rural regions of the world, animals feature largely in people's thinking and is said to influence people's actions and the structure of every day life (Trutnau & Sommerlad 2006). Through investigating the dynamics of rural life in the Okavango Delta and how this interrelates to HCC, a high degree of utilization of the river and its resources by the people that live in proximity to the river was found. This high dependence on the river not only has strong implications for future sustainability and the status of the Nile crocodile in this ecosystem, but also for people's future livelihood strategies.

Utilisation of the Okavango River Resources

Through investigating people's behaviour at the individual level, it helps to give clues about the potential success of prevention and mitigation measures for HWC (Manfredo & Dayer 2004). Therefore trends in the utilization of the river and its resources are of key importance in understanding the social dimension of HCC in the Okavango Delta.

High utilization of the Okavango River and its resources is recorded throughout all age groups and by both genders. Within the genders, males use the river 10% more than females. Utilisation of the river by different age groups provided no significant results, as 83% of the total sample was adults and 84% of the people that utilize the river were adults. However, a large percentage of children do not use the river (25%) compared to other age groups. This could be because children attend school during the day and not all children are expected to carry out tasks such as washing clothes and collecting reeds.

The variability of utilization of the river amongst the villages was observed not to be linked to distance to the river. This highlights the high dependency that people have on the river and its resources, even though the majority of interviews were conducted within five kilometres of the river. The variability of resource use between the villages could be linked to the provision of services and urban development in each locality. The reliance of people on the rivers resources decreases if security was provided via other forms of income, such as trade and commerce, and if more reliable basic services were provided. For example: the main towns in the district are Maun

and Gumare, which are comparatively more urbanized than other rural villages and have a lower percentage utilization of the river than other villages (such as Jao and Samochima).

The uses of the rivers resources are complex and varied within different social categories (i.e. gender and age). Significant differences in either age or gender for a specific activity were evident for most of the activities. This shows that each activity is generally undertaken by individuals of either specific gender or/and a specific age group. For example: the activities of swimming, fishing, drinking water for livestock and guiding clients are more male orientated, while reed cutting, collecting water lily roots and irrigation are activities conducted primarily by females. Clear trends in utilization aide in identifying problem areas of conflict and thus effective mitigation measures can be formulated.

The majority of people in rural areas collect reeds, which are used for the construction of houses and fences. Other common activities that approximately 40% of the people interviewed undertake are fishing, washing and collecting of drinking water. The high number of activities recorded for interviewees living in close proximity to the river emphasizes the possibility of interactions between humans and crocodiles. The crocodiles preferred food source is fish and thus there is competition for this food source between local communities and crocodiles. However, one cannot assume that the speculated decrease in fish populations (Mendelsohn & el Obied 2004) is contributing to increased conflict, as reliable information on fish population dynamics over time is needed to provide better insight into this complex interaction.

Conflict with saltwater crocodiles in Palau (Oceania) is preventing fishermen from visiting certain fishing grounds because of perceived competition for food sources and an increase in number of crocodiles (Matthews 2005). This may increase antagonism between man and crocodile due to restricted use of resources, which has similarly been recorded in Cameroon between wildlife, livestock and people (Weladji & Tchamba 2003). However, protection or restriction of resources has the advantage of safeguarding the future security of riverine resources. In McGregor (2005) fisheries policies banning fishing in Lake Kariba's estuaries and an increase in state protected land had unplanned benefits for crocodiles, by providing them with a protected habitat/sanctuary in which to breed and assisted in recovery of the local crocodile and fish populations.

Local people's perceptions and anticipated reactions towards crocodiles

People's feelings towards crocodiles differ greatly between the genders, with males showing more contrasting feelings of hate and like, while female's feelings are more temperate (fear and dislike). This suggests that different approaches should be considered when attempting to resolve any HCC when addressing the different genders. During a field survey near Etosha National Park, Namibia, by Mfune et al. (2005), it was found that males and females view problem animals differently. Males were concerned about damage affecting financial security of resources (such as livestock and crops), while females were more concerned with livelihoods and security in the home. The importance of gathering a range of perceptions regarding the threats posed by crocodiles amongst different groups in society is highlighted in Matthews (2005), where surveys targeted fishermen and hunters in Palau was not representative of the greater population. Including women's perspectives was said to contribute greatly to more meaningful conservation strategy for the Palau saltwater crocodiles.

The difference in attitudes between interviewees that have experienced an attack on a family relative(s) and those that have not is particularly pertinent to the future resolution of HCC, as strong feelings of hate (low tolerance) could be linked to the possibility of retaliatory killings of crocodiles. A 2% increase within the category of hate is not very concerning and is a positive sign for possible future HCC resolution in the Okavango. However, there was a 10% increase in interviewees who had feelings of dislike towards crocodiles, showing that negative feelings towards crocodiles may be fuelled by direct experiences of conflict encounters with the creatures. In McGregor (2005) fear of crocodiles is affected by memories or personal experiences of attacks and also stories that are passed on in different groups of people. Fear is also said to be fuelled or amplified through association of the animal with witchcraft (the use of powerful medicines for both good and evil use against others). Messmer (2000) states that increasing human tolerance of wildlife damage is a successful way of managing HWC and this involves changing people's perceptions by enhancing their appreciation for wildlife and its non-tangible benefits. This highlights the importance of people's attitudes towards crocodiles in relation to their tolerance levels, as it affects the mitigation strategy of HCC.

People's tolerance in Wisconsin, USA towards wolves was measured through the likelihood that a person would shoot/kill a wolf. Anticipated reactions towards wolves and loss of livestock and pets to the predators was seen as a strong determinant of tolerance towards the conflict species

(Naughton-Treves et al. 2003). This could also apply to this study, where local people's combined reactions to kill or hurt a crocodile was only 6.2% of the sample. People who had experienced an attack on a family member or themselves (N=119, 24.7% of total sample) reaction to either kill or hurt a crocodile only increased by 1.4%. People's reactions increased more towards inquisitiveness (7.56% increase in people who watch crocodiles) and fear (6.18% increase in people fleeing away from crocodiles). In the study on wolf tolerance, 17.4% of the respondents wanted wolves to be eliminated (total sample: N=535) of those that had experienced loss by wolves (N=107, 20% of total sample), 80% favoured reducing or eliminating the wolf population. The difference in levels of tolerance between those that have experienced a direct loss by a predator is vastly different when comparing cases in Wisconsin and the Okavango Delta, Botswana. The only possible reason accounting for the difference between the two cases is that people who were compensated (55.3% of the people experiencing attacks by wolves), were more likely to agree on reducing or eliminating the wolf population than those that had not received any compensation. In the Okavango, only a small number of people are afforded compensation for attacks and this lack of compensation for both livestock and human attacks could possibly be factor influencing people's tolerance towards crocodiles. However, one must be cautious when making such assumptions and further examination of the direct linkages between compensation and tolerance levels is required.

The association between the degree of utilization of the river and an interviewee's feelings towards crocodiles suggests that feelings of hate, like and respect (compared to fear and dislike) are associated with those who utilize the river more often and have a higher chance of being in contact with crocodiles. This is seen where the sightings of crocodiles increase as the total number of activities or utilization of the river increases. People who never see crocodiles tend to utilize the river the least and mostly fear the animals. Those that utilize the river the most, tend to see crocodiles on a daily to monthly basis (Figure 2.24) and most have feelings of fear, dislike and hate towards crocodiles, indicating a low tolerance towards crocodiles. However, it was observed that those who like and respect crocodiles also have a very high degree of utilization of the river and its resources.

It was mentioned previously that tolerance depends partly on how people perceive risks associated with HCC, which influences people's reactions to a conflict situation & is linked with fear/dread of a harmful situation (Knuth et al. 1992 in Decker et al. 2002). I.e. low tolerance

(feelings of hate, dislike and fear) should be linked with adverse reactions towards crocodiles (such as injuring or killing a crocodile). When comparing people's reactions towards crocodiles and their sighting frequency, those that said they would kill or injure a crocodile (low tolerance) saw them often (weekly-daily). And the majority of those that dislike and hate crocodiles said they saw them more frequently. In comparison, some fishermen in Lake Kariba, Zimbabwe who reported daily damage to their nets, said that they fend of crocodiles from their fishing nets by throwing stones at them (McGregor 2005). Daily encounters with crocodiles are 'common' and life as a fisherman was described as "hard and risky". The reaction of killing offending crocodiles was commonly recorded as a direct result of competition over fish. However, an ecological survey on the interaction between fishermen and crocodiles concluded that conflict (on a broader scale) was not severe, as crocodiles only consume 10% of the total annual harvest from the Lake (Games & Moreau 1997 in McGregor 2005). On a smaller scale however, 10% still has an impact on local communities and complaints or political grievances are compounded by heightened fear of the animal.

Extreme anxiety was recorded amongst fishermen who had close encounters with crocodiles and other wildlife (who escaped death when his boat was knocked over in crocodile - infested waters) (McGregor 2005). Heightened anxiety was also linked to stability of their livelihood strategies. People who depended on fishing to derive income for their families are frequently anxious about the presence of crocodiles in the water, as they felt particularly vulnerable to attack (when performing activities close to or in the water) and a lack of resources in rural areas prevents safe fishing. The elevated risk of fishermen being attacked is because they "venture knowingly and repeatedly into places where crocodiles are a threat".

The lack of a clear trend between an individual's reactions towards crocodiles and the sighting frequency, shows that it is difficult to predict how people will react to crocodiles based on how often people see crocodiles. Therefore, one should rather gauge people's reactions in relation to their attitudes towards crocodiles, as an estimated measure of tolerance. However, even this has its limitations, as some people who experienced conflict (with an expected low tolerance) had feelings of respect and even like towards crocodiles (Figure 2.6).

Frequency of crocodile sightings

There is no clear trend for the sighting frequency of crocodiles for the sample as a whole, however when it is further divided into different groups (i.e. gender categories), more clearly defined patterns emerge. Within the different sighting categories, the males on average said that they tend to see crocodiles daily to monthly. While the majority of those that see crocodiles seldom, yearly and never were female. The link between total number of activities performed at the river and visual sighting occurrence of crocodiles, suggests that those that see crocodiles frequently (monthly-daily) perform a high number of activities at the river. Males are therefore more susceptible to attack as they perform more activities at the river than females and come into contact with crocodiles more often. Males also perform more 'high risk' activities (such as swimming, fishing, taking livestock to drink water and guiding clients) which increases the likelihood of crocodile attack.

Traditional beliefs within villages

The majority of traditional beliefs that were recorded across the region were very similar, especially the belief that the flesh of the crocodile and particularly the liver and brain is poisonous when consumed. This belief or fear of death or ill effects from this belief is supported by the extremely low percentage (<1.5%) of people who said that they have consumed crocodile meat. The high variability in percentage of those that have traditional beliefs between villages could be influenced by the social systems that function at a local scale within these villages, where people's opinions or beliefs can influence one another. As previously noted in McGregor (2005), people's fear of crocodiles is influenced by traditional beliefs and also through story telling/sharing of dangerous experiences and fatalities caused by crocodiles in the past. In Zimbabwe and other southern and central African countries (including the study region) the crocodile liver is documented to be a poisonous traditional medicine, together with other body parts that are said to ward off crocodile attacks (e.g. crocodile teeth). Human death by crocodile undoubtedly has a major disruptive effect on social life (as seen in the fishing camps in Lake Kariba) and the combined effect of witchcraft/ traditional beliefs may similarly be a major cause of the low tolerance of crocodiles experienced in the Okavango Delta, Botswana.

In New Guinea and some tribes in Africa, crocodile meat is seen as a delicacy and all edible parts of the crocodile, including the intestines are cooked and consumed (Trutnau & Sommerlad 2006). In Thailand and the USA, highly priced crocodile meat is served in gourmet restaurants. Even

though no physical tests have been conducted on the effects of consuming crocodile brain, it is highly unlikely (in light of the popularity of crocodile meat) that the traditional belief regarding crocodile brain and meat in the Okavango Delta is true. The traditional belief that a crocodile bite is deadly is supported by Trutnau & Sommerlad (2006) which state that crocodiles eat carrion and the bacteria transferred from the teeth can cause lethal infections if a victim is not treated with antibiotics.

In another instance in Madagascar, the resurgence of traditional beliefs helped to promote conservation of the Nile crocodile, as fishing with nets (which depleted fish populations) was seen as taboo by ancestral spirits and the people believed the crocodiles attacked them for not abiding to the ancestral beliefs (Paulin et al. 2003). Unlike Madagascar, the traditional belief in the Okavango Delta is not directly linked to conservation of the species, but rather lowers tolerance levels as it's is linked to the fear or dread of crocodiles. It would be interesting to monitor the support of the traditional belief over time if an educational HCC mitigation strategy is implemented.

In conclusion

Decker et al. (2002) states that the perception of risk by people is influenced by the degree of severity of consequences and the worry or dread associated with certain outcomes. Risks associates with a low probability, but severe consequences (e.g. human death) tend to increase dread and heightened perceived risks. Tolerance is said to decrease as the perception of the probability of the risk increases. In the Okavango Delta Region, the actual threat of attack by crocodiles is lowered by the current suppressed number of adult crocodiles within the population, due to exploitative hunting in the past and other anthropogenic influences (see Chapter 1) and also the frequency that an individual comes into the vicinity of a potentially dangerous crocodile. The overall perceived threat of crocodiles may be elevated beyond the actual threat, due to the combined effect of high resource dependency (for their livelihoods), negative/fearful attitudes towards crocodiles and the influence of heightened fear of attack (which is influenced by local traditional beliefs). The relationship between actual and perceived risk of being attacked may also vary according to degree of resource utilization of individuals, whereby those that utilize the river frequently the actual and perceived risk may be fairly similar, compared to those that do not utilize the river as often where the perceived risk may be much higher than the actual risk of being attacked.

***The following trends should be noted with regards to the above statements*:**

- Males perform more activities at the river and tend to see crocodiles more often than females, thus increasing susceptibility to crocodile attacks.
- The most common activities performed at the river are reed cutting, collecting drinking water, washing, fishing and swimming and one would expect that most people that were attacked would have been be performing one or more of these activities.
- Traditional beliefs may fuel feelings of fear or anxiety of crocodiles and thus affecting tolerance levels of local people.
- The level of tolerance towards crocodiles should be noted in reference to compensation

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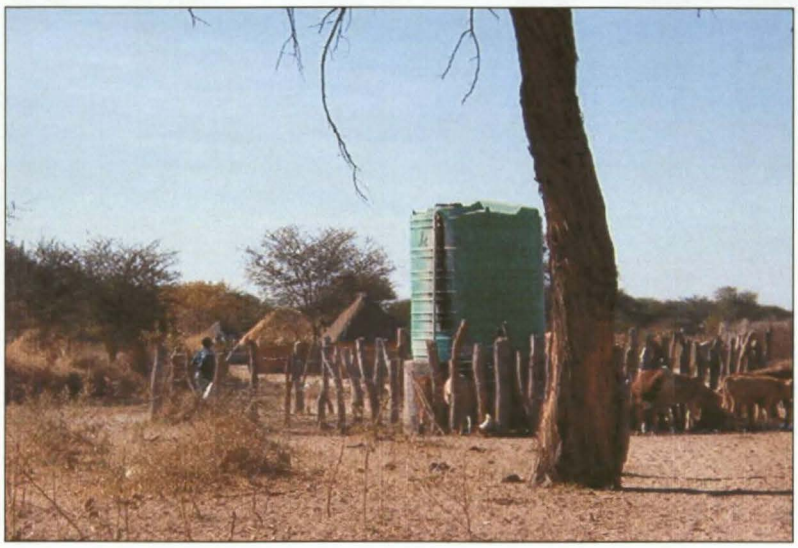
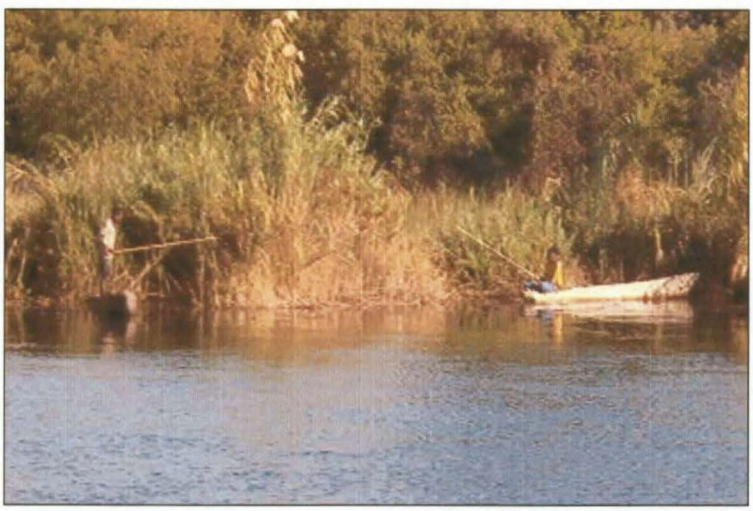
ADDENDUM 2.1

Images of various activities performed in or near the Okavango River, Botswana.

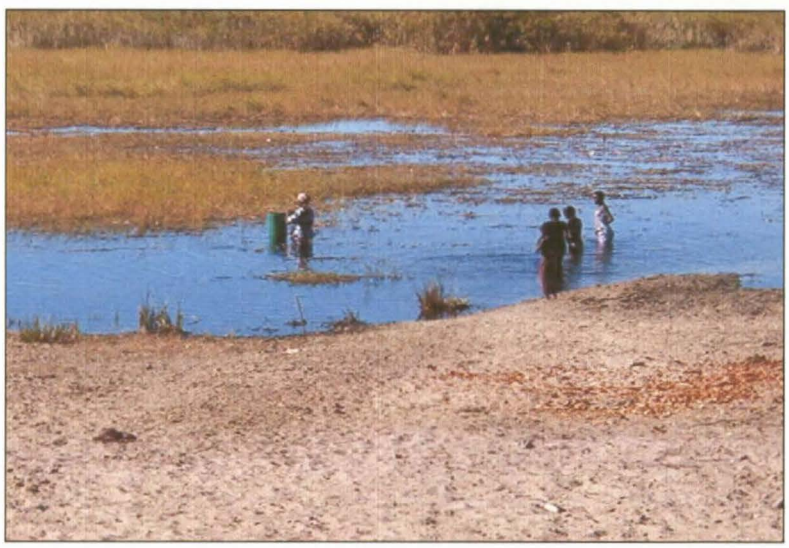


A water storage tank at Etsha 4, where the water is pumped from the river. The fence is supposed to keep cattle away from the water source, as it is used for domestic purposes.



People fishing in mekoros (wooden canoes) in the main channel near Mohembo West, Botswana.

Children in a mekoro crossing Samochima Lagoon, Botswana



People collecting water lily roots in Shakawe, Botswana.

CHAPTER 3

INVESTIGATING THE EXTENT OF HUMAN - CROCODILE CONFLICT IN THE OKAVANGO RIVER SYSTEM, BOTSWANA, WITH REFERENCE TO HUMANS AND THEIR LIVESTOCK

1. INTRODUCTION

One of the most serious causes of HWC (Human-Wildlife Conflict) is fear of being killed by a carnivore or mega-herbivore (Thirgood et al. 2004). Livestock predation is one of the most common forms or sign of HWC globally and therefore a measure of the number of attacks by crocodiles on humans and their livestock is of significant importance. This chapter focuses on the dimensions of attacks by crocodiles on humans and livestock within the study area and attempts to provide a clear understanding of the main trends in HCC (Human-Crocodile Conflict) in the Okavango Delta, Botswana.

2. METHODOLOGY

A section of the sociologically-based questionnaire focused on crocodile attacks on family relatives, friends and the interviewee (total sample size=482) was used in analysis. Details such as date, time, place and injuries were recorded to provide insight into attacks and to help determine any patterns of attacks. The final section of the questionnaire focused on livestock attacks, circumstances surrounding them and compensation.

Analysis of the database is as follows

1. General trends of crocodile attacks on humans and livestock were represented spatially and temporally.
2. The rate of human and livestock attacks (log of number of attacks over time) was calculated.
3. A Regression analysis of human and livestock attacks for the various villages was performed.
4. Compensation estimates were calculated for human and livestock fatalities.

Estimated compensation for humans was based on funeral costs and livestock compensation was based on a specified compensation scheme that is being used by the Department of Wildlife and National Parks since 1998, when the guidelines for compensation was released (Hemson 2003). Table 3.1 shows compensation values for livestock.

Table 3.1: Compensation values for different stock types in Botswana (Department of Wildlife and National Parks 2004) (1BwP=0.19USD, 09h54 15.05.2006 www.oanda.com).

Livestock type	Compensation Value (Pula)	Compensation Value (US $)
Cattle	700	133.00
Goat	120	22.80
Horse	1400	266.00
Donkey	120	22.80
Calf	350	66.50
Dog	0	0
Chicken	0	0

Compensation is only afforded to claimants after the claim has been investigated and verified by Problem Animal Control Unit (PAC) officers. Livestock fatalities are only compensated for the following carnivores: lion, leopard, cheetah and the Nile crocodile.

3. RESULTS

Results are divided into three sections: 1) human attacks, 2) livestock attacks and 3) combined comparison related to sections 1 and 2.

3.1 Human attacks

Figure 3.1 indicates that the gender ratio of those that were attacked by crocodiles was 64% male and 36% female. Human attacks were also compared within age categories and 18% of attacks were on elderly, 27% on children and 54% on adults.

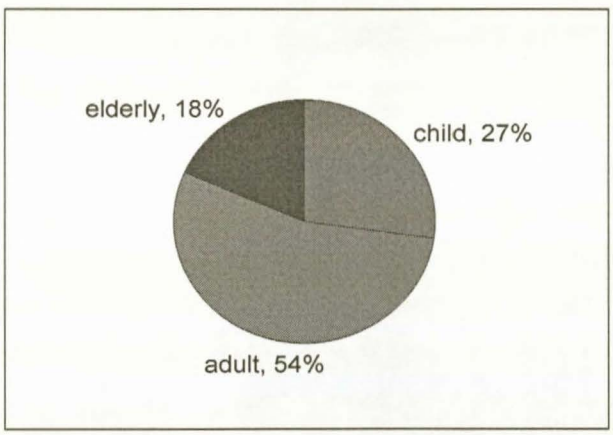


Figure 3.1: A pie chart showing the distribution of people attacked by crocodiles according to different age groups (elderly: >65 years, adult: 18-64 years, child: 13-17 years).

Only 4% of attacks on humans by crocodiles occurred at night and Figure 3.4 shows that most attacks occurred in the morning (57% in the morning vs. 43% in the afternoon/night).

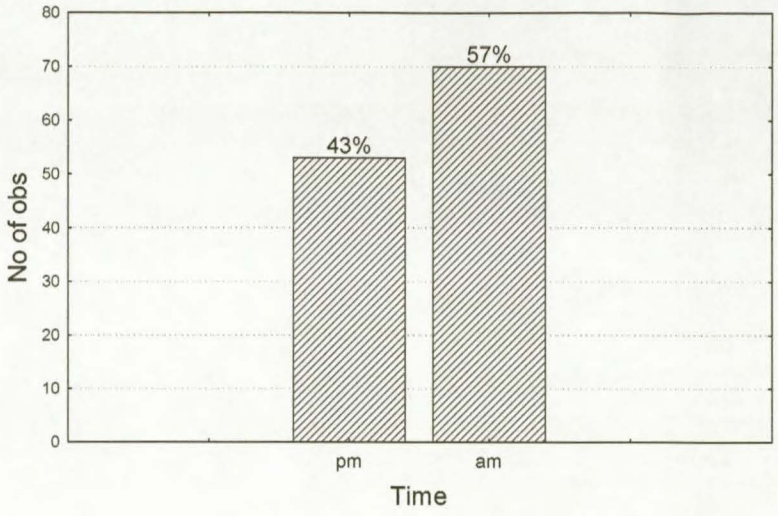


Figure 3.2: Histogram showing the percentage and number of human attacks that occur within two different time categories [pm (13h00-24h59) and am (00h00- 12h59)].

Figure 3.3 shows the number of attacks on humans by crocodiles recorded over a period of 20 years (from 1985-2005). The number of attacks per year ranges between 0-10, with the highest number of attacks recorded in 2003. See Appendix 3.1 for more details on the total number of human attacks over time (from 1940-2004).

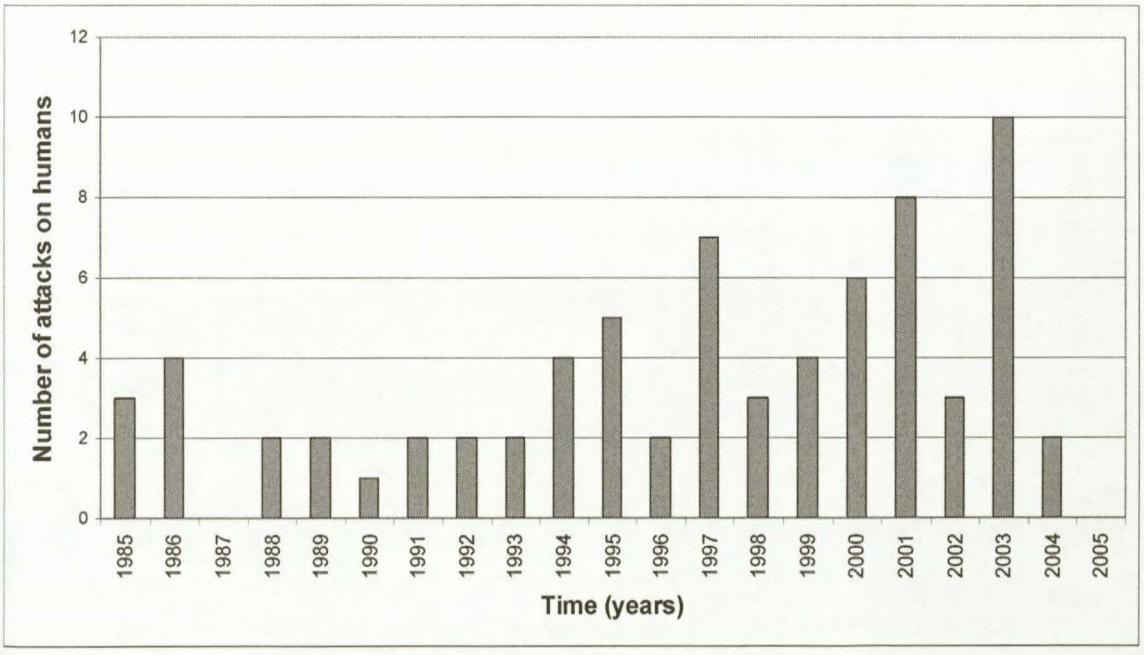


Figure 3.3: Histogram showing the number of attacks by crocodiles on humans over time (from 1985-2005). One year time intervals are used (N=72).

There is a logarithmic increase in the number of attacks over time, with a sudden increase in the number of attacks in 1994. When the logarithm of the number of attacks (log attack) was plotted over time, the rate of attacks on humans was found to be increasing over time (by a factor of ±0.01 each year). The rate of attack is of greater significance than the total number of attacks (absolute number), as it is important to predict the trends of attacks over time and manage HCC in the region accordingly.

Of the 125 attacks on humans that were recorded during this study, 55% were fatal. Figure 3.4 shows the distribution of human attacks according to various categories such as fatalities and injuries. Injury categories are: 'permanent' which is the permanent maiming or removal of a limb and 'cosmetic' are surface injuries (see Addendum 3.3 for examples of permanent and cosmetic injuries). The other two categories refer to fatalities where remains of the victim were found and no remains were found. Three percent of the people who were permanently injured by a crocodile died later on after the attack.

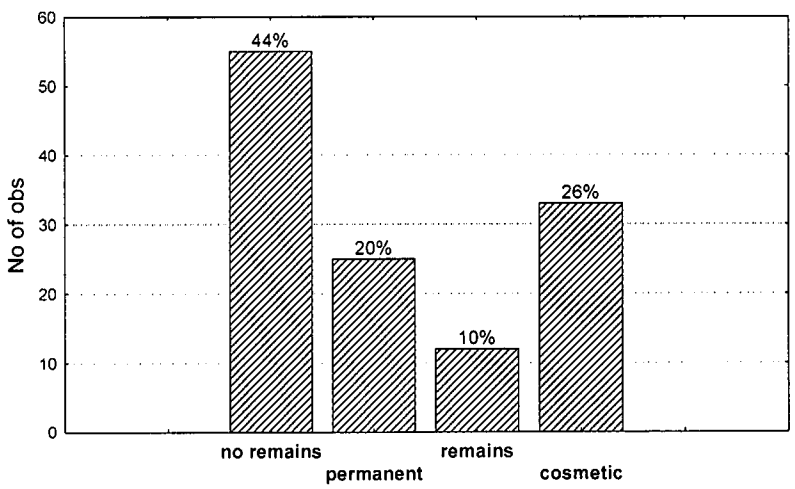


Figure 3.4: The percentage and number of attacks within different categories of injuries and fatalities (fatality: no remains and remains, injury: permanent and cosmetic).

Of the 16 different activities recorded for people who were attacked by a crocodile, the highest percentage of people who were attacked were fishing, followed by swimming and collecting of water. Other hazardous activities include collecting water lily roots, crossing the river, cutting reeds, looking after cattle, hunting and guiding clients (Table 3.2).

Table 3.2: Table showing the percentage and number of people performing certain activities when attacked by a crocodile (N=125).

Activity	Number	Percent
Swimming	23	18.4
Collecting water	23	18.4
Cutting papyrus	2	1.6
Fishing	27	21.6
Reed cutting	6	4.8
Hunting	5	4.0
Collecting worms for fishing	1	0.8
Collecting water lily roots	10	8.0
Looking after cattle	6	4.8
Washing	3	2.4
Boating	1	0.8
Crossing river	10	8.0
Growing crops	1	0.8
Guiding clients	5	4.0
Feeding crocs	1	0.8
Sleeping in a tent	1	0.8

Over a third of attacks were not reported the attack to authorities (45% not reported and 55% reported). Of those that reported crocodile attacks, 74% were reported to the police, 19% to the BDF (Botswana Defence Force), 9% to the DWNP (Dept. of Wildlife & National Parks) and 3% to other authorities such as chiefs, safari companies & lodge owners.

When questioned as to what happened to the crocodile post-attack, the majority of interviewees said that nothing happened to the crocodile after attack (94%), while others said that a crocodile was killed (5%) (although not necessarily the attack animal), 1% claimed that the crocodile was injured by a person and 1% of interviewees said that the crocodile was captured (either by the DWNP staff or the community members themselves).

Location of attack

The distribution of attacks by crocodiles on humans at a localised scale could be beneficial in determining areas of high potential conflict and cross comparisons between villages could possibly help to determine factors that link the likelihood of attacks. Table 3.3 shows the number of attacks on humans occurring at various villages and the total number of interviews conducted per locality (N=125). In many cases the location of attack was not in the same village where the interview was being conducted and therefore some villages have a sample size of zero (because sampling did not occur there).

The highest number of attacks was recorded in the villages of Mohembo West (N=11) and Jao (N=10). Other villages where a high number of human attacks occurred include: Shakawe (N=8), Samochima (N=8), Seronga (N=8), Mohembo East (N=7), Kavxwi (N=6), Gumare (N=7) and Dungu (N=5). No relationship was found between the number of attacks and the number of interviews conducted in specific localities (sample size), as some villages with a large sample size had few recorded attacks. For example: Maun with a sample size of 40 people only had 4 attacks occurred there. Mohembo West and Mohembo East, are located in close proximity to each other near the Namibian border, had a similar high number of human attacks. These two villages are separated by the Okavango River and linked by means of a ferry. Jao is very small village [population size: 234 people (2001 statistics)] on an isolated island in the northern reaches of the delta. Transport to the island is limited and occurs mostly by boat or mekoro (wooden canoe) and therefore people may be more susceptible to attack. Kavxwi is located close to Mohembo East and has a population size of 1,631 people and Dungu, which is a cattle post, has a population size of only 82 people and is located on the eastern side of the panhandle northwest of Seronga.

Trends in the activities being conducted by people when they were attacked at these specific locations could provide further insight into the high occurrence of attacks in these areas. In Mohembo West, five out of the 11 people who were attacked by crocodiles were collecting water from the river, three people were fishing and two were swimming. In Mohembo East, four people were attacked when they were collecting water and three were attacked when collecting water lily roots. In Jao village five out of the ten people attacked were fishing and two were attacked when crossing the river, two were attacked when looking after cattle and one person was attacked when guiding clients.

Table 3.3: Frequency table showing the number and percentage of attacks on humans occurring at different villages, together with the total number of interviews conducted (sample size) per locality (N=125).

Village	No. of attacks	Percent	Sample size
Shakawe	8	6.4	24
Mohembo West	11	8.8	15
Samochima	8	6.4	22
Seronga	8	6.4	21

Nxamasere	4	3.2	14
Xhaoga	2	1.6	5
Mohembo East	7	5.6	16
Kavxwi	6	4.8	11
Delta	4	3.2	0
Gamokwe	1	0.8	0
Xakao	3	2.4	15
Sekondomboro	1	0.8	10
Ngarange	4	3.2	12
Jao	10	8	20
Xakanaka	1	0.8	0
Ikoga	3	2.4	39
Etsha 9	1	0.8	0
Etsha 10	1	0.8	0
Etsha 3	1	0.8	0
Etsha 13	3	2.4	21
Etsha 6	1	0.8	22
Sepopa	2	1.6	20
Maun	4	3.2	40
Gumare	7	5.6	22
Gunutsoga	1	0.8	10
Gudigwa	1	0.8	0
Beetsha	1	0.8	10
Eretsha	3	2.4	10
Mawana	1	0.8	0
Dungu	5	4	10
Shaowe	2	1.6	10
Diseta	1	0.8	0
Weboro	1	0.8	0
Nokaneng	1	0.8	0
Odd Balls	3	2.4	15
Tabazimbi	1	0.8	14
Tubu	1	0.8	0
Xaxanaka	1	0.8	0
Etsha 5	1	0.8	0

Estimated compensation for human attacks

Compensation for attacks on humans was calculated from estimated funeral costs as obtained from the value of livestock (cattle & goats) used for the funeral meal and other costs estimated by the interviewee. The compensation values for people who died from attack by a crocodile was estimated to be between 200-4000 Pula (N=69). Table 3.4 shows that the minimum compensation was 38.00$US, the maximum 760.00$US and the average compensation estimated per person attacked is under P2000, or 178.60$US (1BwP=0.19USD, 09h54 15.05.2006 www.oanda.com).

Estimated compensation amounts were further divided into 500 Pula intervals and it was found that 21% of fatalities estimated compensation were below P500, 35% were between P500-P1000, 13% were between P1000-P1500, 22% were between P1500-P2000 and the remaining 8% were between P2000-P4000. This indicates that most people spend less than P2000 on funeral costs for people who died from a crocodile attack.

Table 3.4: A summary of the mean, median, minimum, maximum value and standard deviation of compensation that is estimated for fatal attacks on humans by a crocodile (1BwP=0.19USD, 09h54 15.05.2006 www.oanda.com) (N=69).

Compensation value	Mean	Median	Minimum	Maximum	Std. Dev
Botswana Pula (P)	1161.32	940.00	200.00	4000.00	766.82
US Dollars ($)	220.65	178.60	38.00	760.00	145.70

Cross comparisons of human attacks

There was a strong bias towards a specific gender amongst different activities, when comparing activity vs. number of attacks ($p<0.0001$). The majority of those that were attacked while fishing, swimming, crossing the river, hunting, guiding clients were male, whilst a high number of attacks on females were associated with collecting water, cutting papyrus and washing of clothes. The gender distribution of interviewees for these activities was fairly similar (Chapter 2), except for the activity of collecting drinking water, with a distribution of 56% males and 44% females, compared to 70% females and 30% males who were attacked.

When comparing the percentage and number of people attacked by crocodiles at different times of the day (pm: 13h00-24h59; am: 00h00-12h59) for different activities that they were undertaking at the river when they were attacked, there was no significant difference ($p>0.05$) in the distribution of attacks between the different activities, with the majority of attacks occurring in the morning. However, there was a significant difference ($p<0.05$) in the distribution of attacks between different activities during the day or the night. The attacks that occurred at night were when the person was sleeping in a tent, boating, hunting or crossing the river. The majority of attacks on people when they were swimming, collecting water and cutting papyrus were fatal, whereas most people who were attacked when fishing, boating, hunting, crossing the river, sleeping in a tent and growing crops were injured.

3.2 Livestock attacks

There were a large number of attacks on all livestock species in relation to the total sample size, with an average of seven livestock attacked (fatal and non-fatal) per interviewee and 3.3 livestock killed per person interviewed. Possible causes for this very high number of attacks that were observed in the study site are a lack of fencing and herding of livestock. Livestock tended to be free roaming during the daytime and in the winter months (June-July) the livestock tended to concentrate close to the river, where grazing was good.

Table 3.5 recorded a total number of 3405 livestock and domestic animal attacks by crocodiles since 1941, with the highest percentage and number of livestock attacks being cattle (41.5%, N=706), then goat (32.2%, N=549), dog (13.9%, N=236), donkey (7.8%, N=133), horse (4.1%, N=70), chicken (0.4%, N=6) and calf (0.2%, N=3). The majority of attacks on cattle were fatal (N=632), followed by permanent injuries (N=24) and cosmetic injuries (N=50). There were a fairly low number of permanent injuries recorded throughout all livestock species, except for cattle. There was also a high total number of cosmetic injuries for all livestock species (N=88), compared to fatal attacks (N=1580) and permanent injuries (N=35).

Table 3.5: The number and percentage of fatal attacks and injuries for various species of livestock. Cosmetic injuries are surface injuries, (such as gashes or minor bite marks/scratches) while permanent injuries are either the removal of a limb or severe maiming.

Livestock type	Fatal	Permanent	Cosmetic	Total attacks	% of total attacks
Cattle	632	24	50	**706**	41.5
Goat	524	4	21	**549**	32.2
Dog	231	1	4	**236**	13.9
Donkey	125	2	6	**133**	7.8
Horse	59	4	7	**70**	4.1
Chicken	6	0	0	**6**	0.4
Calf	3	0	0	**3**	0.2
Total	**1580**	**35**	**88**	**1703**	100

The number and percentage of crocodile attacks on livestock is shown in Figure 3.5. Ninety three percent of attacks were fatal, 5.2% cosmetic injuries and 2.1% were permanent injuries.

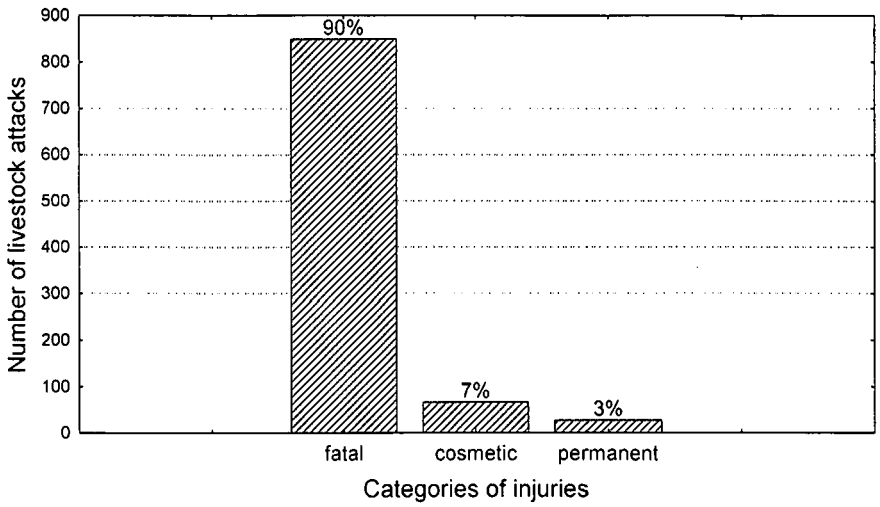


Figure 3.5: A histogram showing the number and percentage of attacks by crocodiles on livestock and the type of injuries sustained. Fatal: the livestock was killed; cosmetic: the livestock was only injured with surface wounds; permanent: the livestock was injured with the partial of complete removal of a limb.

Figure 3.6 shows that recorded livestock attacks have increased greatly since the 1980s, where an average of 43 livestock attacks were recorded per year from 1985 until 1995. Since then the number of attacks on livestock increased substantially with a peak in 2003 (N=203) and 2004 (N=173). A low number of livestock attacks were recorded in 2005 because sampling occurred for only half of the year in the study region. The rate of attack on livestock is increasing linearly over time, by a factor of ±0.03. The rate of attack for livestock is higher than recorded for humans, which could be linked to varying demographic factors.

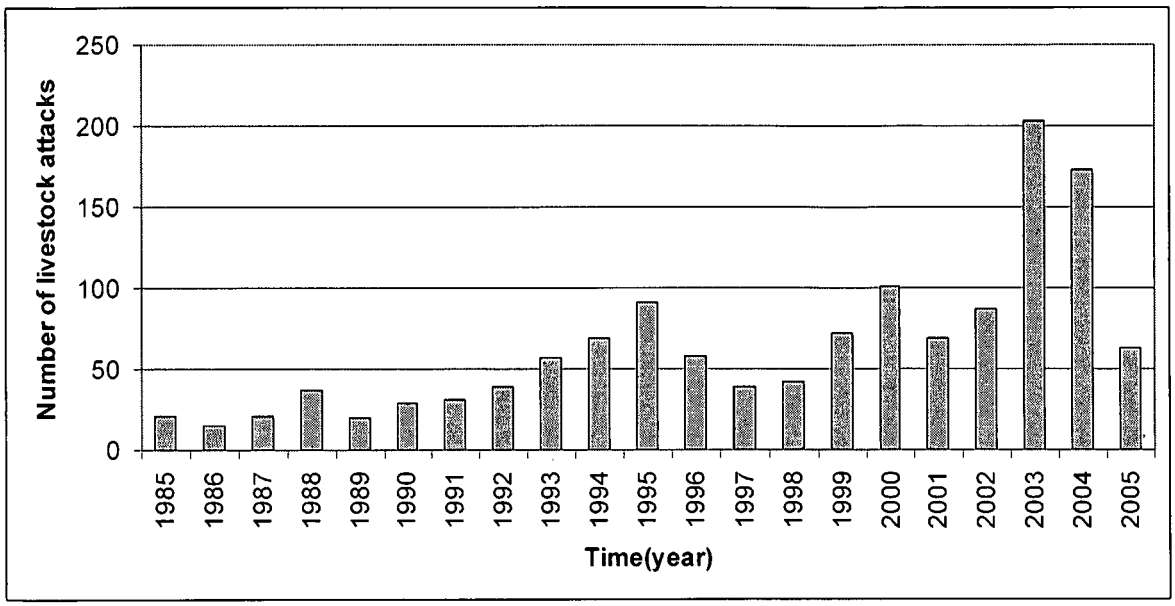


Figure 3.6: Graph showing the number of attacks by crocodiles on livestock for 1985-2005 (one year time intervals are used) (N= 1335). See Addendum 3.1 for more details on the total number of livestock attacks from 1940-2005.

Figure 3.7 shows the percentage and number of attacks on livestock by crocodiles per month, since 1994 (N=43). The highest number of attacks on livestock occurred in the months of March, April, May and December. Although the sample size used in this analysis is relatively small, it provides insight into the seasonality and timing of attacks and other factors that may play a role in this regard

The majority of attacks on livestock occurred during the daytime, in the afternoon (pm: 54%, am: 46%) with only 9% occurring at night.

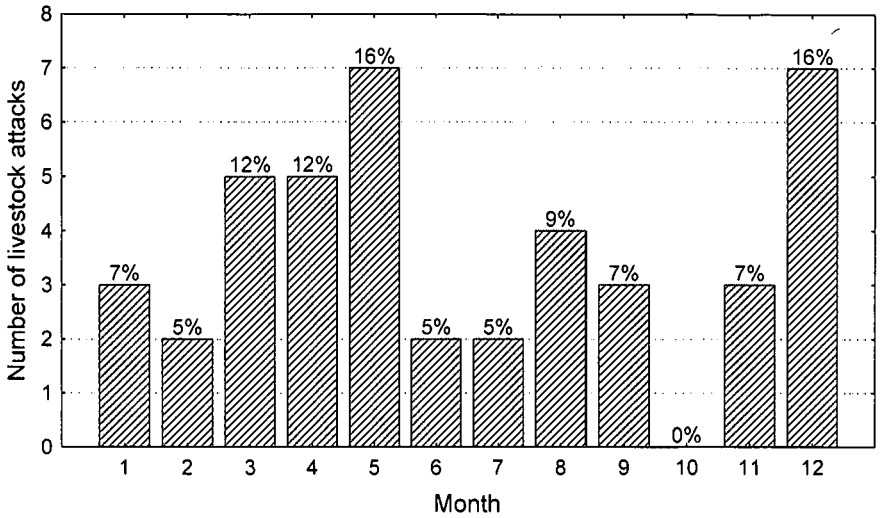


Figure 3.7: Histogram showing the percentage and number of attacks by crocodiles on livestock within different months (1=January, 2=February, 3=March …etc) (N= 43).

Estimated compensation

A total compensation of P671 100.00 or 127 876.58US$ (1BwP=0.19USD, 15.05.2006 09h54 www.oanda.com) was recorded for the sample for all species of livestock, which gives an average of P1 389.44 per person interviewed. The total number of livestock that qualified for compensation claims within the sample was 1458 (as only cattle, horse, donkey and goat are compensated for by the DWNP) out of a total of 1700 fatal attacks, with an average of about 3 livestock per person interviewed. The majority of people's estimated compensation amount lies between 120-1000 Pula (P120 is the value of a goat or calf), with only a few people having larger estimated amounts of compensation valued between P1000-P13000.

Evidence of attack

Recording the evidence of attacks helps to confirm if the claim of attack on livestock by crocodiles is creditable. Claiming the cause death of livestock by a crocodile potentially results in compensation payment through the DWNP. Figure 3.8 shows that 24% of people found no remains of livestock or no actual evidence of a crocodile having attacked the livestock. This provides an estimated margin of error for the total number of false claims for attacks on livestock. Remains of livestock were reported by 28% of interviewees, teeth marks of a crocodile by 3%, foot prints of a crocodile by 13% and other (e.g. sounds of livestock being attacked or livestock were feeding/drinking at the river) by 1% and 32% of attacks were witnessed by people.

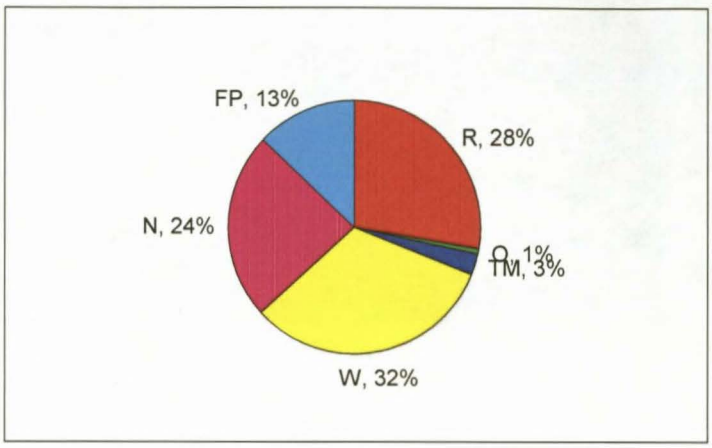


Figure 3.8: A pie chart showing the percentage of attacks on livestock that were recorded for various forms of evidence of attack by a crocodile (R= remains, O= other, TM= teeth marks of crocodile, W= witness, N= no remains or no evidence of attack, FP= foot prints of crocodile).

3.3 Relationship between human and livestock attacks

Figure 3.9 compares the number of human attacks against the number of livestock attacks plotted for each village. It shows that as the number of attacks on humans increases, so too does the number of attacks on livestock increase for each locality.

The relationship between the two variables is highly significant but shows a fairly low correlation. This is possibly due to the extremely high number of attacks on livestock for Seronga (see Addendum 3.2, which shows the distribution of human, livestock attacks and population size of villages within the Okavango Delta.)

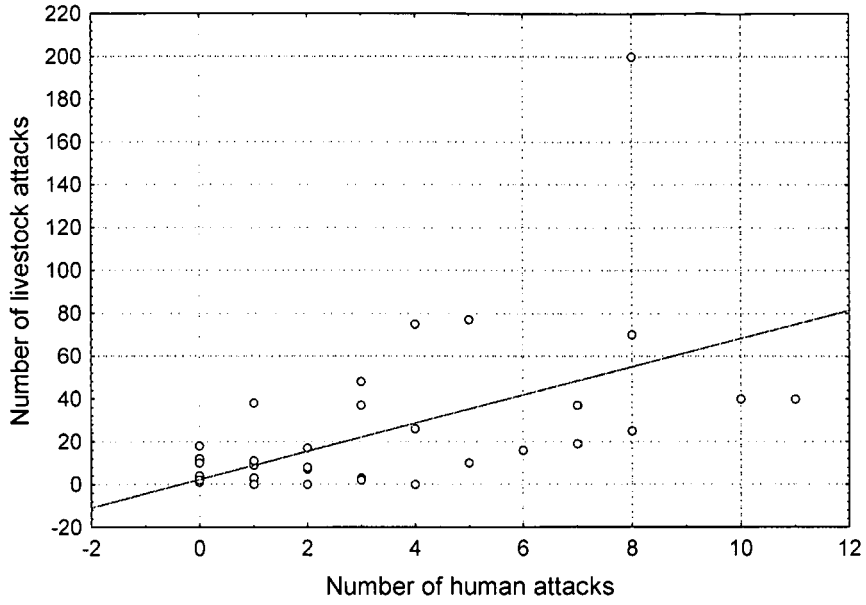


Figure 3.9: A scatterplot showing the number of human attacks plotted against the number of livestock attacks for each village ($p<0.00001$, $r^2= 0.3233$, $r=0.5686$, $y=6.593x +2.2738$).

Figure 3.10 compares the percentage of total attacks on humans and livestock between different villages/ locations. It shows that Seronga and Samochima had an extremely high percentage of livestock attacks together with human attacks compared to other villages. The highest percentage of human attacks occurred at Mohembo West, Jao, Samochima, Seronga, Shakawe, Mohembo East and Gumare villages. The highest percentage of livestock attacks occurred at Seronga, Samochima, Maun, Dungu and Ikoga.

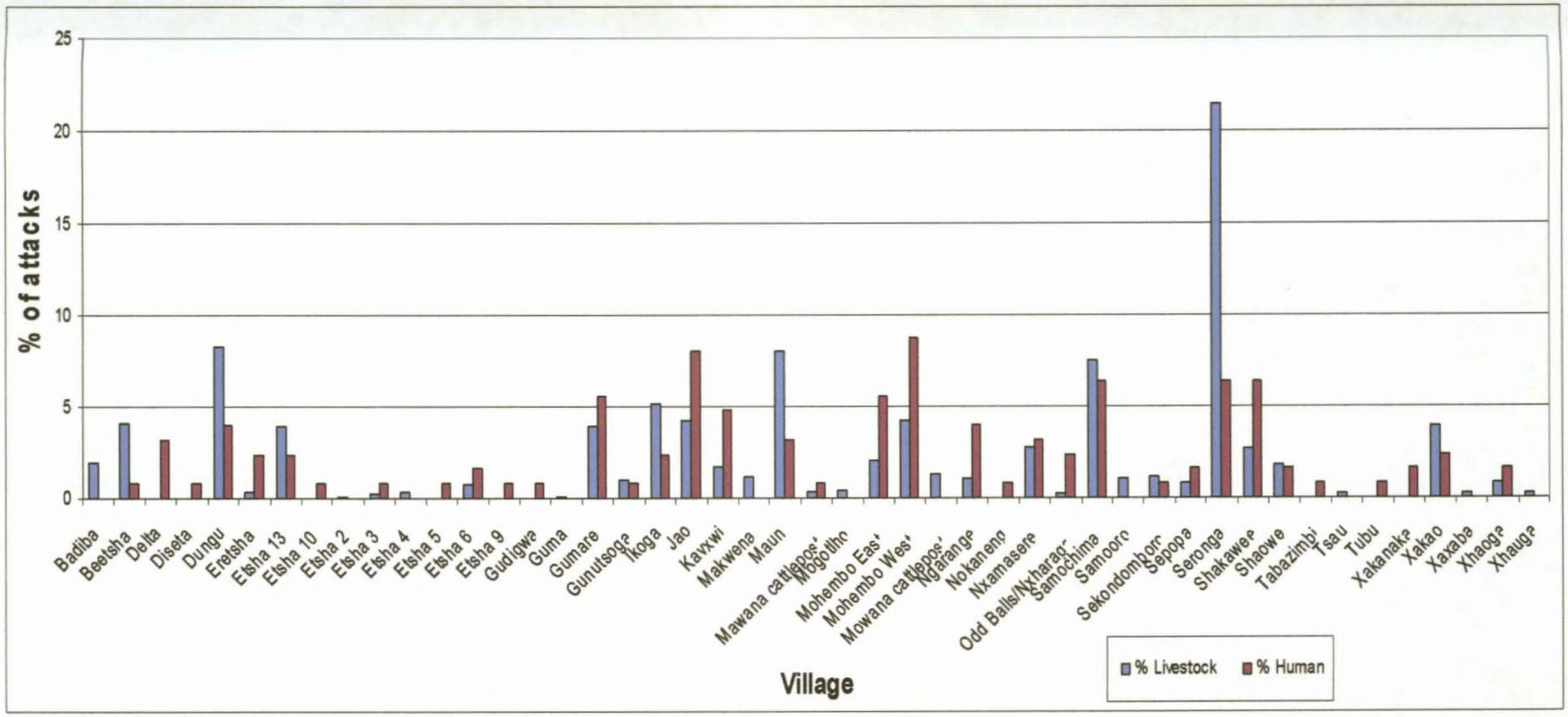


Figure 3.10: Histogram showing the percentage of attacks on both humans and livestock within different villages in the Okavango Delta, Botswana.

4. DISCUSSION

The results show that the number of crocodile attacks on livestock and humans has greatly increased in recent years (the last 5-8 years). However, this trend may be influenced by factors such as interviewee memory of attacks over time (with fewer attacks recorded in the distant past) and potential compensation payments or government action (where people report more attacks in anticipation of compensation payments or government action), which must also be taken into consideration. The rate of attack is of more concern than the absolute number of attacks over time, as the rate of attack (on humans and livestock) is increasing linearly. Therefore, HCC in Botswana may become a serious threat to communities and the crocodile population in the future if no action is taken to prevent attacks. Unfortunately results of the rate of attack on humans in the Okavango could not be compared to other regions of Africa, as the rate of attack by Nile crocodiles has not been recorded in recent years (Fergusson 2004).

The majority of attack victims were males (64%) and this is similar to records from other African countries where 59% of attack victims (N=120) were males (Fergusson 2004). In Australia, records of attacks (N=62) by the Saltwater crocodile (*Crocodylus porosus*) showed that 75% of attack victims were male, with an average age of 31.8 years. Four attacks were recorded on average per year for 2001-2004 in Australia, compared to an average of six people per year within the same time frame for the sample in the Okavango Delta (CSGN 2005 and Caldicott et al. 2005). It is likely that there will be a higher number of human attacks per year for the Okavango Delta, as this it is only a small sample of the entire region. A similar trend of the majority of human attacks by Nile crocodiles during the day time was recorded by Fergusson (2004) for several African countries compared to the Okavango Delta, which highlights the opportunistic nature of crocodiles and man's activity patterns.

The main activity being carried out by people when they were attacked was fishing. Fish is a primary food source and an income for families and also part of a way of life. Humans can be seen as direct competitors for essential food sources in the Okavango Delta. Fishermen are bound to come into contact with crocodiles more frequently, as they seek the same food source as these predators. In a study by Satiapillai & de Silva (2001), the reasons for the decline in the estuarine crocodile (*Crocodylus porosus*) and marsh crocodile (*Crocodylus palustris*) was due to poaching, competition with fisheries and destruction of mangrove habitats. The perceived competition

between crocodiles and fishermen is exaggerated by local people and fishermen (in Sri Lanka) are known to deliberately kill crocodiles for this reason. Crocodiles do not necessarily eat enormous amounts of fish, but they do play a beneficial role in the health of fish populations (Satiapillai & de Silva 2001). The main consumers of fish in many aquatic systems are birds, with pelicans consuming the equivalent of their body weight in 3 days, compared to 125-160 days for crocodiles (Cott 1961 and Satiapillai & de Silva 2001) and cormorants can consume 112-168kg of fish per ha (Winkler 1983 in Sataipillai & de Silva 2001). The highest number of attacks on humans in Australia was recorded for the activities of fishing, hunting and wading in shallow water (Fergusson 2004). In the United States, 34% of victims to alligators were totally submerged in the water (e.g. swimming), 38% were on the shore, 2% on boats and 9% was undetermined where they were attacked (N=236, 1948-1995) (Conover & Dubow 1997). A high number of attacks were also recorded for the activity of swimming in both Australia and the Okavango. Many people were also attacked while collecting water lily roots, which is a traditional food source in the delta.

Estimated mean compensation for human fatalities and livestock attacks

Calculating any compensation for human life is extremely difficult and according to some it is immoral, as one should not put a price on a human life. Nyhus et al. (2004) recorded that families in Zimbabwe were paid the equivalent of 273US$ for family members lost to wildlife and 1300US$ was paid to families in Malaysia for injuries by wildlife and double that amount for fatalities. The mean compensation estimated for human fatalities (funeral costs only) in the Okavango Delta was P1161.32 or 220.65US$. The current lack of compensation for human life, compared to the provision of compensation for livestock fatalities in Botswana, is unjust and the policy should be amended to include either compensation for human life as well as livestock or halting all compensation payments for loss of livestock, so as to redress any inequalities.

The high number of livestock attacks and associated compensation per interviewee shows that crocodiles are potentially having a high economic impact on people within communities in the Okavango Delta. However, one cannot properly gauge the impact of financial loss of livestock without comparing it to livelihood strategies. Compensation and relating issues are further discussed in Chapter 4.

Seasonal distribution of attacks

In St Lucia, South Africa, 85% of crocodile attacks occurred from November to April which coincides with the breeding season of the Nile crocodile and higher air temperatures together with a higher water level (CSGN 2000). Attacks on livestock in the Okavango Delta do not show a similar monthly pattern to St Lucia, as October (which is hot and dry) has the lowest number of attacks recorded and the highest percentage of attacks occurred from March-May (which has lower temperatures but higher water levels) and also in December. A seasonal distribution, similar to St Lucia, was recorded for human attacks by Nile crocodiles in Fergusson (2004) where 78% of attacks occurred from November to May (1994-2004, N=98). These months are generally warmer, wetter months within many African countries (sample: Kenya, Namibia and five other countries not mentioned).

The seasonal differences in the Okavango Delta could be attributed to the following: a) the 'barble-run' in the Okavango Panhandle occurs in late October (which is hot and wet conditions) when there is an abundance of fish available and a low number of attacks; b) rising water levels (previously associated with high crocodile attacks in St Lucia) in the north of the Okavango System (Mohembo/ Namibian border) occur in March which coincides with a high number of human attacks in that locality (Table 3.3 and Figure 3.7). As the water level subsides in July/August in the north, the number of crocodile attacks on livestock decreases (Mendelsohn & el Obied 2004). The higher number of attacks recorded during May could be due to the increased dispersal ability of crocodiles when the water levels rise and alternative food sources may become available outside of their normal ranges. Villages that were once a good distance away from the main river in the low flood season, receive an abundant supply of water in the high flood season and possibly a corresponding increase in the risk of crocodile attack.

Susceptibility of livestock and people to attack

Susceptibility or vulnerability of livestock to predators is primarily due to a three factors: 1) lack of anti-predator behaviour of livestock; 2) reduced abundance of wild prey species due to displacement of livestock herds and 3) livestock husbandry techniques where a reduction in guarding of livestock leads to higher predation (Thirgood et al. 2004). In Malawi, the excessive use of wetland resources by people has decreased the availability of natural food for crocodiles. This is said to be contributing to increasing crocodile attacks on people and livestock in recent

years (CSGN 2000). In Botswana it is difficult to make assumptions on the abundance of the crocodile's wild/natural prey species and the effect that it has on the number of livestock attacks, as there is limited data available on the distribution and abundance of prey species.

Livestock husbandry techniques (factor three above), could possibly be a major factor contributing towards the high number of livestock attacks in the Okavango Delta. Apart from the Veterinary Cordon Fences that separate wildlife and livestock (preventing spread of disease), there are very few fences in the area surrounding the Okavango Delta. Cattle roam freely and are therefore frequently susceptible to crocodile attack. Through the proper application of preventative livestock husbandry techniques one could possibly greatly reduce the number of attacks in the Okavango Delta, Botswana. The significant relationship between human and livestock attacks in the villages implies that the dynamics of HCC in the Okavango are linked to localised circumstances, such as Nile crocodile and human population dynamics and other external factors (further discussed in Chapter 4).

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ADDENDUM 3.1

Table showing the number and percentage of attacks occurring over time (frequency: year).

Date	No. of livestock attacks	No. of human attacks
1900	1	0
1940	0	2
1941	2	0
1942	2	0
1943	2	0
1944	0	0
1945	0	3
1946	2	0
1947	0	0
1948	0	0
1949	0	0
1950	2	0
1951	2	1
1952	0	0
1953	2	1
1954	1	1
1955	0	2
1956	2	1
1957	2	0
1958	0	0
1959	0	0
1960	10	2
1961	0	1
1962	5	0
1963	12	1
1964	4	3
1965	11	5
1966	13	1
1967	10	2
1968	4	1
1969	9	0
1970	18	1
1971	5	1
1972	5	2
1973	18	0
1974	11	2
1975	33	1
1976	13	3
1977	15	2
1978	14	1
1979	18	3
1980	25	2

1981	16	0
1982	28	2
1983	16	0
1984	18	0
1985	21	3
1986	15	4
1987	21	0
1988	37	2
1989	20	2
1990	29	1
1991	31	2
1992	39	2
1993	57	2
1994	69	4
1995	91	5
1996	58	2
1997	39	7
1998	42	3
1999	72	4
2000	101	6
2001	69	8
2002	87	3
2003	203	10
2004	173	2
2005	63	0
Total	**1688**	**119**
Missing	**15**	**6**

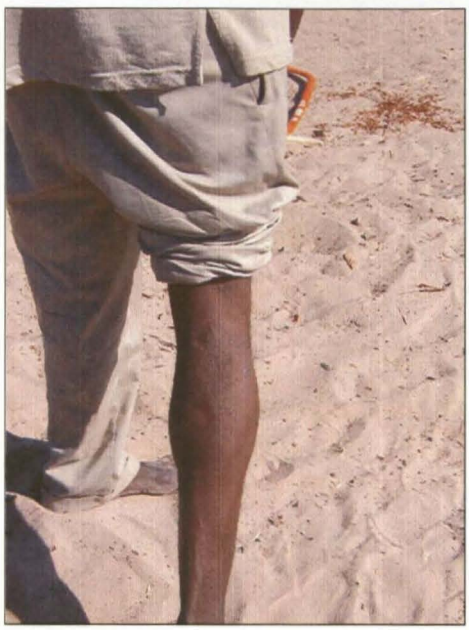
ADDENDUM 3.2

Frequency distribution of the number of attacks on livestock and humans within various villages including their population size per locality

Village	Number of livestock attacks	Number of human attacks	Population size (Census 2001 statistics)
Badiba	18	0	63
Beetsha	38	1	760
Delta	0	4	2688
Diseta	0	1	261
Dungu	77	5	82
Eretsha	3	3	616
Etsha 13	37	3	1975
Etsha 10	0	1	288
Etsha 2	1	0	213
Etsha 3	2	1	78
Etsha 4	3	0	276
Etsha 5	0	1	218
Etsha 6	7	2	2629
Etsha 9	0	1	313
Gudigwa	0	1	732
Guma	1	0	168
Gumare	37	7	6067
Gunutsoga	9	1	506
Ikoga	48	3	699
Jao	40	10	234
Kavxwi	16	6	859
Makwena	11	0	6
Maun	75	4	43776
Mawana cattle post	3	1	69
Mogotlho	4	0	97
Mohembo East	19	7	580
Mohembo West	40	11	1299
Mowana cattle post	12	0	37
Ngarange	10	5	948
Nokaneng	0	1	1590
Nxamasere	26	4	1328
Odd Balls/Nxharaga	2	3	317
Samochima	70	8	847
Samooro	10	0	43
Sekondomboro	11	1	655
Sepopa	8	2	1519
Seronga	200	8	1641
Shakawe	25	8	4389
Shaowe	17	2	557

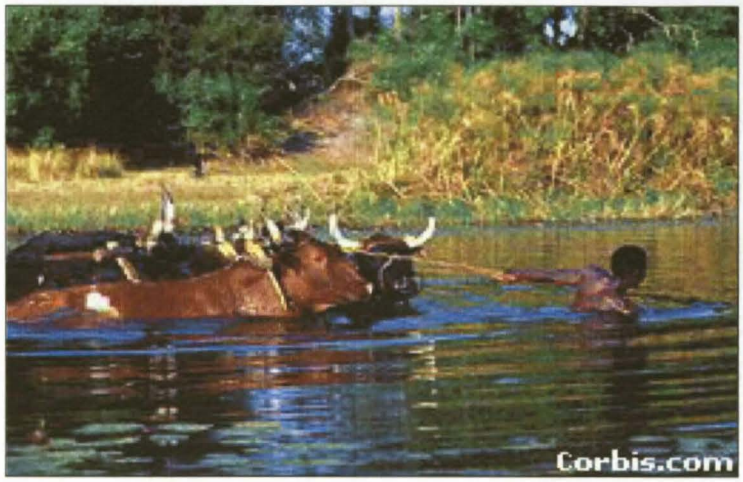
Tabazimbi	0	1	96
Tsau	2	0	1290
Tubu	0	1	392
Xakanaka	0	2	57
Xakao	37	3	1049
Xaxaba	2	0	79
Xhaoga	8	2	42
Xhauga	2	0	390

ADDENDUM 3.3

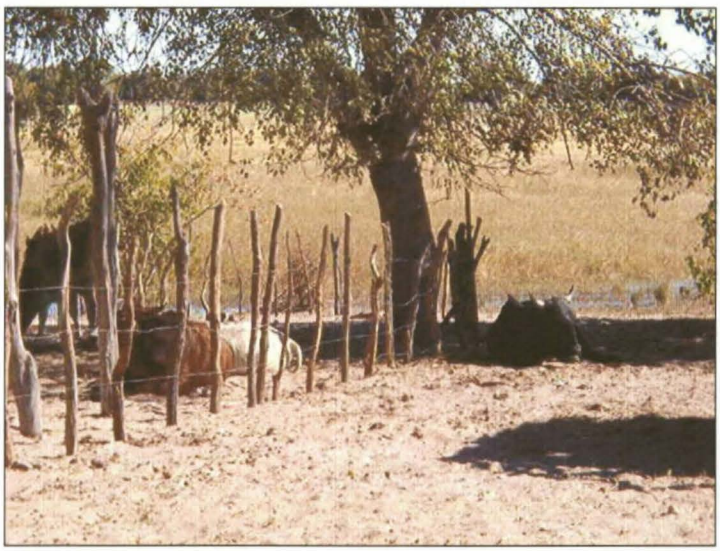


Mr. Leilamang Xhroko showing a scar on his leg from a crocodile attack at Ikoga village, Botswana (2004). This is an example of a cosmetic injury.

Ms. Retsee Sachuma with her mother, who were both attacked by a crocodile when they were collecting water lily roots in Mohembo East, Botswana (2004). This is an example of a permanent injury.



A man swimming cattle across the main channel of the river, from Cassidy (2004).



Cattle near the river at Seronga, showing cattle inside a fence and one that is free to roam around outside the fence near the river.

CHAPTER 4

ASSESSING THE SPATIO-TEMPORAL DISTRIBUTION OF HUMAN-CROCODILE CONFLICT WITH REFERENCE TO HUMAN POPULATION DEMOGRAPHICS AND LIVESTOCK DISTRIBUTION

1. INTRODUCTION

External factors, which are factors or circumstances surrounding crocodile attacks (e.g. human demographics and cattle density) that relate to HCC (Human-Crocodile Conflict) in the Okavango Delta, were investigated in relation to data gathered from questionnaires. These inter-linking factors were the focus of the second objective of this study and background to these factors is given with reference to the demographic and ecological setting of the Ngamiland Region.

Livestock farming occurs widely in the region surrounding the Okavango Delta and cattle are seen as a highly valuable commodity, where the value placed on cattle is unrelated to the income that is generated. Very few people sell their livestock commercially (less than 10% of animals are sold each year), as livestock is generally valued for security and investments (Mendelsohn & el Obied 2004). The grazing resources in the region of the Okavango River System are generally good; however, availability of drinking water, the presence of tsetse fly and other livestock diseases have restricted the development of this sector. Total livestock numbers in the Okavango Region of Ngamiland fluctuate greatly from year to year. This is due to the following: 1) declines in cattle numbers is in drought years; 2) an outbreak of lung sickness in 1996 and 3) Contagious Bovine Pleuropneumonia (CBPP) disease which resulted in the drastic loss of approximately 320,000 cattle that were slaughtered to control the outbreak. In an effort to curb the spread of diseases from wildlife to cattle, northern veterinary cordon fences were erected in the 1990's to demarcate 'cattle free' areas (NRP 2001).

Although livestock numbers have greatly increased in the last 100 years, numbers in recent years have remained fairly constant (Mendelsohn & el Obied 2004). However, there are multiple years where livestock population data was not recorded for the Ngamiland Region and therefore estimates on population trends are not very reliable. The current distribution of cattle is said to be

more dispersed than in the past where animals were concentrated close to the river. The current pattern is supposedly due to the increase of boreholes in areas further away from the river.

The human population has increased in Ngamiland in recent years, with a 2.81% growth rate recorded in 2001 (HOORC 2005), especially in main towns such as Maun, Gumare and Etsha, where 50% of the population lives in an urban/ semi-rural area. It is expected that the number of attacks on humans by crocodiles will increase as the human population size increases. However, the spread of HIV/AIDS in Botswana is having a devastating effect, with 36.5% of the population infected by 2001, which is one of the highest infection rates recorded in the world (statement by the President, Mr. Festus Mogae, CSIS 2003). Most HIV/AIDS related deaths are among people between 25-40 years of age, which has destructive social and economic effects on society.

Although human-crocodile conflict may be considered a minor issue in relation to the HIV/AIDS pandemic and other factors that affect people's livelihoods in Botswana, the direct costs of HCC may be felt more severely due to these pressurized circumstances. People may not be able to cope with the loss of family members and livestock to crocodile attacks when their own health and financial security may be in question. Therefore, it is important to determine the cost or burden HCC may have on the population in light of people's livelihood strategies. Compensation for wildlife damage in Botswana is afforded to claimants under government policy via the DWNP (Department of Wildlife and National Parks) and compensation is limited to four wildlife species: elephant, lion, leopard and the Nile crocodile.

People's livelihood strategies in the rural regions of the Okavango Delta are greatly dependant on agriculture and natural resources, with more land used for farming than for any other purpose (Mendelsohn & el Obied 2004). Agriculture is affected by the natural environment (rainfall, diseases etc.) and socio-economic factors (labour, land availability, market etc.) which makes it a highly unstable form of investment/income. Even though a majority of people farm in the Ngamiland Region, the income from wages, pensions, remittances and other incomes is said to exceed that of farming. However, livestock are highly valued in the region, as they are seen as an indicator of wealth and are also referred to as a 'bank account' (Mfune 2005). Livestock are also used for paying for a bride and are seen as a symbol of cultural status within a community, which may indirectly contribute to an increase in herd size per owner.

Water is a valuable and essential resource in people's livelihoods in the Okavango Delta and collecting water from various sources (communal taps, river and boreholes) takes up a fair amount of time for rural people each day. Eighty three percent of households in Botswana are said to have access to a piped (communal or private) water supply (Goldblatt et al. 1999 in Swatuk & Rahm 2004). Communal taps were only very recently placed in some villages in Ngamiland until fairly recently (from the 1980's onwards). The presence of taps in villages is expected to reduce the people's direct dependency on the river for household purposes and therefore, possibly reduce susceptibility to crocodile attacks.

2. METHODOLOGY

Sociologically based questionnaires were completed as explained in Chapter 2, which was used in this chapter to access HCC in the region of the Okavango Delta with reference to external factors. Recorded crocodile attacks were compared to the following data sources: population census statistics for Ngamiland, cattle densities, DWNP (Problem Animal Control Unit) records on livestock attacks by various predator species, other records of attacks on livestock from neighbouring African countries and Water Unit (Dept. of Water Affairs, Gumare) records of tap placement in villages.

The following specific comparisons were investigated:

1. Trends in human and livestock attacks over time and space were investigated in relation to human demography trends over time, human population density and cattle density.
2. Comparison between Department of Wildlife and National Parks records on livestock attacks against questionnaire sample.
3. Comparison between human attacks and the Water Unit records for the villages sampled. [This was investigated by comparing the Water Unit records to data on human attacks gathered from the questionnaires.]

In the Ngamiland district population censuses were only conducted in 1946, 1964, 1971, 1981 and 2001. However, growth rates were provided. This helped to estimate the total population size for each year from 1940 to 2004 (using STATISTICA version 7.0). This was compared to the total number of human attacks over time by means of a regression analysis. Records of livestock populations in Ngamiland could not be used in comparison to trends in livestock attacks, as data was not complete enough for an accurate statistical analysis.

Compensation payments afforded to livestock farmers for fatal attacks by crocodiles on livestock (only for cattle, horse and goat) were acquired from the DWNP and used in a comparison to calculate compensation for human and livestock fatalities obtained from the questionnaires. This helped to provide an overview of the economic impact that the Nile crocodile is having on communities. A Cost – Benefit Analysis was conducted within the communities in the Okavango

Delta, together with investigating general household incomes within Ngamiland to predict the impact of HCC within a socio-economic, ecological and political context. The Cost - Benefit Analysis was also used in the identification of key areas and obstacles (e.g. a lack of income for communities derived from crocodiles) for the successful mitigation of HCC.

It was also important to view HCC in the Okavango Delta on a broader scale, as it fell within a wider context of human-wildlife conflict in Botswana. HCC incidents were viewed within the scope of other wildlife species and records on attacks on livestock by various predators (DWNP records) were used in comparison to crocodile attacks in recent years. This aided in estimating the scale or extent of HCC in Botswana, compared to other predator species. Data on livestock attacks by various predators in Namibia (the Caprivi Strip of the Okavango River) was also used in comparison to the DWNP records. This further aided in putting HCC in Botswana into a broader context within the greater Okavango River System, which stretches across three countries (Botswana, Namibia and Angola).

3. RESULTS

3.1 Human attacks compared to human population size and density for Ngamiland

Due to a lack of continuous data for total human population size for successive years in Ngamiland, a smooth line was fitted to the population estimate (POPFIT in Figure 4.1) and this was used in a regression analysis between total human attacks and the total human population for Ngamiland. Figure 4.1 shows that the human population is increasing over time, together with the number of human attacks by crocodiles. POPEstimate was calculated using linear growth rates and CENSUS DATA and a smooth population trend-line was fitted (POPFIT). POPEst Projection was a continuation of the growth rate from POPFIT for the next 10 years.

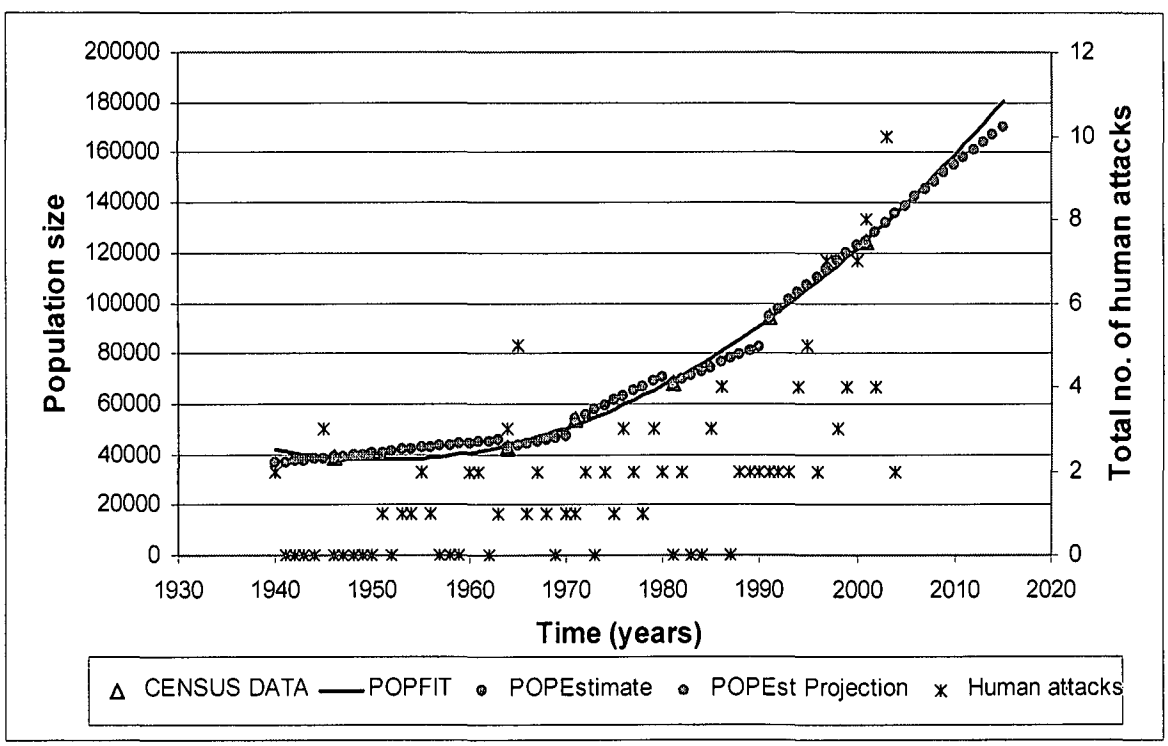


Figure 4.1: The human population size of Ngamiland Region plotted over time showing: population census data for years 1946, 1964, 1971, 1981 and 2001 (CENSUS DATA), estimated population size over time (POPEstimate), smooth-line equation (POPFIT): $y=39025.9+(-405.82)*x+(34.6629)*x^2$ and an estimated population projection (POPEst Projection) calculated using SARIMA in STATISTICA version 7.0.

Annual growth rates used to produce "POPEstimate" were as follows: 1946=1.00%, 1964=1.76%, 1971=3.48%, 1981=2.37%, 1991=3.34%, and 2001=2.81%. The population projection for Ngamiland did not take into account the negative effect of the AIDS virus on growth rate and therefore the population projection (POPEst Projection) should be less than predicted.

A regression analysis comparing total human attacks to total human population size for Ngamiland from 1940-2005 is shown in Figure 4.2. There was a highly significant relationship ($p<0.0001$) between the two factors, with a strong correlation coefficient ($r^2=0.4621$). Total human population used in the analysis was derived from POPFit (Figure 4.1).

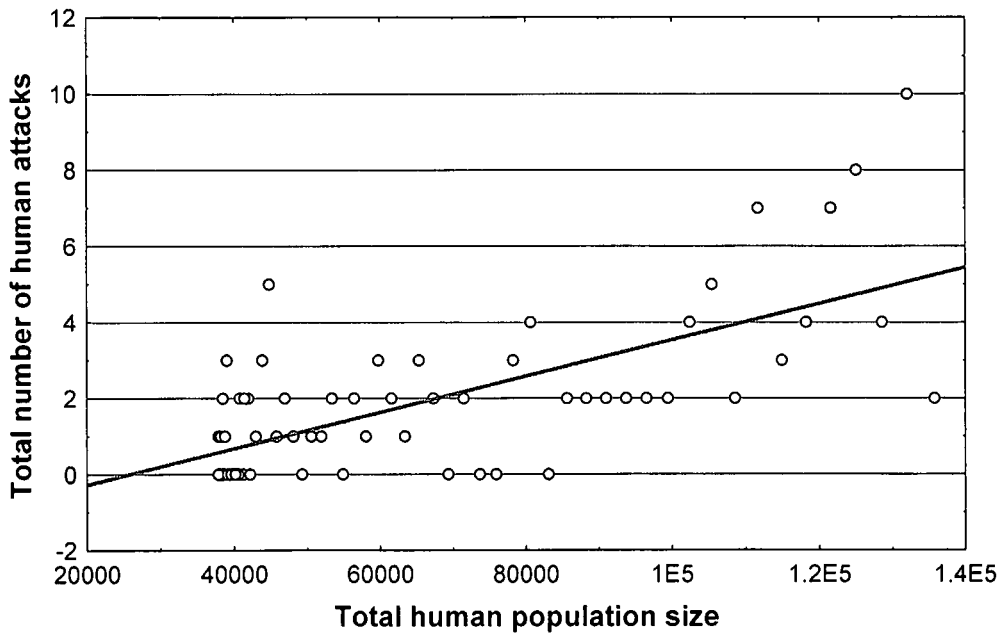


Figure 4.2: A scatterplot showing the total number of human attacks and the total estimated population size for Ngamiland from 1940-2005. The equation of the trend-line: y= -1.2343 +4.7705E-5*x; $p<0.001$; $r^2=0.4621$.

When the data for 2005 was removed and a line fitted, a higher correlation coefficient was observed ($p<0.001$, $r^2= 0.5039$, y = -1.4706 +5E-05*x). Records on human attacks for 2005 were only recorded from January-July and therefore an accurate representation of the total number of attacks for 2005 was not possible.

An exponential curve was used to establish the best fit of the data (Figure 4.3). A higher correlation coefficient was seen (r^2=0.59) when compared to Figure 4.2 (r^2=0.4621). The total number of human attacks is increasing more than expected when compared to human population size over time.

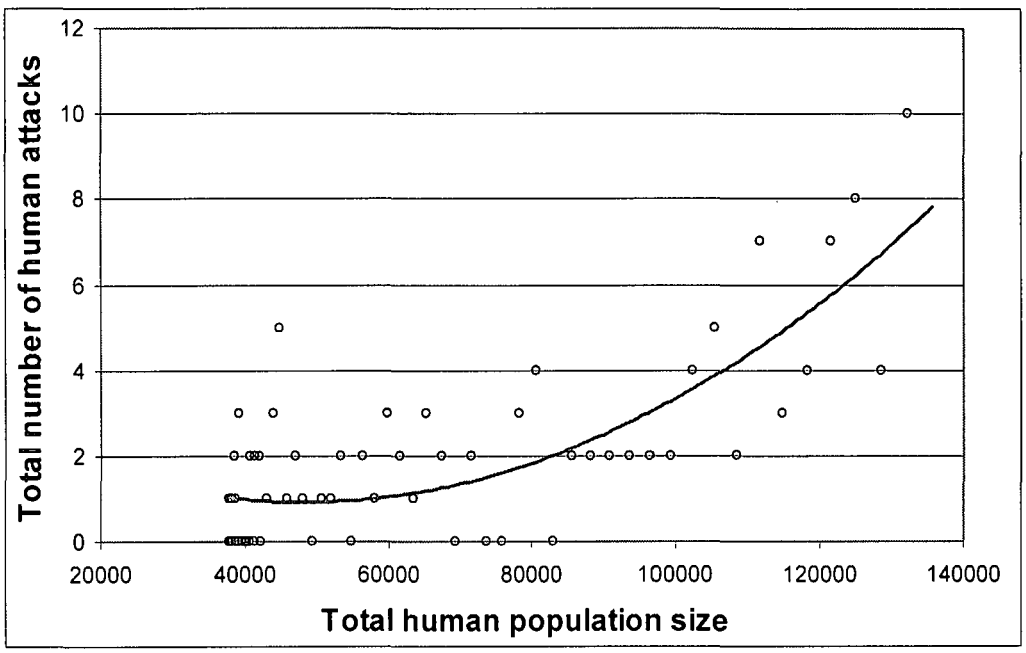


Figure 4.3: A scatterplot showing the total number of recorded human attacks and the total estimated population size for Ngamiland from 1940-2004. The equation of the trend-line: y =3.027 +9E-10*x^2 -9E-05*x; p<0.001, r^2=0.59 (data from year 2005 was not included, as sampling only occurred until July).

Human population size and attacks by crocodiles were compared at a smaller scale (villages), to determine if a similar trend was found (compared to Figure 4.2). Forty five villages were used in the analysis and human population size figure was for 2001 (Census statistics from HOORC, 2005). The village of Maun was not included in the analysis, as it had a very large urban population and a lower dependence (by people) on the seasonal river compared to the other villages that are in close proximity to the permanent river.

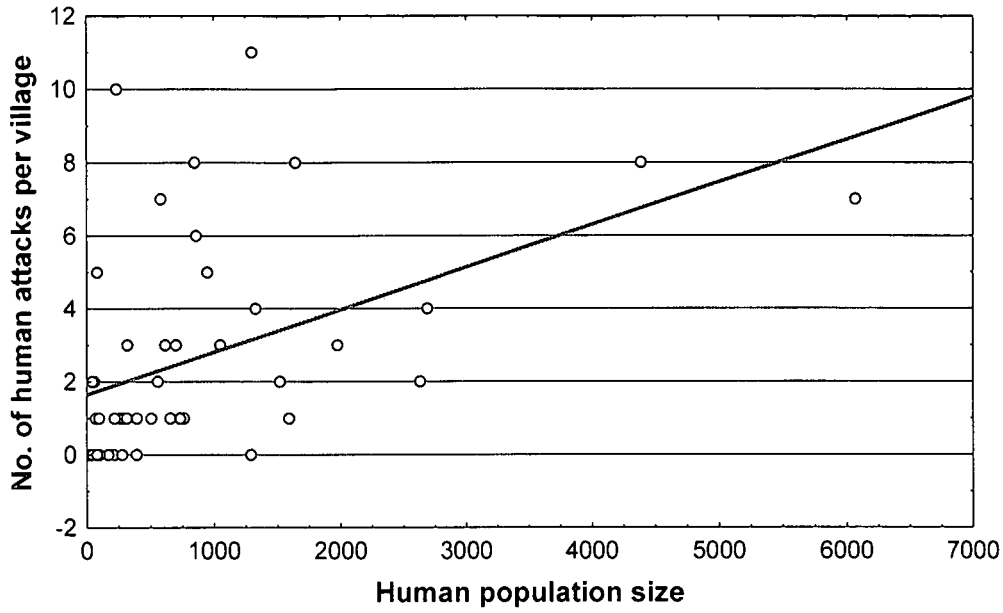


Figure 4.4: Scatterplot showing the number of human attacks per village (1940-2004) and the human population size of the village for 2001. The equation of the trend-line: y =0.0012*x +1.6429; p=0.0012 and r^2=0.2137 (N=45).

Figure 4.4 shows a significant difference ($p<0.01$) in the number of human attacks by crocodiles for the different villages. The correlation coefficient was less than in Figure 4.2, but showed a similar linear increase in the number of human attacks as the human population increases. However, the human population data per village was from the 2001 census statistics and could possibly have influenced the low correlation between the two factors.

Human population density for each village within the total sample was not available and therefore an analysis was not performed. Table 4.1 provides a comparison between a sample of villages, with the recorded number of human attacks versus population density. The comparison reveals that there is no clear relationship between the number of human attacks and local human population density. Villages such as Seronga, Mohembo West and Shakawe had a high number of human attacks, even though the population density was fairly low.

Table 4.1: A comparison between villages with different human population density categories (greater than 100, 100-51 and 26-50 people per km^2), the population size (2001) and number and percentage of human attacks per villages [Population statistics from Mendelsohn & el Obied (2004)].

Town/ village	Population density (people/km^2)	Population size	Sample size	Number of human attacks	% human attacks in sample
Maun	**>100**	43 776	40	4	**10.0**
Gumare	**> 100**	7 478	22	7	**31.8**
Shakawe	**100- 51**	1700 - 7900	24	8	**33.3**
Mohembo West	**100 - 51**	1700 - 7900	15	11	**73.3**
Etsha 6	**100 - 51**	1700 - 7900	22	1	**4.5**
Etsha 13	**100 - 51**	1 700 - 7 900	21	3	**14.3**
Nxamasere	**50 – 26**	< 3 000	18	4	**22.2**
Sepopa	**50 - 26**	< 3 000	20	2	**10.0**
Seronga	**50 - 26**	< 3 000	21	8	**38.1**

3.2 Livestock attacks compared to the human population for the Ngamiland Region

The total number of livestock attacks was compared to the total human population for Ngamiland over time (1940-2004). The human population statistics were calculated from POPFIT (Figure 4.1). Figure 4.5 shows that the human population increases in size, so to do livestock attacks (r^2= 0.8093).

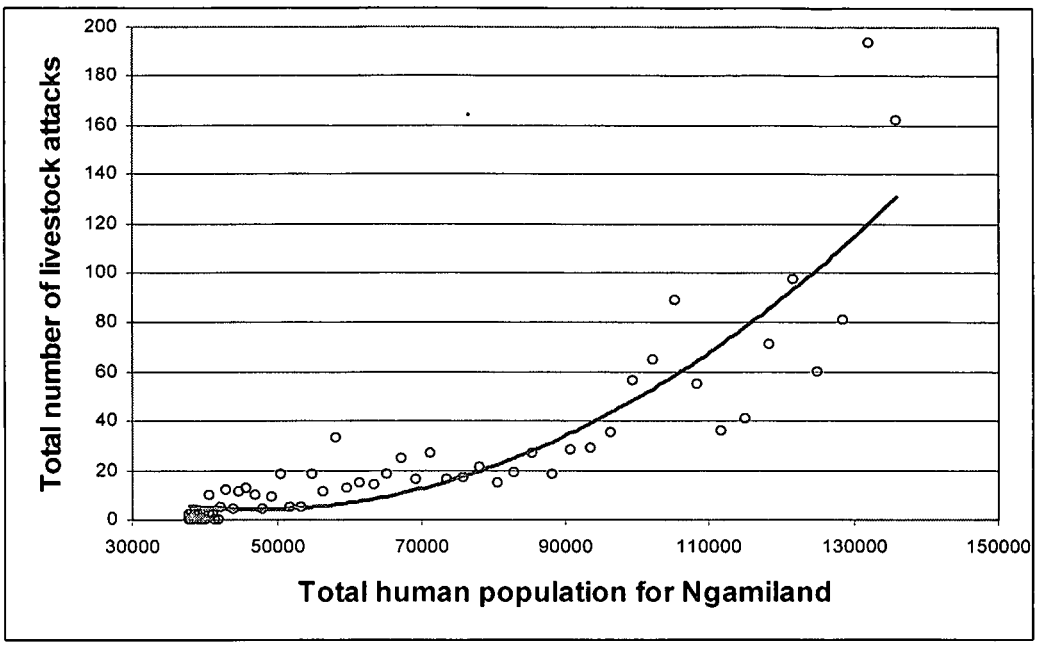


Figure 4.5: A scatterplot comparing the total number of livestock attacks to the total human population size for Ngamiland over time. The equation of the curve: $y = 2E\text{-}08x^2 - 0.0015x + 40.185$; $p<0.0001$; $r^2 = 0.8093$.

When comparing livestock attacks at a more localized scale, no significant relationship was found between the number of livestock attacked per village and the human population for each village. The data for total livestock numbers in Ngamiland were not recorded continuously and fluctuated greatly and therefore it was not possible to compare total livestock attacks with the total livestock populations.

A spatial representation of livestock density is shown in Figure 4.6. The highest density of livestock was recorded in the Gumare, Etsha 13 (SW of Panhandle Region), Samochima (NW Panhandle Region), Ngarange (NE Panhandle Region), Seronga and Gonutsuga (NE of Seronga) Regions (Mendelsohn & el Obied 2004). Medium densities of livestock occur in the Sepopa, Ikoga, Shakawe and Shaowe Regions and a low density was noted in Maun. An area where no cattle were present was the central region of the Okavango Delta, where Buffalo fences restricted the movement of cattle into the Moremi Game Reserve. The total recorded livestock attacks by crocodiles were plotted onto the map to provide a basic representation of the spatial distribution of attacks over the entire region.

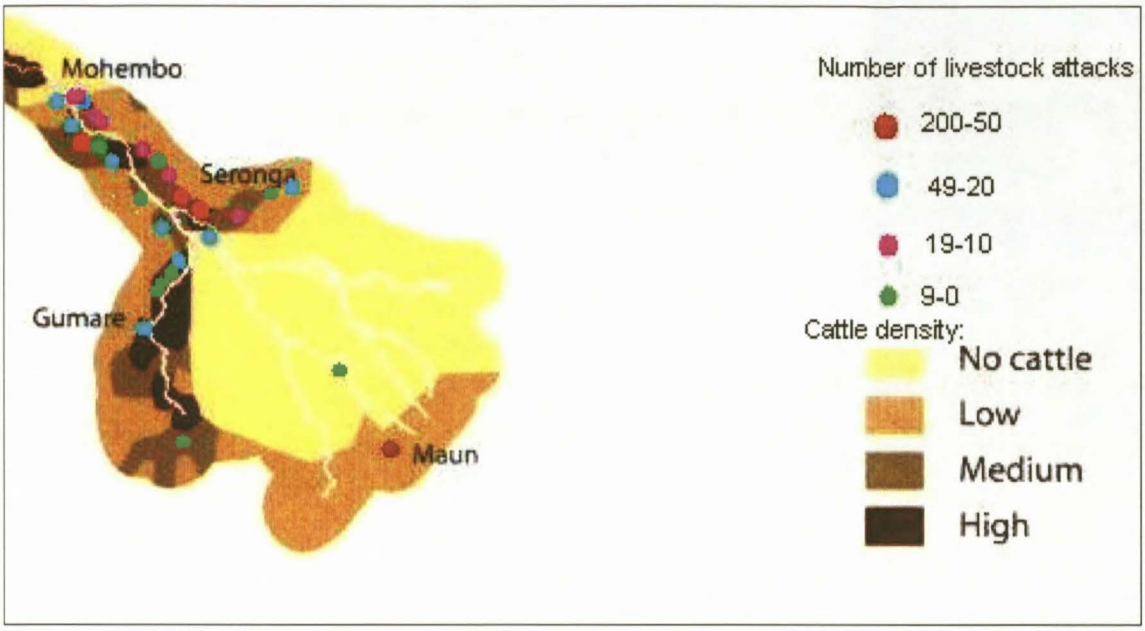


Figure 4.6: A map of the Okavango Delta showing the cattle density and the number of livestock attacks by crocodiles (adapted from Mendelsohn & el Obeid 2004).

The highest number of livestock attacks were recorded in Seronga, Samochima, Maun, Dungu and Ikoga (N: 50-200) and all of these towns were situated in medium to high cattle density zones, except for the village Maun. Dungu and Seronga were situated within close proximity to each other and this was identified as the area of highest conflict (with regards to livestock attacks).

3.3 DWNP records of livestock attacks in the Okavango Delta, Botswana

Records on livestock attacks that were obtained from the DWNP (Department of Wildlife and National Parks) in Maun for 1995- 2003, were analysed and compared to the records from the questionnaires. Results from this comparison indicated that a low number of the livestock attacks were actually reported to the authorities in the 1990's. However, since the year 2000 more attacks have been reported.

Table 4.2: A comparison between the total number of livestock fatalities by crocodiles (for compensated livestock types: cattle, goat, horse) recorded from the questionnaire survey and the reported livestock attacks from the PAC Unit, DWNP for the time period 1995 - 2003.

Year	Number of recorded fatal livestock attacks (surveyed)	Reported number of livestock attacks from PAC Unit, DWNP Maun
1995	77	8
1996	29	5
1997	30	1
1998	31	0
1999	46	23
2000	71	38
2001	47	6
2002	68	48
2003	150	50
Total:	**549**	**179**

DWNP records of attacks by various predator species (lion, leopard, hyena, wild dog, jackal and cheetah) on livestock was used in comparison to crocodile attacks (Figure 4.7). The highest number of reported livestock fatalities was from lions followed by leopard and hyena. The number of attacks by crocodiles on livestock was relatively small in comparison to the other predators. Guidelines for compensation that were drafted in 1996 caused a restriction and stricter control of compensation by the DWNP for certain predators (lion, leopard, spotted hyenas, wild dogs and Nile crocodile). This may have influenced the number of compensation claims for subsequent years (DWNP 1998).

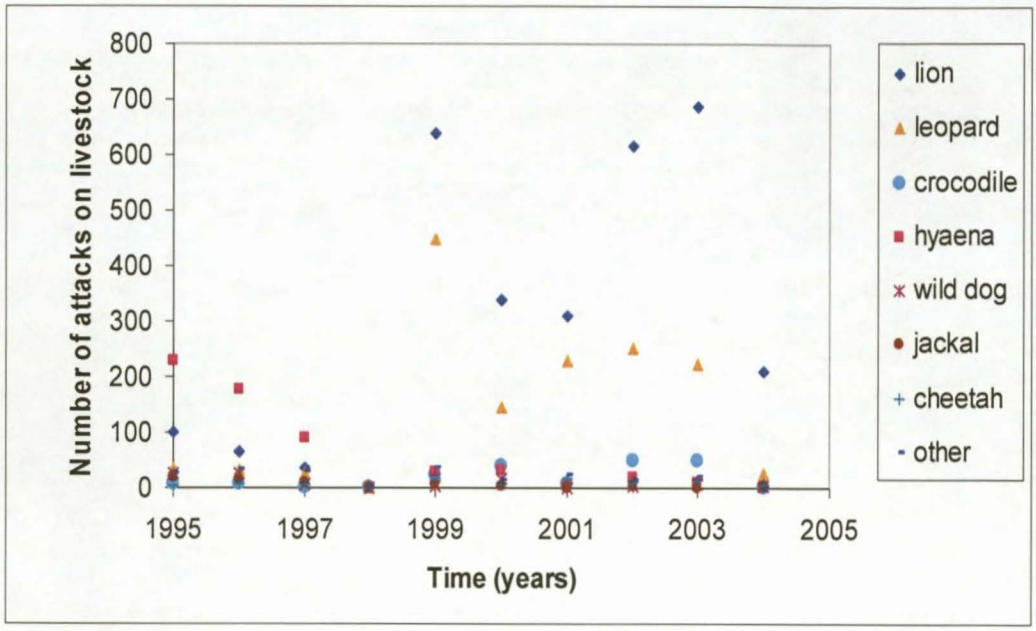


Figure 4.7: Scatterplot showing the reported livestock attacks for various predators for the region of Maun, Botswana (1995-2004) Records were obtained from the Department of Wildlife and National Parks (DWNP).

3.4 Compensation and financial costs of livestock and human attacks

Approximately US$1.13 million (US$227 000 per year) was disbursed by the Botswanan Government from 1995-2000 for compensation of damages caused by various wildlife species (O'Connell-Rodwell et al. 2000). Figure 4.8 shows the amount of money that was spent on Nile crocodile related livestock attacks in the Ngamiland Region from 1999-2003, which ranged from P10 000 to P40 000 per annum.

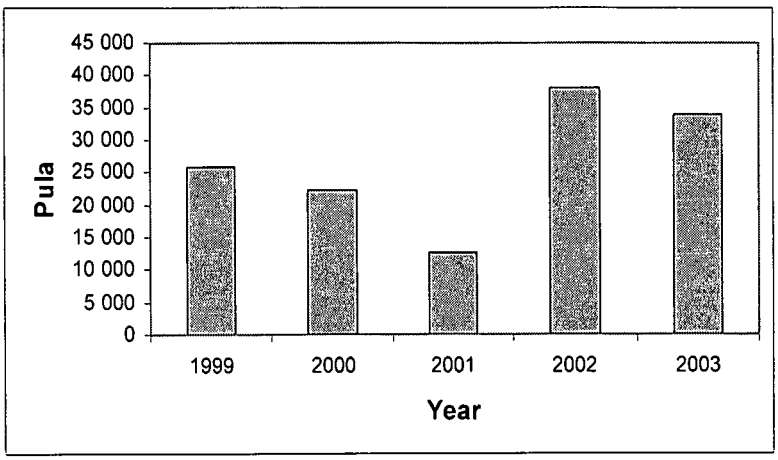


Figure 4.8: The total amount of compensation allocated (in Botswana Pula) by the DWNP to claimants in the Ngamiland District per year (from 1999-2003) for fatal livestock attacks by Nile crocodiles.

Further compensation amounts are shown in Table 4.3, where records are from a region that covers a large section of the Western Panhandle of the Okavango River, Botswana (Gumare DWNP branch). The total compensation for fatal livestock attacks by crocodiles for this region is 13% (for 2002) and 17% (for 2003) of the total compensation recorded for the Ngamiland District (calculated from Figure 4.10).

Table 4.3: The number of reported fatal livestock attacks by crocodiles and allocated compensation to claimants for 2002, 2003 and 2004 for a large section of the Western Panhandle. Figures are from the Gumare regional branch of the DWNP.

Year	Reported attacks	Compensation (Botswana Pula)
2002	6	5,100
2003	9	5,810
2004	18	16,240

Table 4.4 provides calculated compensation amounts from the study records on fatal human and livestock attacks by crocodiles in Botswana Pula and US$ from 1940-2004. The total amount of compensation calculated for livestock fatalities was high (P603 930.00 or 114 746.70US$), but average compensation per livestock was low, due to the vast number of livestock fatalities that were recorded (N=1343 since 1940). The compensation afforded for each human fatality (P631.76 or 120.03US$) was higher than for livestock. However, because only 125 fatalities were recorded, the amount per interviewee was substantially less (P163.84 or 31.13US$). The total average combined (livestock and human fatalities) compensation calculated per interviewee was seen as the direct cost of living in the vicinity to crocodiles, which is P1 416.81 or 269.19US$.

Table 4.4: A summary of calculated compensation (in Botswana Pula and US$) for fatal human and livestock attacks by crocodiles in the Okavango Delta Region, recorded from the questionnaires.

Compensation	**Pula** (BwPula)	**Dollars** (BwP1=0.19$)
Total compensation for fatal *livestock* (cattle, goat, horse, donkey & calf) attacks (N=1343 attacks)	603 930.00	.114 746.70
Average compensation per fatal *livestock* attack	449.69	85.44
Average compensation for fatal *livestock* attacks per person interviewed (N=482 people)	1 252.97	238.06
Total compensation for fatal *human* attacks (N=125 attacks)	78 970.00	15 004.30
Average compensation per fatal *human* attack	631.76	120.03
Average compensation for fatal *human* attacks per person interviewed (N=482 people)	163.84	31.13
Total (combined) compensation: (*livestock & human fatalities*)	682 900.00	129 751.00
Average (combined) compensation per person interviewed: (*livestock & human fatalities*)	1 416.81	269.19

Compensation values were calculated from the values of specific livestock types (only cattle, goat and horse) supplied by the DWNP (see Chapter 3, Table 3.1) and funeral costs are estimated by the interviewees. Records were from 1940-2004. Currency conversion was by Master Currency (2006).

3.5 Records of crocodile attacks in neighbouring regions

The following results were from a study by O'Connell-Rodwell et al. (2000) in the eastern Caprivi, Namibia, which were used in comparison to the data obtained the Okavango Delta. Reports or claims were recorded for four animal species (crocodile, elephant, hyena and lion) that were causing damage to human property and the estimated cost of damage was provided (Figure 4.9).

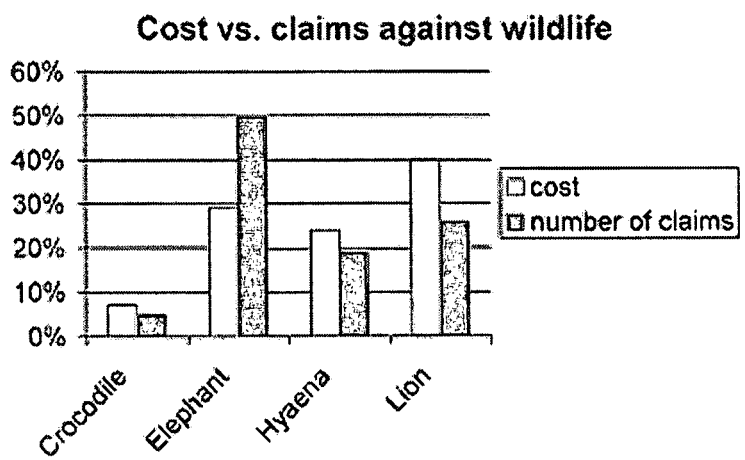


Figure 4.9: The percentage of economic loss per problem animal species compared to the percentage of problem animal claims submitted to the Community Game Guards (CGGs) in the Kwando region, East Caprivi in Namibia from 1991-1994 (O'Connell-Rodwell et al. 2000).

The number of reports of attacks on livestock by crocodiles was small in comparison to other conflict species in the eastern Caprivi, which was similar to the DWNP records in Maun for various predator species (Figure 4.7). The higher cost relative to the number of claims for predator species (lion, hyena and crocodile) was due to the higher market value of the livestock attacked, compared to the elephant, where financial losses to arable land were less per claim. Seventy percent of the claims were submitted for livestock that were unprotected at the time of attack (no fence, barrier or kraal was used to protect the livestock).

Table 4.5 provides a summary of the number of reports or claims made for the various predator species for years 1991-1992 and 1994 for livestock and human attacks in the eastern Caprivi. The only reported human attacks were by crocodiles (N=2) and lion (N=3), and far fewer livestock were attacked by crocodiles (N=31) than by lion (N=147) in the three year period.

Table 4.5: The number of claims and the total cost estimated for problem predator species from 1991-1994 for the Kwando region, East Caprivi in Namibia. The economic value of stock losses was based on the market values at the time of the study (O'Connell-Rodwell et al. 2000).

Stock	Lion		Hyena		Crocodile		Wild Dog		Leopard	
	91-93	94	91-93	94	91-93	94	91-93	94	91-93	94
Cattle[a]	86	61	54	34	23	8	2			
Calf	17		14		3				1	
Goat[b]	4		84		3		1			
Human[c]	3				2					
Total	NS$100,620.00 US$12,577.50		NS$68,240.00 US$8,530.00		NS$19,640.00 US$2,455.00		NS$1,080.00 US$135.00		NS$500.00 US$62.50	

a. Cattle price increase from N$500 to N$800 in 1994 due to increased cattle markets in Caprivi., b. Goat: market price=N$80, c. Undetermined value, (N$: Namibian dollars in 2000, US$:NS$ ±8 to 1 in 2000)

Other records of crocodile attacks on livestock and people (fatalities and injuries) are provided in Table 4.6, for 2000-2004 for the whole of Namibia (CITES 2006).

Table 4.6: Recorded incidences of people and livestock killed and injured by crocodiles from 2000 to early 2004 for the whole of Namibia (CITES 2006).

Year	People		Livestock	
	Killed	Injured	Killed	Injured
2000	3	2	21	2
2001	6		25	2
2002	10	3	70	4
2003	1	6	26	6
2004 (Jan-March)	3	1	16	1
Total	23	12	158	15

In the period from 2000-2004 in the Okavango Delta, Botswana, a total of 29 attacks on humans and 594 attacks on livestock was recorded including both fatalities and injuries (with an average of 7 human and 149 livestock attacks per year). In comparison, records from Namibia included 35 human and 173 livestock attacks over the same time period (with an average of 9 human and 43 livestock attacks per year). Even though the Namibian records were for both the Kavango (Okavango River in the Caprivi) and the Kunene Rivers, while the records from Botswana was only from the Okavango River; the number of human attacks was fairly similar and the number of livestock attacks for Botswana was much greater than for Namibia.

3.6 Cost - Benefit Analysis

Table 4.7 shows a current cost - benefit analysis for the presence of the Nile crocodile close to local communities living within the study region. Costs were described as any negative outcome or result of the presence of crocodiles within the region and benefits were any positive outcome or earnings derived from crocodiles, which can be both quantitative (e.g. monetary) or non-quantitative (e.g. traditional value). In general, very few benefits were recorded, which was very concerning as this implied that there were few incentives to conserve the Nile crocodile in its natural habitat. Social and economic costs, such as severe trauma, disruption of family livelihoods and loss of economic security, were being experienced throughout the communities in the study region.

Table 4.7: A cost – benefit analysis of the presence of crocodiles to communities within the Region of the Okavango Delta, divided into social, environmental, economic and political categories.

Costs	Benefits
Social:	
◦ Severe trauma from death/injury of family members/friends by crocodiles. ◦ Disruption of family life and structure ◦ Loss in attendance of children at schools, so as to provide for household income (due to loss of bread winners). ◦ Heightened fear of crocodiles, linked to traditional beliefs. ◦ Loss of livestock influencing cultural & social status (bride price)	◦ None recorded
Environmental:	
◦ Influence of crocodiles to fisheries	◦ Top predator in ecosystem (keystone species) ◦ Maintains river health and ecosystem

	balance
Economic:	
◦ Costs associated with human fatalities (funeral) and injuries (ambulance) ◦ Loss of working (bread winner) member of family member influencing household income =opportunity cost. ◦ Destruction of fishing nets and equipment. ◦ Loss of livestock (as an investment & source of income) ◦ Cost of preventative HCC measures (fencing, alternative water sources away from river, bathing facilities)	◦ Minimal tourism benefits ◦ Revenue derived from crocodile egg harvesting from the wild (restricted by permits) ◦ Crocodile farming & ranching (mostly privatised) ◦ Revenue derived from small hunting quotas to hunting concessionaries.
Political:	
◦ Conflict between people and DWNP when compensation inadequate or not received. ◦ Land and resource use conflicts with conservation (livestock based)	◦ None recorded

To assess the economic impact that crocodiles have on the rural people of the Okavango Delta Region, the household incomes were investigated. Incomes were wide ranging from agricultural holdings (livestock & fields) and natural resources (grazing, soils, fish etc.), to cash incomes (wages, pensions, remittances & earnings). Table 4.8 shows the relative importance of certain incomes to household's livelihoods in the region surrounding the Okavango Delta (Mendelsohn & el Obeid 2004).

The main source of income (Table 4.8) for households in Ngamiland was from farming (50% of households). Cattle were owned by 52% of the population and 69% of all homes owned some species of livestock (Mendelsohn & el Obeid 2004). Most households had various sources of income, however, the importance of livestock farming as an income increases in more arid areas

surrounding the Delta. This was because crop production becomes more hazardous and unproductive in arid areas, due to a decrease in soil fertility. Large households that had bigger fields and larger herds of livestock were generally wealthier and relied upon multiple sources of cash income. Wealthier families generally lived on bought food (compared to subsistence) and security investments are mostly in the form of livestock. Twenty five percent of households relied on wages and salaries, 16% relied on the government for assistance, 5% relied on small business and 4% on remittances.

Table 4.8: Percentages of total households' main sources of income in the Ngamiland District, Botswana (from Mendelsohn & el Obeid 2004).

Income source	Percentage of households
Farming	50
Wages & salaries	25
Government assistance	16
Small business	5
Remittances	4

3.7 Analysis of Water Unit records in relation to human attacks

Water Unit records on the dates of tap placements within villages aided in estimating the dependency of the local people on the river for drinking water and helped to assess if the provision of water taps was a factor influencing the number of crocodile attacks on humans. Villages such as Samochima, Sekondomboro, Etsha 1, Etsha 4, Mohembo West and Mohembo East only received taps within the last 6 years and some villages such as Badiba do not yet have taps. One would therefore expect that the number of attacks should have reduced in number to some extent, post 1996, for most villages. However, there was no significant difference between the number of crocodile attacks on humans before and after taps were placed in the villages ($p>0.05$; number of attacks = 64). See Addendum 4.1 for pictures of a communal water tap and people collecting water from different sources.

4. DISCUSSION

External factors relating to HCC were very difficult to isolate and quantify, as there were many social, biological, economic and political aspects within various scales (from regional to localised levels) that related to the interaction between man and crocodile in the Okavango Delta, Botswana. Some of the main factors identified (i.e. human demographics, livestock density etc.) were quantified and the effect that these different factors are having on HCC in the study region must be assessed.

The high number of human attacks associated with a high population, at both a local (village) and regional scale (Ngamiland) highlights the crocodile's opportunistic nature (where crocodiles will attack the most abundant and accessible prey type). However, the low correlation coefficient at the village scale shows that there are possibly other localized factors that are influencing the number of attacks. Possible reasons for this are: (1) only the 2001 population size of villages was used and the records of human attacks were from 1940-2004. Therefore, human population dynamics (such as migration and population growth trends) over time were not accounted for; (2) adult crocodiles tend to keep the same home ranges for many years and are known to inhabit areas where daytime disturbances are common (Lang 1987). This could exacerbate the level of HCC in certain areas, if a 'problem' animal is resident near a village. This could be occurring in villages showing a high number of human attacks, even though the population density is fairly low (eg. Mohembo West); (3) the level of urbanization and provision of more services thereby decreasing dependency on the rivers resources, therefore decreasing the number of human attacks.

Human population density of towns within the Okavango Delta Region is generally associated with the provision of services (medical, electricity and water services) and benefits within towns, and the distribution of resources together with various demographic factors (Mendelsohn & el Obeid 2004). The provision of services and benefits in larger towns may reduce the dependency of people on the river and its resources, and thus possibly decrease the interaction between humans and crocodiles. However, there is no clear relationship between human population density and the number of human attacks, which could be attributed to the small sample size of villages used. The changing human population density over time, could also be causing a deviation from the expected outcome. The influence of small scale factors, such as crocodile

behavioural patterns, where crocodiles may move away from excessive human disturbance, may be playing a stronger role than expected.

There was no significant relationship between human population size and number of livestock attacks at a local scale (villages), but the opposite was found at a broader scale (total livestock attacks vs. total population over time). A possible reason for this trend is that human population size cannot be directly linked to livestock numbers and density. This is seen in the village of Dungu, which is situated near Seronga and has a very low human population size, but a high number of livestock attacks. This is most probably because it is the main cattle-post in the area and most people from Seronga station their cattle there. Even though a positive correlation between human and livestock attacks per locality was found, one must be cautious when making assumptions between these two factors. Local dynamics relating to livestock attacks may be more complex than realized and other factors, such as the presence of boreholes, cattle posts and herding techniques, should be further investigated.

Data from the study indicates that the number of livestock and human attacks are increasing more greatly over time than the rate of human population increase. As mentioned previously, interviewee memory could be contributing to this trend, but it could also be linked to changes in the Nile crocodile population, natural prey abundance and other factors. As local prey abundance may decrease due to increasing pressure from livestock herds. This is recorded in India, where there is a higher proportion of domestic to wild ungulates has resulted in a high number of livestock attacks by snow leopards (*Uncia uncia*) and wolves (*Canis lupis*) (Mishra 1997). Prey populations can also decline due to forage competition (competitive exclusion) with livestock (Mishra et al. 2003). A similar effect could be occurring within the study region, where the highest concentration of wildlife is in the seasonal floodplains of the Okavango Delta (Mendelsohn & el Obeid 2004) and the surrounding regions (eg. the Panhandle) have a low to medium wildlife biomass. These areas of low to medium wildlife biomass coincide with areas more highly populated by livestock and people.

Although the spatial representation of the cattle density shown by Mendelsohn & el Obeid (2004) did not provide any quantifiable data, it was still useful in assessing the distribution of livestock attacks in relation to cattle densities in the region. The high density of cattle near the river's edge could be a major factor contributing to the heightened number of livestock attacks. High livestock

densities can be detrimental to individual livestock production, as the quality of rangelands decreases due to overstocking which compromises livestock production (Mishra et al. 2003). The cultural status of large livestock herds in the region surrounding the Okavango Delta, may be having an impact on the quality of natural resources close to the river, which could possibly undermine not only wild prey populations, but also crocodile nesting habitat (Shacks 2006).

Even though no direct quantifiable comparison was made between total livestock population size and total livestock attacks over time, it is still important to assess factors that could be affecting HCC in the Okavango Delta Region. Major fluctuations in livestock populations are apparent for specific years: from 1996-1997 most cattle within the Okavango Delta were eradicated to control the spread of lung sickness and by 2000 cattle numbers again increased to well over 100,000 in the Ngamiland Region (Mendelsohn & el Obeid 2004). Periods of low rainfall were recorded from 1986-1987, 1992-1993 and 1995-1996 and this can possibly be linked to temporary and sporadic declines in cattle numbers (Mendelsohn & el Obeid 2004). Notable declines in livestock attacks were seen in 1986, 1992 and 1997 which coincided with years of low rainfall and a possibly lower number of cattle for the Ngamiland Region (Chapter 3). More accurate, current data on livestock population size and density, together with continued monitoring of livestock attacks by crocodiles is needed for the mitigation of more effective HCC strategies.

Comparisons between the DWNP records and livestock fatalities (this study)

The very low number of reports by the DWNP from 1995-1999 is not a true representation of the HCC situation of livestock attacks by crocodiles in the Ngamiland District. The number of livestock attacks from the study were more than the DWNP reports for that time period. The increasing number of attacks in recent years could be due to various effects such as interviewee memory (as mentioned previously) and in the case of DWNP records, increased efficiency in recording of attacks reporting procedure. The extent and severity of livestock attacks by crocodiles within the Okavango Delta Region, is estimated to be far greater than the records from the DWNP suggest. The sample size is only a small fraction of the total population (less than 0.5% of the population) and the level of conflict recorded could possibly be an underestimation of the actual HCC situation in the region.

The low number of reported crocodile attacks or claims made to the DWNP could be due to various logistical and technical difficulties. In Tanzania, information on crocodile attacks often

does not reach authorities due to the remoteness of sparsely distributed settlements (CSGN 2001). Similarly, this could be a major cause of the low number of reports in the study region, as there are only a few DWNP branches (in the main towns of Gumare, Shakawe, Seronga and Maun) covering large areas. Many rural people may find it not worth the effort to travel long distances to report livestock attacks at the DWNP branches. The procedure for reporting livestock attacks is time consuming, complicated and one is not always guaranteed of compensation. Reporting of attacks on livestock may also be influenced by the amount of compensation available and also due to the restriction of compensation to certain livestock species (only cattle, horse and goat).

Records from the DWNP of livestock attacks by various predator species

The low number of reports on livestock attacks by crocodiles, compared to other predator species may indicate that crocodile attacks on livestock are just not as numerous as other predator species, (especially lion and leopard). It has also aided in assessing the extent and severity of HCC on a larger scale (within broader HWC issues). Attacks by other predators may also be more easily verified than crocodile attacks, as remains of livestock by crocodiles were only recorded for 28% of attacks, which may hinder verification of claims (Chapter 3). Verification of compensation claims requires a DWNP official to assess if the attack was an authentic claim, which may only occur up to 14 days after the incident (Hemson 2003).

Comparisons with other studies

Although the study by O'Connell-Rodwell et al. (2000) is in a different region and river system to this study, it aided in comparing attacks by different predators in neighbouring regions. The predators that account for the highest number of livestock attacks for both regions are lions, with the number of crocodile attacks being very low. DWNP records in 2003 show a vast difference between lion and crocodile attacks, with 14 times more lion attacks when compared to crocodiles. Even though the comparative number of recorded crocodile attacks is not very high, it does not mean that the cost to communities goes without notice.

The more recent records from Namibia, which included attacks on crocodiles for the Kavango and Kwando (East Caprivi) river systems (CITES 2006), showed a similarly high number of human attacks by crocodiles (for years 2000-2004) to records from the questionnaires in Botswana. Unfortunately, the Namibian records were not separated into the different river systems, as this would have greatly aided in assessing HCC in the whole of the Okavango River

System (the Kavango is the name given to the Okavango River in Namibia). Migration of crocodiles between the two countries is possible and may influence HCC in particular in the northern Panhandle Region (e.g. Mohembo Village has a high number of human attacks in relation to the local population size).

Water Unit records

The lack of any clear trend with regards to human attacks in relation to water tap placement could be attributed to the multiple usage of the river for purposes other than drinking water (Chapter 2). The relative distance of households between the river and the nearest tap could also have an effect, as one would expect that people would travel the shortest distance to any available water resource. Since not all households were in proximity to the nearest communal water tap, they may prefer to collect water from the river instead. Households may also have no other alternative but to collect water from the river when the water taps in the villages malfunction or are not supplied with a constant supply of water from the Water Abstraction Stations (Pers. observation). The proper placement of taps in villages and continuous maintenance thereof is still a possible prevention measure against future crocodile attacks on humans, even if the results were not highly significant. In South Africa, there were 16 recorded crocodile attacks on people (mostly women) that collect water from the Nyalazi River in KwaZulu-Natal from 1984-1999. Since then a mobile water treatment plant has been placed near the river to reduce incidences of attacks (Krysko 1999).

Costs and benefits of living with crocodiles in relation to people's livelihood strategies

When comparing DWNP records to the study records, it showed that on average less than one third of the interviewees who had fatal attacks on livestock by crocodiles were compensated. This discrepancy is possibly causing conflict between the DWNP and community members that have not received payment for their loss. This potentially volatile situation could compromise any current or future attempts in mitigating HCC in the Okavango Delta. Another potential conflict situation is that compensation payments are not worth the replacement value of the livestock, rather they are for no more than 80% of the actual value (DWNP 1998). Possible outcomes from these discrepancies in compensation payments, are retaliatory killings of crocodiles and/or destruction of crocodile nests or breeding sites. In India, when compensation for livestock attacks by tigers was delayed (mostly due to lengthy governmental procedures) retaliatory killings of

tiger occurred and in response to curb killings, the procedure and time period for compensation payments to claimants was improved (WWF 2005).

It was noted that smaller households potentially suffer the effects of loss of family members and livestock by crocodiles, and the resulting secondary costs (e.g. a decrease in farming production) more severely than other households. These households tend to have a higher dependence on primary forms of income (especially livestock farming) which are subject to high stochastic variability (e.g. diseases and unreliable rainfall). The traditional dependence of cattle as an investment and source of security is concerning, as the rate of HCC attacks is recorded to be increasing over time and other environmental factors (such as drought), could greatly undermine the stability in this investment, therefore affecting the local economy.

The general lack of tangible benefits of crocodiles to the community is highly concerning and it is necessary for it to be addressed in order for a long term resolution of HCC to occur. Centrally administered conservation programs that implement conservation goals, solely through the use of force (preservationist principles), are very limited in areas where local people utilize wildlife habitats (Mishra et al. 2003). If tangible economic incomes are not derived by communities from wildlife, they are often unwilling or unable to adopt conservation practices. In the Okavango Delta there is a strong likelihood that HCC will escalate greatly in years to come (especially between DWNP and the community) and it is only a matter of time when conservation policies will be overlooked by communities (that are hardly receiving any tangible benefits from crocodiles) and as a result uncontrolled retaliatory killings of crocodiles could possibly occur.

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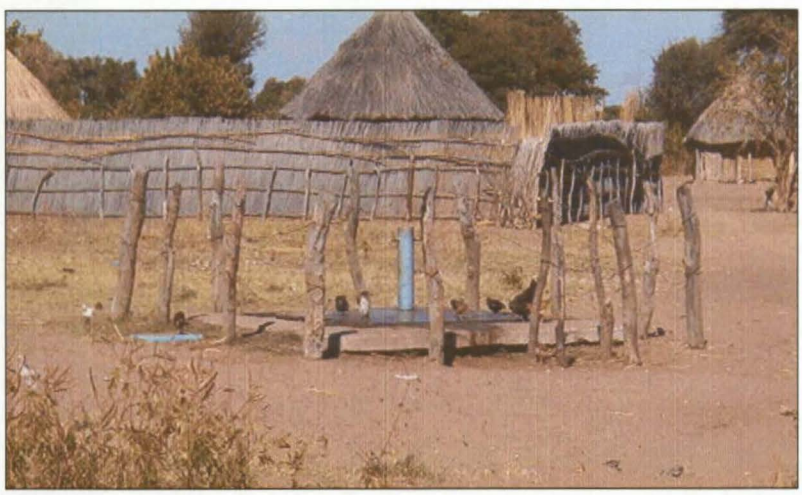
ADDENDUM 4.1

Children in Seronga Village using buckets to collect water directly from the Okavango River.



A communal water tap in a rural village near the Okavango River, in the Ngamiland District.

CHAPTER 5

RECOMMENDATIONS FOR HUMAN-CROCODILE CONFLICT MITIGATION

1. INTRODUCTION

The setting in which HCC (within the context of HWC) exists is continually being shaped by social, cultural, political, ecological and geographic factors. Messmer (2000) states that the success of mitigation programs is said to largely depend on the availability of decision makers and managers to recognize, embrace and include different stakeholder values, attitudes & beliefs into the policy making process. HWC is said to escalate when authorities and local people delay in addressing conflict issues and when they are inadequately empowered to deal with it (Madden 2004). Nyhus et al. (2004) state that compensation is said to be only one tool in mitigating human-wildlife conflict and a comprehensive approach, that includes proactive measures to firstly prevent conflict, and secondly the control of problem animals and incentives to modify land-use practices is needed.

Human-crocodile conflict is in many ways seen as an unwanted result of conservation policy measures (Western & Waithaka 2004), which can be sourced in past protectionist approaches. In Kenya, the Wildlife Department (KWD) removed all economic incentives (such as consumptive use of wildlife) in an attempt to mitigate HWC, which resulted in centralization of conflict resolution by the KWD and thus creating a dependency on the local institutions. Communities placed all the blame for HWC on the KWD and their protectionist policies and therefore local public inactivity resulted with regards to mitigating HWC themselves. Other possible causes of HWC may have been disregarded by the community, such as human activity or even population growth. A lack of wildlife benefits to rural communities and high costs resulting from HWC was seen as one of the main causes of conflict in this situation (Western & Waithaka 2004).

Formulating tangible practical recommendations for the mitigation or management of human-crocodile conflict (HCC) in the Okavango Delta, Botswana is no simple task. This is highlighted by a statement by Fergusson (2004): "The problem (of HCC) is essentially quite simple. Resolving it may be difficult and time consuming". This is due to a lack of information on

crocodile populations, incomplete data on crocodile attacks, insufficient understanding on inter-relating social and economic aspects of community life (such as poverty, rural development, education) and also a lack of technical and financial support in many African countries (Fergusson 2004).

The focus of this chapter is to provide recommendations for local communities in mitigating HCC and recommendations for policy in mitigating HCC. The recommendations are formulated according to localized factors and circumstances (as suggested in Paulin et al. 2003), but can be used to a certain extent within the wider context of HCC. However, caution should be taken in applying specific recommendations to other contexts or regions, as the recommendations have not been formally tested and mitigation measures are formulated within the context of specific study site characteristics.

The context within which the recommendations are formulated include the ecological, cultural, political, socio-economic and geographical dimensions of HCC in the Okavango Delta, as which are outlined in Chapters 1-4. Key mitigation factors that are outlined in this chapter include: (i) *preventative techniques* [education, zoning, livestock management, increasing wildlife values through consumptive (crocodile farming and ranching) and non-consumptive use (tourism)] and (ii) *reactive techniques* ('problem' animal control; lethal control or relocation and compensation).

2. METHODOLOGY

Suggestions or recommendations with regards to HCC in the Okavango Delta, Botswana were provided by local communities and analysed in a tabulated format. These recommendations were recorded in the last section of the questionnaire, as 'suggested conflict resolution'. The suggestions from interviewees will be discussed together with various literature sources on HCC and broader HWC mitigation measures that have been successfully applied worldwide. Through investigation of other HWC studies, more accurate recommendations are provided with reference to mitigation of HCC in the Okavango Delta, Botswana.

Recommendations provided for HCC in this study were divided into two sections: 1) recommendations for local communities and 2) recommendations for policy. The focus of recommendations for communities was practically based, enabling people to apply the suggestions to their own unique situation, which will possibly reduce future HCC and foster coexistence between man and crocodile. Policy recommendations were provided so as to ensure the future sustainability of the Nile crocodile population in the Okavango Delta, together with long term mitigation of HCC in relation to rural livelihoods and relating social pressures mentioned in Chapter 4. Amendments to policy were followed by prevention measures that could be used as policy instruments for long-term mitigation of HCC. The prevention measures provided were incentive-based, with the aim of the successful adoption of the policy amendments provided. Relevant legislature is provided in the Addendum.

3. RESULTS

Recommendations recorded from the last section of the questionnaire are provided in Table 5.1, together with the number and percentage of people within each suggestion category.

Table 5.1 shows that most people within the sample did not provide any recommendations. However, it is interesting to note that only one person said that the presence of the Nile crocodile is good for tourism and another suggested that they should "sell crocodiles". These comments were the only ones listed indicating that people might derive a tangible benefit from crocodiles. It is important to note that the majority of people who provided recommendations (8.2% of the sample) said that crocodiles should all be killed. Some interviewee's reactions were very negative towards crocodile conservation with 8.2% saying that all crocodiles should be killed and 3.3% said that all crocodiles should be removed from the river. Some useful recommendations that could be applied are: guard livestock at water, people should stay away from the river, awareness of crocodiles at the river, more fences, help people when being attacked and livestock should be kept at the cattle-post away from the river.

Table 5.1 The percentage and number of interviewees within 24 different categories of suggestions for conflict resolution of human-crocodile interactions. A sample of interviewees (N=244) were used within the study region of the Okavango Delta.

	Suggestion/ comment:	**Number**	**%**
1	No suggestions	143	58.6
2	Kill all crocodiles	20	8.2
3	All crocodiles removed from river	8	3.3
4	Put crocodiles in a dam	5	2.1
5	Do not kill the crocodiles	1	0.4
6	Sell crocodiles	1	0.4
7	Put crocodiles in a farm	9	3.7
8	Guard livestock at water	8	3.3
9	More boreholes	2	0.8
10	People should stay away from the river	6	2.5

11	Government should do something to stop attacks	4	1.6
12	Discussions with government (about crocodiles)	1	0.4
13	Awareness of crocodiles near river	6	2.5
14	Fence	6	2.5
15	Researcher should know (how to solve the problems)	1	0.4
16	Run away from crocodiles	2	0.8
17	Help people when they are being attacked	1	0.4
18	Crocodiles are good for tourism	1	0.4
19	Reduce crocodile population	5	2.1
20	Respect crocodiles	1	0.4
21	Livestock should be kept at cattle-post away from river	4	1.6
22	Problem crocodiles should be taken to farm	1	0.4
23	Crocodiles should be removed from where people live	2	0.8
24	People must not attack crocodiles	1	0.4
25	People and crocodiles can live together in same river	1	0.4
26	Wildlife Department (DWNP) should do something (to stop attacks)	3	1.2
27	Chase crocs away when crocs on river bank	1	0.4
	TOTAL:	**244**	

4. DISCUSSION

For successful mitigation to occur, human-crocodile conflict should be addressed within the scale of national conservation policies, which "...calls for a clear sense of the overall national conservation goals and specific strategies for reconciling the positive and negative impact of high-conflict species on different interest groups" (Western & Waithaka 2004). Conservation policies relating to HCC are key aspects in mitigation, as they provide structure and framework and have the potential to greatly shape the outcome or success of many conservation initiatives (Madden 2004). HWC laws, policies and programs should be designed to empower local authorities and include stakeholders to deal with issues (Madden 2004).

Botswana has many success stories of CBNRM (Community Based Natural Resource Management) initiatives and the government is committed to maintain a rich natural heritage, but they lack adequately trained man power to implement national strategies and action plans (Arntzen 2003; Totolo 1998). Policy recommendations can only be successfully implemented if they are properly supported by government and are practically relevant to the situation (Dublin et al. 2006). Therefore, policy recommendations for HCC mitigation require policy instruments for effective adoption and implementation, together with practical recommendations that equip people to deal with issues at a grass roots level (Western & Waithaka 2004; Mfune et al. 2005; Box 5.1 & 5.2).

A Vertical and Horizontal Integration Technique is suggested by the African Elephant Specialist Group (AESG), which coordinates action for HEC (Human-Elephant Conflict) mitigation at different levels (vertical: national, provincial and district levels) and links various stakeholders (horizontal: government departments, private sector parties, Non-Governmental Organisations and communities) [Dublin et al. 2006]. In so doing, forming a concerted and better coordinated force, that operates at multiple levels to mitigate conflict. This requires clearly defined actions and responsibilities that should be implemented and properly monitored over time. This approach would be very beneficial in the formation and coordination of HCC mitigation techniques or strategies within various countries, as many African countries still need to draft national crocodile management plans to alleviate HCC (Fergusson 2002).

Box 5.1: ***Founding principles that should govern mechanisms to ensure effective management of HWC (from HWC workshop in Namibia 2005)*** **(Mfune et al. 2005)**

- Policy must consider people's rights and livelihoods as well as biodiversity conservation
- Decision-making needs to be at the lowest appropriate institutional level (so problems can be solved quickly and efficiently)
- Devolution needs to occur together with capacity building, accountability for actions and monitoring
- Integrated policy environment
- Communication and clear guidelines
- Sustainability and transparency
- Representation of all stakeholders
- Appropriate incentives
- An adaptive framework, changing with various needs

Box 5.2: ***Principles suggested by Western & Waithaka (2004) that should be set out in the formation of policy measures for HWC:***

A strategy for conflict-resolution should be aimed at reducing costs and increasing the benefits/value of conflict species.

- Devolution of authority of conflict resolution to the lowest practical and verifiable level (i.e. a community-based approach)
- Clearly defined rights and responsibilities for transferring and delegating responsibility for mitigation of HWC.
- A democratic and transparent political process is necessary for conflict resolution.
- Monitoring of mitigation actions and measures based on verifiable indicators of success.
- A range of conflict-mitigation measures that can be applied to specific circumstances and are cost-effective and humane procedures.

A community-based approach to HCC

Incorporating communities into HWC mitigation and management is seen as a crucial aspect of the process that greatly influences the long term success of many conservation initiatives (Madden 2004). WWF (2005) state that HWC mitigation initiatives or programmes need a full and active participation of stakeholders (especially the affected communities) in the long term, to take increasing levels of control (of a HWC initiative) and to become as self sustaining as possible. Parker (2003) suggests a community-based method of Problem Animal Control (PAC) for elephants in the southern Luangwa region of Zambia. Government enforced PAC techniques designed to decrease the impact of crop damage by elephants are inadequate, especially in remote rural areas. CBPAC (Community-Based PAC) is a decentralized form of HWC management that adds to current PAC methods, that enables communities to take responsibility for their own conflict issues by using locally available tools or resources to prevent and combat HWC. Therefore, ensuring that communities are not solely dependant on outside agents to solve HWC issues. The community-based approach can be described as an enabling process, whereby the affected parties are equipped to deal with their own HWC problems and to take responsibility for

their own issues through active and passive methods. Passive methods include mitigation techniques that impede the access of problem animals into areas (eg. buffer zones, fences and early warning systems) and active methods are designed to frighten or chase away problem animals (e.g. fires and pepper spay for elephants) (Osborn & Packer 2003).

There have been some recorded advancements with community involvement in HCC mitigation. In Malawi, in the Lower Shire Valley, a management plan is being developed to ensure the Nile crocodile's population is maintained at a sustainable level while reducing HCC in the area, by involving communities in crocodile management & application of indigenous knowledge (Ligomeka 2000). In Madagascar, the Nile crocodile is under threat and efforts to protect local communities from crocodiles (while allowing them to carry out traditional cultural practices) include: community outreach, training crocodile guides and data collectors to gather data on human/crocodile interactions and ecological observations (Hekkala et al. 2000). Even though there have been some advancements in HCC mitigation in Africa, a broader mitigation strategy is yet to be developed.

There are two main techniques in mitigating HCC (which are discussed below with reference to other studies), which are preventative and reactive techniques. Prevention techniques are mitigation measures that can be implemented to reduce HCC over the long term, through application of prevention measures such as: the construction of barriers, education and public awareness campaigns etc. Reactive techniques are mitigation measures that are generally implemented after a HCC incident has occurred and are described as reaction-based (e.g. lethal control of the 'problem animal' or compensation).

4.1 Prevention techniques for HWC mitigation

Preventative control of HWC is described by Osbon and Anstey (2002) and is said to be the most effective long-term mitigation strategy, as it leads to general awareness among people about HWC issues and fosters coexistence with conflict species. Implementation of preventative measures are seen as an enabling process, where people are taught how to combat HWC problems through their own means and resources in preventing conflict in the future. Preventative techniques are further discussed with reference to HCC in the Okavango Delta.

a) Education

Education can be seen as a tool in modifying human behaviour (Karanth & Madhusudan 2002), whereby negative attitudes (prejudices or intolerance towards a conflict species) are altered through explaining the role or benefits that the species provides to them. Human-wildlife conflicts are decreased by: (1) reinforcement of traditional toleration of animal damage; (2) changing in livestock husbandry practices (more guarding, effective protection techniques etc.); (3) changing land-use from conflict-prone farming practices towards other alternatives, such as ecotourism and safari hunting and (4) preventing retaliatory killings through compensation, which also includes preventative compensation or insurance for livestock or crops (Karanth & Madhusudan 2002). It is also important to link conservation education with livelihoods to ensure support from local people, so that mitigation strategies are implemented (Aiyadurai 2004).

In some cases, ignorance of the beneficial role of crocodiles to wetland ecosystems is a cause of the perception that crocodiles are pests (In Sri Lanka, see Satiapillai & de Silva 2001). This highlights the importance of education in changing attitudes towards coexistence rather than exclusion. In the Okavango Delta, the highly polarized attitude (that crocodiles should be killed) may become an obstacle when fostering coexistence between man and crocodile. This low tolerance of crocodiles should be monitored to assess possible attitude changes over time.

Environmental Education through the DWNP in Botswana occurs via the Wildlife Conservation Education Division, which runs educational programmes for public awareness (e.g. seminars and workshops for the general public) and they have also helped establish Environmental Clubs (previously called Wildlife Clubs) in schools (Totolo 1998). These clubs occur in 90% of schools in Botswana and newsletters, articles and radio programmes help to educate the younger generation on environmental topics. Other NGOs (Non-governmental organizations) such as Conservation International (CI), the Forum on Sustainable Agriculture (FONSAG), KCS (Kalahari Conservation Society), Every River has its People Project and Chobe Wildlife Trust are also involved in environmental educational projects within Botswana (Totolo 1998). These various structures already established organizations could greatly aid in dissimilation of HCC mitigation information to the broader public.

In Madagascar, warning signs were erected notifying people of the dangers of crocodiles in rivers (Hekkala et al. 2000) and in Malawi an extensive public awareness campaign with regards

to HCC through community meetings, drama, radio & other various forms of communication are being used (Ligomeka 2000). Isolated rural communities in the Okavango Delta that are affected by HCC may be more easily reached via educational radio programmes aiding them in preventing HCC. In India, HWC information was communicated through the radio, info information pamphlets, awareness teams were sent to inaccessible areas, an emergency hotline was set up to report attacks, schools incorporated relevant HWC information into the syllabus and capacity building for teachers on HWC issues took place (Aiyadurai 2004). Warning signs have also used in Australia (Caldicott 2005) and South Africa (Jackson 2000).

b) Zoning

Zoning can be seen as the partitioning of the landscape into 'human' and 'wildlife' areas (Woodroffe et al. 2004) in an attempt to reduce spatial overlap between people and conflict species (Linnell et al. 2004). Different zones or areas are distinguished through the application of differing, but complementary management tools. Separation is usually achieved through the use of fencing or barrier technology. However, fencing may not be very effective over large areas and restriction of people from the crocodile's habitat may increase conflicts, as water resources are highly valuable to many rural people. Other limitations are that other wildlife species (such as elephant or hippo) may be able to cross fences thus destroying the barrier between livestock, humans and crocodiles. There is also a high cost involved in construction and maintenance of fences/barriers and wire from fences may be used illegally for snares and hunting (Woodroffe et al. 2004). Ecological impacts of barriers are a reduction in carrying capacity and long term genetic and demographics effects on migratory wildlife populations. For example: veterinary cordon and buffalo fences in the Okavango Delta (Mendelsohn & el Obied 2004).

Preventative spatial separation of humans and wildlife was also suggested by Karanth & Madhusudan (2002) as a means of conflict reduction. This involves the voluntary resettlement of people away from high conflict zones to less conflict prone areas. In this study region, the effect of distance to river, on the utilization of the rivers resources was not significant (Chapter 2). Therefore, due to the high dependency of interviewees on the river and its resources, preventative spatial separation as a means in reducing conflict may not be very effective and may even cause increased conflict. Buffer zones or a re-zoning of land use was a less drastic approach suggested by Verdade & Campos (2004) compared to Karanth & Madhusudan (2002). This could be

applied to the situation in the Okavango Delta, whereby livestock are restricted in their movement near the water's edge, thus preventing attacks.

c) Livestock management (changes in husbandry practices)

Workshops and educational programmes focusing on improving livestock management practices with regards to HWC resolution have previously been conducted in Botswana by various NGOs (CCB 2006). Livestock husbandry techniques specifically aimed at reducing HCC in the Okavango Delta are still greatly needed, as each predator species' behaviour pattern is different and requires specific management strategies.

Verdade & Campos (2004) suggest that reducing the time livestock spend in the predator's habitat, would decrease the chance of attack. This exclusion technique requires providing livestock with feed and drinking water, away from the crocodile's habitat. This may be more difficult than expected, as grazing in the dry season in the Okavango Delta is primarily focused near the river's edge and the river is freely accessible. This compared to borehole water which is privately owned & expensive or through abstraction, where livestock owners may need to pay a small fee per head of cattle to cover costs and maintenance (Swatuk & Rahm 2004). Other livestock management techniques suggested is the improvement of livestock management through fencing and night sheltering (Verdade & Campos 2004; and O'Connell-Rodwell et al. 2000).

Changing of livestock husbandry practices from free-ranging native cattle breeds to more high-yielding, stall-fed breeds was suggested by Karanth & Madhusudan (2002). This requires a transition from rural to commercial livestock practices, which results in increasing livestock densities, market driven economic forces and possibly a breakdown of cultural values. However, traditional tolerance of conflict species was recorded to decrease with the influence of the previous mentioned factors and therefore one should be cautious in adopting extreme strategies for mitigation, without considering the various outcomes.

d) Increasing wildlife values through consumptive and non-consumptive use

The most successful HWC mitigation strategies recorded in Walpole & Thouless (2004) included both non-consumptive and consumptive (or extractive) use of conflict species in order for profits generated to offset the costs of living with wildlife.

i) Non-consumptive use: Tourism

Tourism can be seen as only one of the many tools in HWC mitigation whereby wildlife tolerance is improved in communities (Walpole & Thouless 2004). The potential benefits that tourism can provide are: a) income/resources to directly fund mitigation strategies, b) spatial zoning where buffer zones for ecotourism occur near protected areas, and c) may be more sustainable than compensation if insurance schemes are included.

For tourism to act as a successful economic incentive to increase tolerance towards wildlife, substantial profits must be generated in order to cover direct and indirect costs of living with wildlife (Walpole & Thouless 2004). In order for this to happen the following conditions must occur: 1) tourism businesses must provide net benefits for communities, 2) distribution of benefits among community members must take into account the variation in individual cases and costs associated and 3) a clear understanding of the link between benefits received from wildlife and the need for conservation of the species is needed (Walpole & Thouless 2004). Hekkala et al. (2000) suggest that ecotourism will benefit communities by viewing live crocodiles in the wild. Botswana has a strong tourism industry and there is great potential in developing this as possible aspect of HCC mitigation. Tourism can also be combined with raising awareness of Nile crocodiles. For example: the St Lucia Crocodile Centre, South Africa, where 23 000 visitors were recorded in the first year of opening (Loveridge 1980). Ecotourism is said to bring more people into contact with crocodiles therefore reducing people's heightened fear or apprehension of the predator, i.e: fostering tolerance of crocodiles through education (Caldicott et al. 2005).

ii) Consumptive and/or extractive use

Consumptive or extractive use (e.g. hunting and sustainable use) provides a direct link between wildlife and benefits (together with ecotourism). Consumptive use can also include the control of problem animals and can therefore possibly increase tolerance of the conflict species (Walpole & Thouless 2004). Sustainable use programs can be seen as a more effective way in improving local tolerance if income generated is directly used to offset the costs of living with conflict species (Woodroffe et al. 2004).

Most of the crocodile farms and ranches in the Okavango Delta are privately owned and the community gain little benefit from the earnings generated by the captive crocodiles. Joint or fully owned/managed community crocodile farms or ranches need to be developed so that

communities can derive tangible benefits from Nile crocodiles. In Malawi, in the Lower Shire Valley, HCC is a severe problem and communities are being involved in crocodile management with the formation of a joint plan between ZBWCRUP (Zambezi Basin Wetlands Conservation and Resource Utilisation Project) and communities (Ligomeka 2000). Profits gained from crocodile harvests (an annual quota through CITES) are shared with the community in return for their participation in sustainable crocodile management. Crocodile farming in developing countries in Africa can be used to generate income from international trade and could in turn facilitate economic growth.

Another form of consumptive use is trophy hunting, whereby considerable revenues are generated in hunting prized wild animals (WWF 2004). This can be a source of significant income for economic development in some communities. For example: in the Serengeti District there is a high percentage use of hunting quotas in communities and many people are deriving an income from hunting (WWF 2004). However, revenue received from trophy hunting needs to be adequately linked to conservation objectives and should be directly transferred to affected local communities that are experiencing HWC for it to be effective as a mitigation strategy.

e) Other preventative techniques

Successful mitigation of HCC recorded over two years in Madagascar was due to the enforcement of a ban on net fishing (to decrease over-fishing) and the installation of wells as an alternative water source to crocodile-inhabited rivers and lakes (Hekkala et al. 2000). Protective barriers at the water's edge to allow for bathing and washing were also installed and this may have reduced crocodile related human fatalities. Barriers around water collection points to protect people from crocodiles were also mentioned by McGregor (2005). Another preventative technique was to advise fishermen not to leave food scraps (e.g. remains of fish) near the river so as to avoid attracting crocodiles (Caldicott et al. 2005).

Water pumps and a mobile treatment works in St Lucia, South Africa, aided in preventing further crocodile attacks on people that collect water from the river (Krysko 1999). In the Okavango Delta, the highest recorded number of attacks was on people collecting water, or swimming and therefore provision of more water sources (away from the river) could aid in preventing further attacks. Other suggestions to combat HCC in Malawi are provided by Ligomeka (2000),

including the use of larger boats which are less susceptible to crocodile attacks than smaller dugout canoes.

Conflicts can also be resolved by modifying wildlife behaviour (Karanth & Madhusudan 2002), which some cases is easier than modifying human behaviour. This could be implemented through establishing barriers and removal of problem animals. Behaviour modifying drugs for wildlife are even being developed in the USA to mitigate HWC (Fall & Jackson 2002).

4.2 Reactive mitigation techniques for HWC

The reactive mitigation techniques that are discussed are: compensation (monetary or non-monetary), lethal control and non-lethal control (which involves the translocation or relocation of 'problem animals').

a) Compensation

The purpose of compensation is said to redress the costs associated with the presence of wildlife populations (Naughton-Treves et al. 2003) and many believe that it encourages tolerance for losses by minimizing the economic impact of these losses (Nyhus et al. 2003). However, compensation does not greatly prevent the problem from occurring (Hemson 2003) and is therefore primarily seen as a reactive mitigation technique for HWC. Compensation can be in various forms: monetary and non-monetary in the form of, for example: goods, food, crops or livestock when predation occurs and other social benefits. Many wildlife managers hope that compensation will improve tolerance for problem animals and discourage retaliatory killings. However, a study by Naughton-Treves et al. (2003) whereby tolerance levels were tested for various compensation schemes showed something quite different.

Three different compensation strategies were tested to ascertain whether compensation increased tolerance of affected persons involved in HWC (wolf depredation of livestock) in the USA. These strategies were: 1) Compensation was given to people experiencing depredation on livestock no matter what livestock management technique was used, 2) Compensation was only given to people experiencing depredation, depending on the livestock management practices used and 3) No compensation was given to people experiencing depredation on livestock. The results showed that compensation payments did not improve individual tolerance towards wolves and people

who were fully compensated (without consideration of livestock management practices) were more likely to approve of lethal control of the predators. This suggests that compensation is inadequate in long term resolution of HWC (Dublin et al. 2006). However, completely ceasing compensation payments is known to cause retaliation and increased hostility to wildlife departments and the conflict species (Bangs et al. 1998 in Naughton-Treves et al. 2003). Other disadvantages of compensation are that it is generally insufficient, cumbersome, highly sensitive to corruption and people tend to exaggerate wildlife damage because they feel that the government will not compensate them sufficiently otherwise (Naughton-Treves et al. 2003, Woodroffe et al. 2004 and Dublin et al. 2006)

A successful compensation strategy is described in Nyhus et al. (2004) which involves: 1) accurate and rapid verification of HWC damage, 2) quick and fair payment through a transparent process, 3) long-term sustainable funding that is able to cope with fluctuations in damage over time, 4) rules and guidelines that are clear and are linked to sound management practices and 5) an ability to monitor the conflict species' population over time. When compensation programs are carried out effectively (using the strategy above), they can potentially raise awareness about HWC issues and shift responsibility to the greater public (Nyhus et al. 2004). However, compensation cannot solely mitigate HWC and other measures should be included.

Compensation is said to only be used to support severely affected individuals and is a short-term strategy that should be replaced by other strategies. The key to a successful mitigation strategy is to combine compensation (a reactive technique) with preventative techniques which requires stakeholders to adopt 'risk-friendly' practices before they are eligible for compensation (Nyhus et al. 2004); i.e: claimants will be denied compensation if they do not follow guidelines for damage prevention (e.g. keeping livestock in protected bomas at night). People's dependency on a single source of income (e.g. subsistence agriculture or livestock farming) should also be reduced through development of alternative non-agricultural sources of income, insurance, improved marketing, traditional community-based support schemes and income generated from tourism (Dublin et al. 2006). In the Okavango Delta Region the enforcement of such alternatives to state-funded compensation may cause conflict between the DWNP and the claimants, if the community is not consulted prior to implementation. This may work against the preventative measures that are being promoted to mitigate HCC in the Okavango Delta, Botswana.

An Insurance based strategy for wildlife damage is mentioned by Nyhus et al. (2005), whereby people who experience wildlife damage are compensated by a non-governmental organization. A successful community-based insurance program developed by Project Snow Leopard in Pakistan, relies on community participation, whereby farmers pay a sum per head of livestock and are compensated for livestock that are killed by snow leopards. Funds are also derived through another ecotourism fund when their claims exceed their premium amount. Disadvantages or difficulties associated with insurance-based compensation are false verification of damage, fraudulent claims, it's expensive to those who have limited budgets and it is influenced by people's perception of damage. In Zimbabwe, people were unwilling to finance insurance based compensation for damages caused by wildlife, as they perceived it to be the government's responsibility (Nyhus et al. 2005). Insurance-based compensation also tends to only benefit registered members and its success greatly depends on the amount of funds available (Dublin pers. comm. 2005).

b) Lethal control

The disadvantages of lethal control are that it generally has a short-lived effectiveness and selective lethal control can be flawed. Recolonisation of territories left vacant often occurs after removal of 'problem animals' and generally there is also a high rate of removal of non-target animals (animals that are not causing any conflict problems) (Treves & Naughton-Treves 2004).

If cautious management of culling programs occurs, together with a careful balance between human and wildlife needs in high conflict situations, then culling has the potential to reduce wildlife densities without causing regional extinction (Treves & Naughton-Treves 2004). However, one should be cautious when applying this management strategy as it is important for the government to have strict control over all other forms of wildlife killing that could possibly undermine wildlife population stability and persistence. It is crucial that local and regional population size and health of the conflict species should be accurately assessed before any culling program is suggested (Treves & Naughton-Treves 2004).

An advantage of lethal control is that killing of a problem animal may have the benefit of placating locals from possible uncontrolled retaliatory killings (i.e: seen as a public relations act). However, this does nothing to instil a sense of ownership or responsibility for the species by the local people, thus undermining the possibility of coexistence of communities and conflict species

(Treves & Naughton-Treves 2004). Communities are likely to continue resenting the offending species if there is a lack of benefits (economic and material) derived from the conflict species.

If a specific wildlife population recovers to sustainable levels and it's range expands, a more flexible participatory form of population control could be more beneficial to long-term conflict resolution, involving sustainable use 9 for example: in the case of Tanzania in CITES (1999). The Okavango Delta's Nile crocodile population is just starting to recover from extensive utilization and currently this management approach is not advisable as a strategy for human-crocodile conflict mitigation. Similarly in Madagascar, the Nile crocodile is still under threat and consideration of removal of potentially dangerous large crocodiles from an area of high human activity is seen strictly as a last resort (Hekkala et al. 2000). Sport or trophy hunting of 'problem animals' is seen as a feasible strategy in generating income to compensate for damages caused by HWC (Verdade and Campos 2004). However, this requires monitoring and precise/correct identification of the 'problem animal' and in Graham et al. (1992) the harvesting of wild adult crocodiles from the Okavango River System is ill-advised.

c) Non-lethal control: translocation/relocation of 'problem' animals

Translocation of 'problem' crocodiles became more common following the development of the immobilizing drug G*allamine trithiodide*, in Zimbabwe in the early 1970s (Loveridge 1980). Translocation of 'problem crocodiles' in Botswana is not commonly undertaken by the PAC Unit of the DWNP in Botswana, but involves the capture and transportation of the offending animal into an area where it poses no threat (Hemson 2003). The destination of translocated crocodiles in the Okavango Delta is either to crocodile farms/ranches or to another region of the Okavango Delta. Various destinations of translocated 'problem animals' have different outcomes.

Relocation to different regions within the same river system is generally known to be unsuccessful in solving HCC. For example: the Salt-water crocodile in Australia and crocodilian species in Florida have been known to show homing behaviour that enables them to travel back to their original home ranges after a relocation attempt (Guynup 2003; Walsh & Whitehead 1993). As a result of this behaviour, wildlife managers are now resorting to lethal control of 'problem animals'. Other disadvantages of translocation of 'problem animals' is that it is expensive and often ineffective, as it requires specialized equipment, trained personnel and the HWC problem may become an issue in another area (Verdade & Campos 2004).

Relocation to crocodile farms is similar to lethal control, as a potential breeding adult is removed from the natural environment and no longer contributes to the population. However, translocated adult crocodiles can still contribute to the wild population if some of the offspring are successfully released back into the ecosystem, which is seen as the most desirable outcome.

5. RECOMMENDATIONS

5.1 Recommendations for local communities

Specific areas of high conflict, that had the highest number of recorded attacks on either humans or livestock, should be given considerable attention:

a) Villages experiencing a high HCC with regards to livestock attacks include Seronga, Dungu, Samochima, Ikoga and Maun

b) Villages experiencing a high HCC with regards to human attacks include Mohembo East & Mohembo West, Jao, Samochima, Seronga, Shakawe and Gumare.

The following recommendations are made with reference to mitigation of livestock attacks, focusing on group (a) villages mentioned above:

i. Cattle should be prevented from having open access to the river, as livestock should not roam freely around or near the river's edge. This can be achieved through fencing them some distance away from the river. Fencing materials can be sourced from locally available thorn or acacia branches, or purchased in the form of wire and wooden poles.

ii. Cattle should be preferably watered away from the river at cattle stations, boreholes and water abstraction points.

iii. If i) & ii) above are not possible, then specific fencing could be constructed at the rivers edge to allow for livestock to safely drink water. One option is suggested in Figure 5.1. The impenetrable fence can be made from solid poles or tall tree logs standing next to each other or out of lethaka reeds at a minimum height of 3meters and jutting out into the shallow water of the river in an arc shape from the river bank

iv. Livestock guarding could occur when the livestock are drinking at the river, and one should be especially vigilant in the months of March, April, May and December when the possibility of attack is noted to be higher than other months.

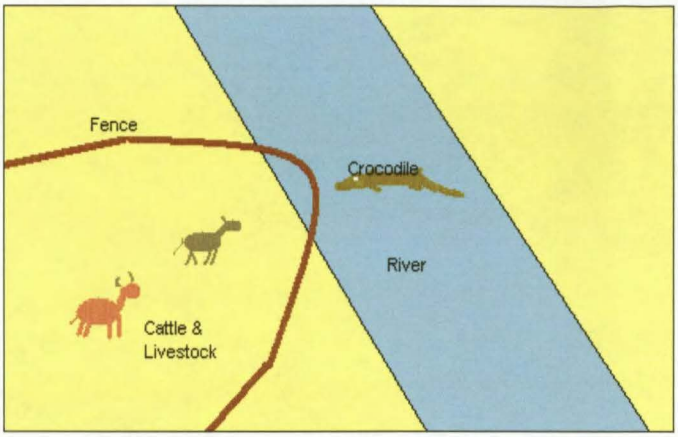


Figure 5.1: A simplified diagram showing a possible solution for preventing attacks on livestock by crocodiles, so that livestock can safely drink water from the river.

Even though the above recommendation has not been formally tested, it was a suggestion from a livestock farmer in the Okavango Delta. He personally tested the method and remarked that no attacks on his livestock have occurred since the construction of the fence (that he regularly maintains). Possible disadvantages of the fence are that it may require high maintenance (as the wood poles may rot), the fence may be destroyed by hippos or other wildlife or even swept away by the river current/flood. The fences should be constructed when the river is at its lowest, therefore allowing for seasonal variation in water levels.

This suggestion is not highly recommended as a long term solution, due to its listed downfalls and is only recommended if the livestock owner has no other means to watering livestock away from the river. Dependency of livestock on the river should be decreased for a longer lasting HCC mitigation strategy, which will require developing alternative watering points for livestock away from the river. Traditional approaches to reducing wildlife impacts are often highly successful (Woodroffe et al. 2004), for example: night sheltering of livestock in bomas and should be encouraged.

The following recommendations are made with reference to mitigating human attacks, focusing on group (b) villages mentioned above:

i. Warning signs should be placed near the river discouraging people from swimming, washing and collecting water from the river. These signs should be in the form of pictures or graphics which are easy for all to understand. Schools and households should educate

children with regards to the danger of swimming in the river, as this accounted for the second highest numbers of fatalities.

ii. Households should use water taps provided instead of collecting water from the river. If no communal taps are available, people who collect water should not make a habit of collecting water from the same place and at the same time of day, as crocodiles may become aware of behavioural patterns and take advantage of this.

iii. People should be encouraged to develop forms of income other than from fishing (fishing showed the highest number of attacks). The development of fresh water aquaculture in dams is a possible alternative to fishing in the river. Fishermen should not clean fish or leave food scraps (fish remains) or bait in or near the river, so as to avoid attracting crocodiles.

iv. Construction of dams or ponds away from the river to grow water lilies, so that women do not have to wade into the river to collect water lily roots which are highly sought after food source. It is not advised to enter the river if one has an open wound or is bleeding, so as not to attract crocodiles as they rely on their acute sense of smell to locate prey (Pooley 1982).

v. People should not wash (themselves or clothes) in the river or at the river's edge. They should use communal taps, if provided, or make use of buckets a safe distance away from the water.

vi. The construction of protected bathing facilities in the river will prevent crocodile attacks. An example of a protected bathing facility is seen in Figure 5.2, where a wire mesh structure is suspended into the river and is kept afloat by air-filled drums. The wire mesh prevents the crocodile entering the protected environment where the swimmer can bathe in safety. This bathing facility was not completed when the photo was taken. It should also include a secure railing and more mesh surrounding it on the outside and pathway to the bathing area, therefore preventing crocodiles from attacking people who are standing on the platform.

Figure 5.2: An example of a suspended or floating swimming pool in the process of being built at Ngepi Lodge, Caprivi in Namibia (2004).

Before implementation of any policy recommendations, it will be necessary to consult with community members and other stakeholders and involve them in the process with reference to livestock management techniques and other suggestions. Efforts should also be made to accommodate their input and to incorporate ideas into the revised legislation. The following procedure is suggested below for implementation of the recommendations provided.

Suggested procedure of action plan:

- Elders, chiefs and headmen in villages experiencing high conflict should be notified about the HCC problems.
- Educational forum/workshops should be held in villages or settlements within the vicinity to the Okavango Delta to notify community members of the conflict issues.
- Suggested preventative recommendations should be provided to community members to help quip them in preventing attacks on both humans and livestock by crocodiles. People should be encouraged to develop their own mitigation strategies.
- Policy recommendations should be presented to the communities, discussed and feedback should be recorded (a participatory approach).

5.2 Recommendations for policy

The recommendations for policy provided here have been formulated with reference to the human-crocodile conflict (HCC) situation that was investigated in the Okavango Delta. There is an urgent need for the implementation of an integrated approach that incorporates both

preventative and reactive techniques for the long term mitigation of HCC in the Okavango Delta. HCC is expected to escalate in the future and current methods of HCC mitigation are already inadequate excluding the predicted increase. Therefore policy instruments have been suggested to aid in the implementation of the suggested policies and also act as an incentive to communities to adhere to these policies.

Prevention measures are crucial for the long term mitigation of HCC, as it integrates the socio-cultural dimension of conflict into the mitigation strategy. The focus of prevention measures is to address the cause of HCC and attempt to foster coexistence between man and crocodile. The incorporation of local communities into mitigation procedures will also aid in reducing conflict or tension between the DWNP and local people. Even though the prevention measures may initially require some financial input, the long term advantages of this approach is that it has the potential to reduce dependency on compensation schemes and will alleviate pressure off on valuable wetland resources.

Even though reactive techniques, which are generally implemented after a conflict incident has occurred, (e.g. compensation and problem animal control), may not contribute greatly to the long term resolution of HCC in the region of the Okavango Delta, they are still a necessary part of the mitigation strategy. If reactive techniques are exchanged exclusively for preventative techniques, without a transition period or inclusion or participation of the local community, there may be a high possibility of retaliatory killings due to a termination of compensation payments (noted previously).

5.2.1 Suggested policy amendments

The following recommendations are given for changes in legislation with reference to Human-Crocodile (*C. niloticus*) Conflict mitigation in the Okavango Delta, Botswana:

1. Regulating the use of open access water resources (termed "public water" in Addendum A. i.e. lakes, river etc.) by people and livestock through the application of permits. With reference to Part II, section 5. (a-c) of the Water Act [Act 40 of 1967] (see Addendum 5.1 for relevant legislature).

2. Amendments to compensation payments relating to damages caused by Nile crocodiles (*C. niloticus*), with reference to Wildlife and National Parks Act: 28 of 1992 (see Addendum 5.2).
3. Amendments to Problem Animal Control methods with reference to Wildlife and National Parks Act: 28 of 1992 (see Addendum 5.2).

a) Regulations of water use

A permit-based scheme is suggested whereby livestock owners are restricted from watering their cattle at open access water (i.e. the Okavango River/Delta), unless they have a permit issued by local authorities. A structure of authority should be established within villages to ensure an unbiased process, regulating the issuing of permits. Permits should only be provided under the following circumstances: (1) if no other alternative water sources (such as borehole water, abstracted water or a well) are available to the livestock owner, (2) to a restricted number of livestock owners that may pay for access to the resource (amount should be a fixed sum that contributes towards HCC mitigation in that area). Free permits (for access to water at the river) should only be given to people who do not have an alternative water source available for their livestock to be watered at, as mentioned in circumstance (2).

b) Compensation

Monetary compensation (for losses to livestock by a crocodile) should slowly be phased out over time through provision of other benefits and the application of prevention measures (where policy instruments act as incentives). If state-funded compensation is to continue, compensation for human lives and injuries should be a priority over the compensation of livestock. Compensation to family members of people killed by a crocodile should at least cover funeral and other related costs (ambulance cost to hospital and funeral costs should be no less than BwP163.84) (see Chapter 4). The compensation afforded to people who have suffered an injury from a crocodile attack, should be linked to the severity of the injury. If a limb is removed (whole or partial), a prosthetic limb or funds to cover the cost of obtaining a prosthetic limb should be provided. Compensation may not be necessary if injuries on a person are only superficial, as hospital treatment is generally free of charge. However, the cost for the ambulance should be compensated to the victim or the victim's family.

Phasing out of compensation on livestock attacks should occur where compensation is only afforded under certain conditions. These conditions depend on the level of implementation of prevention measures/policy instruments (outlined in the previous section on recommendations to communities). Sufficient benefits (derived from crocodiles, such as: tourism and ranching) should be accrued by the communities to cover costs derived from crocodile attacks on people and livestock in order for government compensation to be phased out.

This incentive-based form of compensation should be implemented during the intermediate stage. In other words, after communities are properly allowed to adjust/change livestock management techniques when compensation payments start to be phased out. During the initial stage of inception of new restrictions, compensation amounts/payments could be reduced (where they receive a percentage reduction of the previous compensation amount), if the claimant is not practicing the livestock management techniques stipulated. Over time the compensation payments to claimants can be reduced (become stricter), until no payment is made. However, the reduction in compensation has to be linked to a subsequent increase in benefits (that are derived through crocodiles), otherwise it may result in retaliatory killings of crocodiles.

c) Problem animal control

Problem animal control units within the Department of Wildlife and National Parks in all regional offices should be well equipped to deal with issues related to HCC. Extensive, regular training should be given on the relocation of crocodiles (non-lethal control), lethal techniques should only be implemented when all attempts at non-lethal control have failed. Necessary equipment should be provided together with information resources (eg. educational pamphlets on HCC) and capacity building for HCC mitigation in a community context.

i) Non-lethal control: Relocation

Relocation of problem animals (within the river system or to crocodile ranches where a percentage is offspring is later released) should be considered before lethal control. Problem animals that are relocated to crocodile ranches/farms should not be killed for their skins, rather they should be used as breeding animals and at least 5% of the young should be released back into the ecosystem (refer to recommendations provided to the DWNP by A Leslie). Relocation of 'problem animals' should be seen as a public relations act where retaliatory killings may be a threat.

ii) Lethal control

Lethal control of 'problem animals' should only occur as a last resort when there is no means to relocate the animal (lack of trained personnel, lack of funds and no crocodile farm/ranch nearby), or when all attempts of non-lethal control have failed. Lethal control also depends on the local abundance of the Nile crocodile in the river system and its intrinsic and economic value to the public. Hunting quotas are issued annually by CITES as a means of population control. However, there should be no increase in the number of hunting quotas in the Okavango Delta, until the status of the crocodile population has been ascertained.

If relocation is not possible, sport or trophy hunting of problem animals could possibly generate income for communities, if a hunter is are willing to pay to hunt the 'problem animal' (Hoogestein et al. 1993 in Verdade & Campos 2004). This should only occur under supervision of experienced and well trained wildlife personnel (preferably the Problem Animal Control Unit). The funds generated could provide compensation to people or households who have suffered due to a crocodile attack. There is a high margin of error in identifying and exterminating the wrong 'problem' animal and therefore the conflict may still remain. Accurate identification of problem individuals is required for this method to be effective. This mitigation measure only solves short term problems, while the long term effects of HCC may still remain.

5.2.2 Prevention measures that can be used as policy instruments

a) Public awareness, education and raising tolerance levels

Educational workshops and information on HCC should be provided to affected communities annually by the DWNP and/or other qualified NGO's. This should include capacity building of teachers in schools and providing them with the necessary information and skills to promote conservation of the Nile crocodile and to facilitate coexistence with crocodiles. This can be further facilitated by annual visits to schools (at all levels) by the DWNP in connection with the Wildlife Clubs. Communities should be involved and encouraged to discuss new methods of preventing crocodile attacks within their villages.

Education about the beneficial role of crocodiles to communities and the environment could be included into the school syllabus. Educational workshops could be implemented at primary school level, as there is generally at least one primary school per village within the Ngamiland

District. Figure 5.3 and 5.4 are an example of an educational outreach in a school that is situated near to the Okavango River.

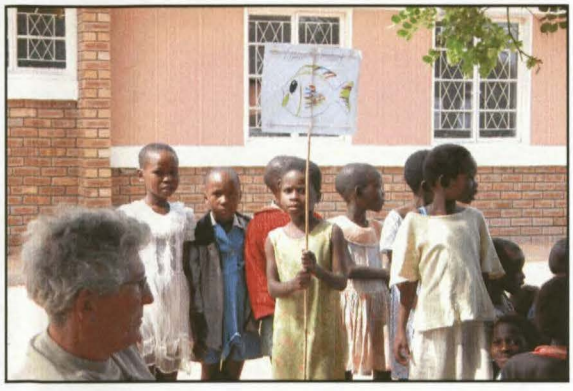


Figure 5.3 School children participating in an activity to illustrate the importance of the ecosystem of the Okavango River

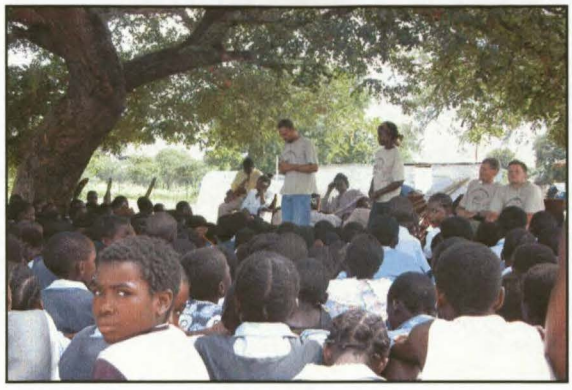


Figure 5.4 Okavango Crocodile Research team giving a talk to a school in Panhandle Region of the Delta.

b) Development of alternative water sources (apart from the river)

For domestic use

Communal water taps should be provided to households in the region of the Okavango Delta, especially to those that live near the river. It is also crucial that taps have a constant water supply and they should be timely and well maintained within the villages. This will reduce the possibility of people being attacked by crocodiles, as well as decrease their direct dependence on the river as a water source. People will still have the choice of using the river at their own risk of being attacked, however, people should be encouraged to use the taps provided. All villages or settlements should have an alternative water source, otherwise compensation/remuneration should be given to households for attacks on humans, which do not have access to a communal tap.

For livestock and agricultural use

Alternative water sources (such as boreholes, water abstraction points/stations, cattle posts and water storage tanks) should be provided to livestock owners for watering of livestock away from the river. People will then have the choice to water their livestock at an alternative water source, or at the river at their own risk. This will prevent attacks on livestock by reducing their dependency on the river and will also help to prevent river-bank erosion.

c) Improvement of livestock management practices

Livestock owners should be encouraged to change their management practices aimed at preventing livestock attacks by crocodiles. These are stated in the recommendations provided to communities and can be enforced through various incentives. For example: reduced or no compensation should be provided to livestock owners that do not comply with the new HCC livestock management guidelines.

d) Zoning

Zoning that completely excludes people from having access to the river is not recommended, as it may exasperate conflict between people, crocodiles and the DWNP. However, buffer zones can be created along the river's edge, where access by livestock and people is restricted through an incentive based approach (stated previously in provision of water taps).

e) Provision of benefits

People who are directly affected by HCC should receive tangible benefits to promote coexistence with crocodiles. Possible benefits are: (i) a share or percentage in the money received from crocodile egg collection for crocodile ranching; (ii) if a problem animal is killed for a specific reason, any earnings from the meat or skin should be given back to that community where the HCC occurs, (iii) a percentage of earnings from trophy hunting of crocodiles should be paid to communities affected by HCC, (iv) if a live crocodile is removed from the river and put onto a crocodile farm/ranch and if any income is gained from that animal, then a percentage of the earnings or benefits should go towards the community near to where it was captured. Although sustainable utilization of the Nile crocodile could possibly help to offset costs incurred through HCC, it is currently ill-advised to harvest adult animals from the Okavango Delta (Graham et al. 1992). Non-monetary compensation in other forms such as food, goods, provision of services or social benefits, could also be provided.

f) Insurance schemes

Community based insurance schemes should be investigated with reference to crocodiles, as government funded compensation may become exhausted in the future. Retaliation against crocodiles could result when monetary compensation is terminated. Insurance schemes may be more viable if the number of attacks on livestock for a specific area is very high, and it could also incorporate other conflict species, such as elephant, lion, hyena and leopard. Community-based

insurance schemes have the potential to relieve pressure on government as state-funded compensation is becoming increasingly unpopular in both conservation and governmental bodies.

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ADDENDUM 5.1

CHAPTER 34:01
WATER
ARRANGEMENT OF SECTIONS

PART I
Preliminary

SECTION

An Act to define the ownership of any rights to the use of water; to provide for the grant of water rights and servitudes; and to make provision incidental thereto.

[*Date of Commencement: 9th February, 1968*]

PART I
Preliminary (ss 1-3)

1. **Short title**

This Act may be cited as the Water Act.

2. **Interpretation**

In this Act unless the context otherwise requires—

"**Board**" means the Water Apportionment Board;

"**borehole**" does not include any borehole constructed in prospecting for minerals;

"**domestic purposes**" includes the watering, spraying and dipping of stock;

"**effluent**" does not include water discharged under the provisions of section 7(3) or 17(1)(*a*) or which has been used for irrigation;

"**existing right**" means any right to public water—

(*a*) which at the commencement of this Act has been lawfully acquired, is possessed by, and is being beneficially exercised by, any person; or

(*b*) lawfully acquired by any person before the commencement of this Act for the purpose of supplying water to the public;

"**public stream**" means a watercourse of natural origin wherein water flows, whether or not such watercourse or any portion thereof is dry for any period or whether or not its conformation has been changed by artificial means;

"**public water**" means all water flowing over the surface of the ground or contained in or flowing from any river, spring or stream or natural lake or pan or swamp or in or beneath a watercourse and all underground water made available by means of works, but does not include any water which is used solely for the purposes of extracting mineral substances therefrom or water which has been lawfully appropriated for use;

"**servitude**" means a right to enter on the land of another for the purpose of constructing or maintaining works thereon, or storing the water thereon, or carrying water under, through or over such land, or for all or any of such purposes;

"**underground water**" means water naturally stored or flowing below the surface of the ground and not apparent on the surface of the ground;

"**Water Registrar**" means the person appointed by the Minister as the Water Registrar for the purposes of this Act;

"**water right**" means a water right granted or deemed to have been granted under this Act and, subject to the provisions of section 10, includes an existing right;

"**well**" does not include a borehole;

"works" includes canals, channels, reservoirs, embankments, weirs, dams, wells, boreholes, pumping installations, pipe-lines, sluice gates, filters, sedimentation tanks or other work constructed for or in connection with the impounding, storage, passage, drainage control or abstraction of public water, or the development of water power, or the filtration or purification of water, or the protection of rivers and streams, against erosion or siltation or flood control, or the protection of any works, or the use of public water for any purpose, or the conservation of rain water.

3. **Establishment of Water Apportionment Board**

(1) The Minister shall appoint a Board, to be styled the Water Apportionment Board, which shall consist of such number of persons as the Minister may determine, being not less than three nor more than 15 persons.

(2) The Board shall have the functions conferred upon it by this Act, and may perform such functions notwithstanding any vacancy in its membership.

(3) The Minister shall appoint a Water Registrar who shall be *ex officio* Secretary of the Board.

(4) Neither members of the Water Apportionment Board, nor the Water Registrar shall be personally liable for, or in respect of, any act done or omitted to be done in good faith in the performance or supposed performance of their functions under this Act.

(5) In the performance of its functions under this Act the Board shall have regard to any relevant international agreement regulating the use of water to which Botswana is a party.

PART II

Ownership of and Inherent Right to the Use of Public Water (ss 4-11)

4. **Use of public water and construction of works**

Notwithstanding anything to the contrary in any other written law there shall be no right of property in public water, and the control and use thereof shall be regulated as provided in this Act or in accordance with the provisions of the Waterworks Act.

5. **Casual use of water in a public stream, etc**

Any person may, without a water right, while he is at any place where he has lawful access to a public stream or to a natural lake, pan or swamp, take and use public water therein for the immediate purpose of—

(*a*) watering stock;
(*b*) drinking, washing and cooking; or
(*c*) use in a vehicle,

but nothing in this section shall be construed as authorizing the construction of any works.

6. **Use, etc., of water by owners and occupiers of land**

(1) Subject to the provisions of this Act and of any other written law, the owner or occupier of any land may, without a water right—

(*a*) sink or deepen any well or borehole thereon and abstract and use water therefrom for domestic purposes, not exceeding such amount per day as may be prescribed in relation to the area where such well or borehole is situated by the Minister after consultation with an advisory board established in pursuance of section 35 in respect of that area:

Provided that this paragraph shall not authorize the sinking of any borehole within 236 metres of any other borehole (other than a dry borehole) or authorize the deepening of any borehole which is within this distance of any other borehole;

(*b*) construct any works thereon for the conservation of public water, and abstract and use public water so conserved, for domestic purposes:

Provided that this paragraph shall not authorize the construction of any

works in a public stream unless—

(i) the whole of the catchment area of that stream above the works lies within such distance of the works as may be prescribed in relation to the area where the works are situated by the Minister after consultation with an advisory board established in pursuance of section 35 in respect of that area; or if no such distance is prescribed, within four kilometres of such works; or

(ii) the Minister after consultation with such a board as aforesaid has prescribed that that stream or the portion thereof where the works are construed shall be deemed not to be a public stream for the purposes of this section.

(2) Where any person is authorized under the provisions of subsection (1)(*a*) to construct or deepen a borehole, he may also construct or deepen stand-by boreholes ancillary thereto:

Provided that the total quantity of water which may be abstracted under this section from a borehole and any stand-by borehole ancillary thereto shall not exceed in aggregate the total quantity which may be abstracted from a single borehole under the provisions of that paragraph.

(3) Nothing in this section shall be deemed to authorize an occupier of tribal land to do any of the things referred to herein except to the extent that he is permitted to do so under any customary law applicable to him or by agreement with the owner of such land.

7. Right to water for mining purposes

(1) The holder of any right under the Mines and Minerals Act to mine any mineral shall have in respect of the land to which his right relates the same rights as are conferred by section 6 on the owner or occupier of any land and may also abstract and use any underground water encountered in any workings and construct any works required for or in connection with the use of such water.

(2) The holder of any right under the Mines and Minerals Act to prospect may, within the area which he may lawfully so prospect and subject to all rights which others may have to the use of water—

(*a*) abstract and use for prospecting purposes any public water to which he has lawful access;

(*b*) construct or enlarge any well or borehole in any land on which he has a right to explore or prospect, and abstract water therefrom, not exceeding 22,750 litres in any one day; and

(*c*) abstract and use any underground water encountered in any workings and construct any works required for or in connection with the use of such water.

(3) Any person abstracting water under the provisions of this section shall comply with the directions of the Water Registrar regarding the disposal of such water as is not used.

(4) Failure to comply with any direction given under subsection (3) shall be an offence, and the offender shall be liable to the penalties prescribed in section 37.

8. Right to water for forestry purposes

The holder of rights granted under the provisions of the Forest Act to take forest produce may, within the area within which such rights may be exercised and subject to all rights which others may have to the use of water—

(*a*) abstract and use any public water to which he has lawful access, not exceeding 22,750 litres in any one day or such other quantity as may be prescribed, for logging and sawmilling operations of a temporary nature:

Provided that no such operation shall be deemed to be of a temporary

ADDENDUM 5.2

Wildlife Conservation and National Parks Act (Act No. 28 of 1992).

Long title: An Act to make further and better provision for the conservation and management of the wildlife in Botswana, giving effect to the CITES and any other international convention for the protection of fauna and flora to which Botswana is, from time to time, a party, to provide for the establishment, control and management of national parks and game reserves, and for matters incidental thereto or connected therewith.

Date of original text: 1992.
Date of consolidation/ reprint: 1993.

Abstract:

This Act provides a comprehensive framework for wildlife and national parks management under the supervision of a Director of Wildlife and National Parks, and for giving effect to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and other international conventions to which Botswana may from time to time be a party. Part II designates specific areas as National Parks, and gives power to the President to declare any State or bequeathed land as a national park. The responsibility for control, management and maintenance of national parks shall fall on the Minister, with specific responsibilities set forth in section 6. The Minister may delegate his responsibilities to the Director or any wildlife officer. A list of activities prohibited in parks is provided, including the entry of persons without permission, the cutting of trees, the removal of animals, etc. This part also gives the President power to declare game reserves and sanctuaries, and private game reserves. Part III provides for the establishment of wildlife management areas and controlled hunting areas by the President, and the enables the President to draw up regulations regarding such areas. Part IV specifies a list of protected animals in Botswana, and imposes a fine of P10 000 and imprisonment of seven years for persons who hunt or capture such animals without authorization, with higher fines for rhinoceros. Part V deals with hunting generally, and provides that licences are required for the hunting of all animals, except in the case of personal consumption of non-protected animals outside of a national park or game reserve, or in the case of hunting non-protected animals by someone holding "landholder's privileges" on the land subject to that privilege.
Even in the latter cases, however, hunting is subject to certain restrictions. Subsequent sections of the act deal with game ranching (Part VI), the types and issuing of hunting licences (Part VII), and the issuance of permits for certain special situations, such as the capture of any animal for scientific research or the killing of animals in a park or reserve where the Director is satisfied that such killing is necessary for protection of life or property or in the interests of conservation (Part VIII). Part IX provides rules regarding professional guides and hunters defines unlawful methods of hunting, and covers situations such as the killing of animals in self-defense or accident. Part X deals with the sale or export of animals or animal parts, while Part XI deals specifically with ivory and rhinoceros horn. General provisions in Part XIV pertain to topics such as hunting in forest areas (for which permission must be obtained under the Forest Act), the keeping of animals in confinement, the ownership of animals on private land, and the issuing of regulations.

Amended by: [LEX-FAOC006472] - Wildlife Conservation and National Parks (Amendment) Act, 1993 (Act No. 16 of 1993). - 15 December 1993.

Full text available: http://faolex.fao.org/docs/pdf/bot4728.pdf

Comments: The abstract is based on the Act as amended by Act No. 60 of 1992 and Act No. 16 of 1993.

Source: FAL No. 43, 1994, pp. 272-276. *Government Gazette, Supplement A, No. 60, 11 December 1992, pp. A 117-233.*

CHAPTER 6

DISCUSSION AND CONCLUSION

1. DISCUSSION

Human-wildlife conflict can be seen as one of the 'war zones" of conservation where rivalries between people and wildlife are unending. It is described as "not just a litany of specific problems, but a whole unacknowledged perspective on reality" (Western & Waitaka 2004). Therefore one cannot just view HWC in terms of damage caused by wildlife, but rather in a larger context with multiple dimensions. This complexity is sourced in the ancient interaction between wildlife and man, where one can see conflict as the result of an imbalanced relationship between the two, due to pressurized anthropogenic circumstances.

The actual extent, scale and dynamics of human-crocodilian conflict in the world today are largely unknown. It is said that the Nile crocodile is responsible for more human fatalities than any other crocodilian species, which is due to its wide distribution and high dependency/reliance of communities on water resources in Africa (Ross 1998). Most people become aware of HCC through anecdotal and highly publicized human attacks, but this is only brushing the surface of a very interesting and dynamic relationship between man and crocodile. In the Okavango Delta, Botswana, the primordial fear of the Nile crocodile is heightened by the traditional belief that the brain and liver are used as a poison to kill one's enemies.

The increasing rate of crocodile attacks on humans in the Okavango Delta is concerning, as mitigation strategies need to be adaptive and must be able to cope with future trends. At the moment it is questionable if the current compensation and 'problem' animal control strategy in Botswana will cope with the expected increase in crocodile attacks in the future. This type of reaction-based HCC resolution strategy is not just limited to Botswana, but can be seen in other African counties (eg: problem animal control in South Africa, in Stadler 2006) and this "knee-jerk" response to conflict is a reason for failure of many HEC (Human-Elephant Conflict) mitigation strategies in the past (Dublin et al. 2006). Various strategies that include local communities have been recently been attempted [Madagascar, Malawi and Zambia (Hekkala et

al. 2000, Parker 2003, Ligomeka 2000)] to curb HCC, but none have been formally tested in their effectiveness and no official guidelines to mitigate HCC globally have yet been formulated.

To develop a successful strategy of coexistence between humans and crocodiles, [which means a balance is formed between crocodile conservation needs and human needs (Dublin et al. 2006)], requires a consideration of both macro and micro level factors (see Chapter 1) (Manfredo and Dayer 2004). These factors broadly relate to the social/cultural, economic and environmental context of HCC and site specific factors in the Okavango Delta are further discussed.

Socio-cultural considerations

Attention to the socio-cultural environment is a crucial aspect of HCC determining lasting effectiveness of mitigation measures, which requires ethical involvement of different affected groups (Manfredo & Dayer 2004). In Morris (2000), people are described as social agents whose actions and choices are applied in the context of their cultural identity and therefore people's actions towards crocodiles are expressed in the context of their culture. The influence of cultural beliefs and values on people's feelings and reactions towards crocodiles was worthwhile investigating, as it helped to identify and deal with the origin or cause of conflict and not just the symptoms (e.g. feelings of hate or heightened fear).

Intolerance towards crocodiles is an obstacle hampering the success of HCC mitigation in Botswana. Possible causes of intolerance in people are the combination of ignorance or prejudice (resulting from lack of knowledge or misconceptions about the beneficial role of crocodiles in the ecosystem) and heightened fear linked to traditional beliefs (that particularly the crocodile brain is poisonous). This is similarly seen in fishing communities in Zimbabwe where crocodiles are associated with evil in Lake Kariba (McGregor 2005). Other possibly causes of intolerance that were not investigated are: increasing competition for natural resources between man and wildlife, increased standards of living and increased social and economic aspirations and a history of paternalistic methods of "problem" animal control whereby people see HWC as a government problem (Dublin et al. 2006).

Retaliatory killings or persecution, which is seen as a backlash reaction by intolerant individuals towards conflict species, are seen as a major threat to the conservation of some threatened conflict species. For example: African Wild Dogs are being persecuted by livestock farmers in

Botswana (Swarner 2004) and local people are often known to "take matters into their own hands" and kill tigers suspected of predating on livestock in Southeast Asia (Nyhus & Tilson 2004)]. With regards to HCC in Botswana, retaliatory killings are not currently seen as a problem [observed in the low number of people that responded that they 'hate' crocodiles (10.4%) and would kill crocodiles (3.12%)], however, it could possibly become an issue in the future. Attitudes and behaviour patterns of people are seen as individual or micro level factors (Manfredo & Dayer 2004) in HCC and should be incorporated into HCC mitigation. Additionally these factors should be monitored over time so as to assess tolerance levels of people living in close proximity to the Okavango Delta.

Macro - level factors relate to community dynamics of HWC, which involve human – human conflict where people have different or conflicting goals, values, wealth and levels of empowerment (Madden 2004). HCC in the Okavango Delta could be aggravated by empowerment imbalances among people, which also include political agendas and social needs (such as access to resources). Marginalised or impoverished families are expected to suffer the consequences of HCC more severely than others and those who have the resources (such as boreholes, fencing, alternative investments and incomes) are better equipped to prevent and cope with crocodile attacks. Social issues, such as the HIV/AIDS pandemic, together with poverty, create an "environment of risk" and may heighten the perception of risk associated with crocodile attacks (Drimie 2002). People's fear of the lack of stability in their livelihoods, combined with their high dependency on the river and its resources, may cause an elevated fear or intolerance of crocodiles, as being attacked by a crocodile is seen as a more tangible threat than a slowly dehabilitating disease.

Economic considerations

The economic context (a macro-level factor) in which HCC is occurring in Botswana may not be as stable as perceived. Even though Botswana has one of the highest economic growth rates in Africa, nearly one third of the population live below the poverty line and vast differences in affluence occur between individuals (Bouzaher 2005). It also has one of the highest rates of HIV/ AIDS infection in the world (Whiteside 2002). The future implications to HCC are that severe pressure will be placed on financial resources and this can potentially undermine many government-reliant conservation funded initiatives, such as compensation for HCC damage (Drimie 2002). This implies that compensation of HCC claims may simply not be feasible in the

future and thus emphasizing the urgency of implementing preventative measures for HCC as soon as possible in the Okavango Delta.

It is highly concerning that there is currently very little perceived or tangible benefit for local communities from crocodiles in the Okavango Delta Region. Crocodile egg collection hardly provides any benefit to communities, as the funds derived from the egg collecting fees are paid directly to the DWNP (Dept. of Wildlife and National Parks). In the Masai Mara, negative attitudes of local communities towards elephants were said to be caused by a lack of related benefits (Wasilwa 2003). To raise people's tolerance levels, a Human-Elephant Conflict mitigation strategy was applied which involved the development of elephant – related benefits such as eco-tourism. If rural communities are to tolerate and co-exist with wildlife, then they should derive sufficient benefit from it to compensate for the costs (Kiss 1990). Monetary compensation has some benefits to local people in Botswana, however it does not motivate people to try and prevent attacks and is largely inadequate in addressing such a complex issue. Inconsistencies in compensation payments may also further increase conflict within the community and also towards the DWNP.

Development of alternative forms of income in rural areas that reduce pressure on the Okavango Delta, could include improvement of land management and better used of resources (Mendelsohn & el Obied 2004). However, even if alternative incomes are developed it does not imply that conservation of the species and HCC mitigation will occur. People may still remain intolerant towards crocodiles, unless a tangible value is attached to these creatures. Tourism has the potential to positively influence conservation of wildlife, as well as providing a value or benefit from the animals in a non-consumptive form. However, benefits that are derived from tourism can be easily monopolized by private companies (e.g. trophy hunting through private hunting concessionaries) or parks. Equitable distribution of benefits derived from crocodiles to communities worst affected by HCC should occur in the future, otherwise there is no incentive for the people to conserve the species. Tourism can be negatively influenced by turmoil in a country (social & political), as revenues may become unreliable (Newmark & Hough 2000) and therefore it is unwise to rely solely on this form of benefit to increase tolerance towards the conflict species.

Environmental considerations (biotic & abiotic)

The environmental context of HCC in the Okavango Delta is influenced by biotic and abiotic factors. With regards to biotic factors, the wild prey population abundance should be considered as it is thought that the decrease of wild prey (through hunting and habitat destruction) may increase the frequency of livestock predation (Mishra et al. 2003; Patterson et al. 2004). This was the case with tigers in Southeast Asia, when their natural prey density was low (due to hunting or habitat degradation) they were more likely to attack livestock (Nyhus & Tilson 2004). The encroachment of livestock herds in the Okavango Delta and consequent exclusion of the natural prey of crocodiles could be a possible reason for the heightened number of recorded livestock attacks. Prey availability is also linked to climatic variability and this can influence depredation behaviour of predators (Swarner 2004). In a study by De Leeuw et al. (2001) a negative association was recorded between livestock and the distribution and diversity of wildlife in northern Kenya. It shows that livestock exerts a negative impact on wildlife (a possible food source for predators) and competition for food could possibly be the cause. However, this theory has not yet been tested with regards to crocodiles and information relating to it tends to be speculative rather than conclusive (Hemson 2003).

A biotic factor that could be considered in HCC mitigation is that wildlife damage problems can be resolved through managing the behaviour of wildlife's (Fall & Jackson 2002). In Swarner (2004) altering predator behaviour was expected to be more troublesome that altering human behaviour as a means to mitigate conflict. However, it is important to understand how animals react in conflict situations and thus can facilitate the advancement of mitigation technologies, and improve monitoring and management of HWC (Fall & Jackson 2002 and Mfune et al. 2005). Unfortunately, there have been very few studies on Nile crocodile behaviour in the wild and they are unpredictable and cryptic creatures (Pooley 1982).

Abiotic factors in the region of the Okavango Delta are linked to agriculture (farming and livestock) and since Botswana is seen as a dry country, the influence of rainfall and flooding is a crucial factor that should also be considered in the management of HCC. The influence of global climate change and the rising demand on water resources may also have severe implications for HCC (Swatuk & Rahm 2004).

The rising demand of water from the Okavango River System from neighbouring countries such as Namibia and Angola is due to the increasing pressures from agriculture, industry and various other uses (Mendelsohn & el Obied 2004). Increased water and resource use by humans from freshwater ecosystems, implies a reduced supply to biodiversity (Swanson et al. 1999) and possibly increasing resource conflicts between man and crocodile. Predicted anthropogenic disruptions in flood cycles in the Okavango River System could potentially influence seasonal ecological processes, resulting in a decrease in biodiversity, therefore possibly threatening the Nile crocodile population and also communities' dependant on the river for their livelihoods (Mendelsohn & el Obied 2004).

Obstacles to overcome

Livestock management in the Okavango Delta has various management implications for HCC. There is a high demand for land and due to increasing wealth, overstocking and overgrazing has resulted. Herds therefore come into increasing conflict with wildlife as they are pressed into 'marginal' lands (Swatuk & Rahm 2004). Evidence of this is seen in the construction of the veterinarian cordon fences in the Okavango Delta to reduce transmission of disease from buffalo to cattle. This has also resulted in conflicts within wildlife conservation community. Secondly, traditional grazing systems in Botswana are generally dominated by a cattle post system, where livestock owners water their livestock at a centralized watering point. There is generally little fencing and livestock tend to be free roaming. Grazing is usually part of mixed small - holder farms and this could make it very difficult to change grazing systems to mitigate HCC.

Livestock are greatly affected by drought, as they are highly dependent on water resources (de Leeuw et al. 2001) and this usually results in an increased number of boreholes [60 additional boreholes are drilled each year in rural areas in Botswana (Swatuk & Rahm 2004)] rather than fewer livestock numbers. This is primarily due to the concentration of livestock holdings among elites that can afford the financial cost of drilling boreholes (Swatuk & Rahm 2004). Therefore, those that cannot afford to sink more boreholes are then forced to water their cattle at the rivers edge with the associated high level of risk attached. This is also aggravated by grazing pressure which increases in the more fertile areas along the river edges in the dry season.

There are also financial obstacles in HCC with regards to livestock management. Cattle owners in Botswana are required to pay a fee per head of cattle to the Water Utilities Corporation (WUC) to

cover maintenance costs of equipment and the supply of water to water-points away from the river (Swatuk & Rahm 2004). These direct costs of water use away from the river, compared to the free access to water resources at the river, could possibly hinder the acceptance or implementation of recommendations to reduce the interaction between livestock and crocodiles.

Further obstacles in HCC mitigation in Botswana (with reference to socio-cultural linkages) surrounds the neo-patrimonial approach of the current government, which has resulted in an attitude that the 'government will provide' (Swatuk & Rahm 2004). This could influence the degree of support for community-based HCC mitigation initiatives and impede implementation of HCC mitigation strategies. Compensation and problem animal control can be seen as the 'easy way out', however, the problem is never actually solved and this reaction-based approach is insufficient in shifting attitudes towards tolerance (McGregor 2005). Popular hostile attitudes towards crocodiles are seen to be difficult to change in both Southern Africa and in an international context, with conservationists 'battling against adverse opinions' (McGregor 2005), instead of tacking a different approach through education.

Site specificity and species specificity of HWC (see Chapter 1) was described as a major obstacle in the coordination of HWC mitigation together with a lack in sharing of expertise, resources, time and energy of local stakeholders (Madden 2004). Patchy or uneven distribution of HWC is commonly recorded in many cases throughout the world (Woodroffe et al. 2004) and is also seen in Nile crocodile attacks in the Okavango Delta, Botswana. This uneven distribution has both positive and negative implications. Negative attitudes of people towards conflict species is possibly fuelled by the patchy distribution, because even though regional losses may not be significant, individuals or specific groups may be severely and repeatedly affected by localised high HCC (for example, an extremely high number of livestock attacks were recorded in the village of Seronga). High local and individual costs associated with conflicts may cause a perception that the risks of conflict are higher than they actually are. This means that conflicts can be more easily reduced by focusing efforts and resources in HCC 'hotspots'. Further comparison of sites having varying degrees of conflict (with regards to environmental and social factors), may reveal additional causes of conflict and help to provide better management strategies for HCC mitigation.

Successful mitigation of HCC in Okavango Delta

It was emphasized that communities need to be sufficiently empowered to deal with HCC, otherwise conservation efforts may become undermined through a lack of local support (Madden 2004). The enforcement of conservation policies need to be balanced with inclusion of communities' needs, livelihoods and opinions. If not, conservation may be seen as if it is given priority over people's interests and rights, potentially leading to increased conflict and retributive action. For peaceful coexistence to occur, benefits should offset the perceived risks of living with crocodiles (Western & Waithaka 2004). The perception of risk is said to be influenced through the provision of benefits (Messmer 2000 and Knuth et al. 1992), which positively affects the tolerance level towards problem species even if the actual risk remains constant. Provision of benefits linked to crocodiles (suggested in Chapter 5) could greatly benefit communities in the Okavango Delta and will foster coexistence over time. One cannot simply exclude wildlife from a community, as they are an integral part of the ecosystem and a "solution requires a concept of sustainable wildlife management by and for people on their land, not in spite of them." (Western & Waitaka 2004).

Paralleled to macro level factors of HWC, micro level factors (Manfredo & Dayer 2004) must also be considered to effectively apply mitigation measures at a local scale in the Okavango Delta, Botswana. However, at the same time one has to consider that the Nile crocodile's distribution is influenced by regional factors and mitigation policies need to 'blanket' over all communities which include the micro level factors for effective long term HCC mitigation.

2. CONCLUSSION

Gauging human-crocodile conflict (tools)

There is a continuing need to monitor human perceptions and attitudes towards crocodiles, as it is a highly complex relationship and changes over time due to social pressures and other influences. Investigating tolerance of people towards crocodiles in this study was beneficial (in assessing potential retributive killings of crocodiles and scope for mitigation action) and should continue to be monitored, together with recording crocodile attacks on humans and livestock not only in Botswana, but in other areas.

HCC cannot be removed, but rather needs to be managed (Mfune et al. 2005), which requires a concerted and combined effort throughout all levels of society. It should not be seen as a top - down approach in policing laws (protectionist approach), but should facilitate, equip and empower people to solve problems within a local context, together with backing from government and private organizations. The value- laden aspect of wildlife in people's lives needs to be incorporated and highlighted as a solution to the issue of HCC. The challenge of mitigating Human-Wildlife Conflict is described by Woodroffe et al. (2005) as: "If we fail (to resolve HWC), then we will either not meet our fundamental ethical obligation to steward the world's species and natural systems, or not meet the obligation to sustain our fellow human beings."

Future scope/ predictions

Mitigation of HCC is no easy task, as it is due to the high complexity of the interaction between humans and wildlife and how they influence each other. HCC in Botswana is expected to be increase in the future, with crocodile attacks on people and livestock having a severe effect on society. Combined with HIV/AIDS it has the potential to undermine many people's livelihoods. Reactive techniques to HCC mitigation should no longer be used in isolation and if preventative techniques are implemented to mitigate HCC, it will certainly reap its rewards in the future and will hopefully foster an attitude of coexistence within communities.

Future research

Even though there have been great advancements in general crocodilian biological and ecological research, there is a great need for research to be carried out on the dynamic relationship between humans and crocodiles. Aspects that need attention are: the influence of demographic factors (such as crocodile and human population density), sociological factors, natural prey availability and livestock dynamics (density, population and distribution) on crocodile populations and rural communities.

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