ADOPTION OF ELEPHANT CROP-RAIDING DETERRENT INNOVATIONS BY SUBSISTENCE ARABLE FARMERS IN THE OKAVANGO DELTA, NORTHERN BOTSWANA

By

SEKONDEKO RONNIE NOGA

[Student no: 201406664]

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SUPERVISOR: Associate Professor Oluwatoyin D. Kolawole

CO-SUPERVISORS: Drs Olekae T. Thakadu and Gaseitsiwe S. Masunga

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Statement of Originality

This MPhil thesis is solely my own original work done under supervision. The research data contained herein were obtained in a survey carried out and completed by the author at the University of Botswanaôs Okavango Research Institute between February and July, 2015. Where the work of others was used it was paraphrased (except where it was quoted verbatim) and due reference made. Parts of this work have been published in peer-reviewed journals, such as the African Journal of Science, Technology, Innovation and Development and The Journal of Agricultural Education and Extension in 2015 and 2016, respectively. Neither the thesis nor the research work therein has been submitted previously for the award of any degree or other qualifications of the University or elsewhere.

Authorôs signature _____

Date: _____

DEDICATIONS

To my departed daddy, it would have been very great if you were still with us. Nonetheless your firm but affectionate fatherly guidance will forever be part of me and those of others. Thanks to my mom, brothers and sisters for your words of support and encouragement. I simply couldnôt have done it without you.

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LIST OF ACRONYMS

HEC	Human Elephant Conflict
ECDIs	Elephant crop-raiding deterrent innovations
DWNP	Department of Wildlife and National Parks
CSO	Central Statistics Office
GEF	Global Environment Fund
KAZA TFCA	Kavango Zambezi Transfrontier National Park
NGO	Non-Governmental Organisation
NRP	Natural Resources and People
ODMP	Okavango Delta Management Plan
PAC	Problem Animal Control
PA	Problem Animal
VPC	Village Project Committee
AfESG	African Elephant Specialist Group
ODP	Okavango Delta Panhandle

ABSTRACT

This research study investigated factors influencing adoption of elephant crop-raiding deterrent innovations (ECDIs) in the Okavango Delta, Botswana. The study was conducted on the eastern Okavango Panhandle region in five rural communities that are riddled with human-elephant conflict and are participating in a pilot project initiated by the Department of Wildlife and National Parks (DWNP) aimed at testing the efficacy of chilli pepper and beehive fence as ECDIs.

The sample comprised a total of 388 randomly selected, subsistence arable farmers from the list of all households in the individual villages, and 12 purposively selected key informants ï two extension agents from the DWNP, and 10 community leaders: that is, five village *dikgosi* and five village project committee (VPC) chairpersons. The key informants were selected based on the knowledge they possess about the investigated matters, and special positions of responsibility and influence they occupy in their communities or those in which they operate.

The study used a structured interview schedule to collect data from the subsistence arable farmers. Individual farmer interviews were complimented by focus group discussions (FGDs) which elicited farmersô response on the delivery and adoption of ECDIs as well as their perception of chilli pepper and beehive fence as elephant deterrent measures. Key informant interviews and field observations were also used to collect data on factors influencing adoption of ECDIs in eastern Okavango Panhandle region. Rooted in Rogersô diffusion of innovations theory, the study used a descriptive, cross-sectional survey design. Prior to the main investigation, a reconnaissance survey was carried out with a view to ensuring adequate planning and informed decision-making to guide and improve the main survey efforts. The survey was also conducted to ascertain the extension agencyôs claim that it had introduced

ECDIs to farmers and affirm the adoption of the deterrent innovations. The survey showed that the pilot project meant to test the efficacy of introduced ECDIs was formally launched in 2010 in the study area. Data were generally analysed using descriptive statistics, binary logistic regression and chi-square of independence.

Results showed varying levels of innovation uptake among farmers. A significant proportion of farmers (69%, n = 268) adopted chilli pepper innovation. Only one farmer (0.3%) incorporated beehive fence in their farming practice, with two (0.5%) adopting both the deterrent innovations. However, a large proportion of famers (30.4%, n = 118) did not adopt any of the ECDIs. Farmersô income, education, and perceptions, extension agentsô credibility and dissemination strategies were significant predictors of farmersô ECDIs adoption. Further, the study elicited institutional relations, availability and/or supply equipment of ECDIs, and labour constraints to have contributed significantly to farmersôadoption decisions of ECDIs.

In the end, a more participatory approach that empowers local people to take a prominent role in decision-making processes regarding human-elephant conflict management seems to be more likely to achieve farmersô sufficient adoption of ECDIs and reduce crop-raiding. But without genuine institutional support, it will count for nothing. Thus, creating a genuine farmer-scientist-extension linkage would facilitate exchange of useful information and bringing about better understanding of the innovations. In doing so, it would help develop an effective and sustainable strategy for promoting any future mitigation measures.

KEY-WORDS: Adoption, Botswana, Conservation, Elephant crop-raiding deterrent innovations, Extension, Perceptions, Small farmers, Okavango Delta

CHAPTER 1

INTRODUCTION

1.1. Background and Context

Elephant conservation in both Africa and Asia faces daunting challenges, which the rapid increase in elephant and human populations, economic development pressures, and expansion of agricultural settlement will compound in vulnerable areas (Tchamba, 1996; Aziz *et al.*, 2008; Guerbois *et al.*, 2012; Tchamba & Foguekem, 2012). By reducing elephantôs habitat and blocking their migratory pathways, these factors have increased the people-elephant interface, thereby exacerbating human-elephant conflict (HEC), particularly crop-raiding. Although potential remedies to this conflict exist, they will take effort and determination to achieve. Among others, one of the remedies that particularly draw national and international attention is an integrated approach to mitigating crop-raiding, which takes into account elephant management issues and rural development objectives such as provision of livelihoods (see for instance, Adams *et al.*, 2004; Fungo, 2011; Barua *et al.*, 2013). Above all, the approach recognises that local communityôs perspectives of the conflict is a critical link between peopleôs attitude and behaviour (Hill, 2000), and their overall participation in agreed mitigation processes. Nonetheless, crop-raiding often jeopardises an integrated response from local community and wildlife authorities (Fungo, 2011).

In Africa and Asia, farmers generally lose about 10-15% of their agricultural produce to raiding elephants (Lamarque *et al.*, 2009; Madhusudan & Sankaran, 2010) but the damage can sometimes be more pronounced in certain countries. For example, farmers around the Kakum Conservation Area in Ghana lose about 70% of their food crops to elephant depredation alone

(Barnes et al., 2003 *in* Lamarque *et al.*, 2009). Such losses can have a significant negative impact on rural farmersô livelihoods and food security (Kaswamila *et al.*, 2007; Barirega *et al.*, 2010). In southern Africa where most elephant range (~80%) is outside protected areas (Cumming & Jones, 2005), crop-raiding (and HEC in general) remains a serious conservation concern and is likely to continue over several years (Hanks, 2006).

Botswana is particularly vulnerable as a result of the continued increase in both human and elephant populations (Central Statistics Office, 2011a; Chase, 2011; DWNP, 2012), and the conflicting development objectives that aim to conserve and manage elephants while also promoting subsistence farmersô agriculture-based livelihoods (through various and subsidised farming programmes), including in human-elephant conflict hotspot areas (Warner, 2008; Gupta, 2013; Mayberry, 2015). All these factors together have created a significant development conundrum for the country. Consequently, subsistence arable farmers throughout northern Botswana are in constant conflict with óproblemô elephants (Masunga, 2007; Warner, 2008; Gupta, 2013; Mayberry, 2015). In the Okavango Panhandle region, which is one of the HEC hotspot areas in northern Botswana (ODMP, 2002; NRP, 2006), studies on HEC have shown that crop-raiding by elephants have significant effect on food supply and security of subsistence farmers annually (Mosojane, 2004; NRP, 2006; Songhurst & Coulson, 2014).

Mosojaneôs (2004) baseline study has shown that up to 40% of the potential annual harvests of farmers are destroyed by elephants along the eastern Okavango Panhandle. In the 2004/5 cropping season, NRP (2006) observed that, in some instances, elephants destroyed farmersô entire fields in the same area. Moreover, the results of a recent study conducted in 2008-2010 provide compelling evidence of elephant crop-raiding activities and its adverse impact on farmersô potential crop harvest (Songhurst & Coulson, 2014). The study showed that 162 ha of

crops were damaged in the 788 fields which were raided by elephants. This can cause food insecurity and consequently, resentment of elephants by rural farmers (Davies *et al.*, 2011). It is, therefore, necessary to develop and implement a comprehensive, concerted strategy that integrates development of rural agrarian livelihoods into elephant conservation agenda.

1.2. Community methods for deterring problem elephants

People living and farming within elephant range have used every available means to protect their food crops against marauding elephants. Some of the methods used in most African countries include tin or drum beating, shouting and throwing objects in the direction of elephants, guarding, lighting fire all night, digging trenches, fencing (mostly with thorn bushes) and, occasionally, shooting in the air to scare away elephants (Hoare, 1992; Thouless & Sakwa, 1995; Osborn & Parker, 2002). However, these techniques are believed to have short-term deterrent effect, as elephants become habituated to them (AFESG, 1999; OôConnell-Rodwell *et al.*, 2000; Hoare, 2001a). Eventually, problem elephants are sometimes killed, either legally or illegally, with the aim of preventing others from returning (Nelson *et al.*, 2003; Osborn & Parker, 2003; Omondi *et al.*, 2004). However, elephant killings (for whatever reason) pose a major threat to the long-term survival of African elephants, especially at a continental level (DG Ecological Consulting, 2003).

As in other parts of Africa, farmers in rural northern Botswana (where the Okavango Delta is situated) spend sleepless nights banging tin cans or drums, shouting and lighting fire in their attempts to prevent crop-raiding elephants from entering their fields (Mosojane, 2004). Indeed, farmers also use torches which are waved towards elephants to scare and keep them away. In some instances and due to limited supply of resources, farmers use a beverage tin can fence

which is usually placed on the one side of the field (possibly in a direction, which farmers believe elephants would normally come from).

As it has been previously stated that elephants quickly become accustomed to traditional deterrent measures, the Okavango Panhandle reflects this phenomenon. Elephants sometimes can enter a crop field despite the empty threats of drum/tin beating and human shouts (Mosojane, 2004). In such cases, elephants can get irritated by the noise and become aggressive toward farmers, giving them no choice but to evacuate, as OôConnell-Rodwell *et al.* (2000) observed in the Caprivi region, Namibia. Such fear among farmers may reduce field defence, and farmers would ordinarily hold wildlife officers from the Department of Wildlife and National Parks (DWNP, a ministry-based extension system tasked with the onus of managing and protecting wildlife and the environment) responsible for crop losses (Osborn & Parker, 2003).

1.3. Interventions by wildlife/conservation authorities

Among the interventions used in the mitigation of elephant crop-raiding by problem animals (PAs) managers across Africa and Asia are barriers erected around conservation areas, reduction of the elephant population (culling, passive dispersal and translocation), and killing problem animals, as well as providing compensation for damaged crops (Sukumar, 1991; Hoare, 1995; Thouless & Sakwa, 1995; Envik, 2000; Blanc *et al.*, 2007). Although some of these strategies have had successes in reducing the conflict, their long-term efficacy is often marred by practical challenges arising primarily from a lack of adequate resources and the adaptable behaviour of elephants (Osborn & Parker, 2003). In areas where, for example, electric fencing has been used, installation and recurrent maintenance costs have typically undermined the long term effectiveness of the fence (Osborn & Parker, 2003; Graham & Ochieng, 2008). Compounding

this, there have been cases where elephants broke through electric fencing (Thouless, 1994), indicating that, with time, elephants learn how to surpass any seeming obstacle.

Equally, strategies aimed at ódriving awayô elephants from farmersô fields such as scare-shooting do not necessarily resolve the conflict of crop-raiding, but instead, they shift the problem to other locations (OôConnell-Rodwell *et al.*, 2000; Graham & Ochieng, 2008; Hill & Wallace, 2012). Most importantly, many of the problem animal control (PAC) interventions appear to suffer from logistical and management deficiencies, especially in remote and expanse areas (Osborn & Parker, 2003). Consequently, managersô reaction to reports of elephant crop raiding is restricted. Nevertheless, failure by managers to attend to farmersô reports always leaves farmers resentful of elephants and of their efforts (OôConnell-Rodwell *et al.*, 2000). While farmers can be compensated for their damaged crops, some critics contend that this strategy is not effective in preventing conflict (as it does not address the root causes of elephant damage) and/or encourage good relations between affected communities and wildlife authorities (Envik, 2000; AFESG, 2007). Furthermore, Naughton-Treves *et al.* (2003) have argued that even well-structured compensation schemes do not necessarily lead to increased tolerance for raiding wildlife like elephants. And with problem elephant management largely centralised (without communities having any real influence on decision-making) in most southern African countries such as in Botswana (Taylor, 1999; NRP, 2006), the problem of crop-raiding becomes even more difficult to resolve.

Eventually, the effective and sustainable way to resolve the conflict between people and elephants is to use a community-based approach to HEC management that gives local people the responsibility of crop protection (Osborn & Parker, 2003). The basic assumption of community-based HEC management is that local community involvement plays an important

role in shaping their perceptions of elephants and conservation (Naughton *et al.*, 1999; Messmer, 2000). In doing so, scholars of human-elephant conflict have recommended the use of simple, cost-effective, and humane strategies (such as chilli pepper, early-warning systems, and beehive fence) in the mitigation of crop-raiding by elephants (Osborn, 2002; Sitati & Walpole, 2006; Hedges & Gunaryadi, 2010; King *et al.*, 2011). Hence, countries grappling with endless incidences of elephant crop-raiding, like Botswana, are increasingly taking up these farmer-managed strategies in an attempt to address the problem.

But to reduce crop-raiding and HEC in general, elephant deterrent techniques must be adopted in the trial communities. Presently, research on this theme is scanty. There is, therefore, need for systematic scientific research to be conducted on adoption of elephant deterrent technologies in order to generate data that can reveal the extent of deterrents use and the factors influencing their adoption by subsistence arable farmers in elephant hotspot areas of northern Botswana in general and the Okavango Panhandle region in particular.

1.4. Statement of problem

Human-elephant conflict (HEC) due to crop-raiding is a serious management and conservation concern across Asia and Africa. Studies have shown that crop damage by elephants can have a significant impact on farmersô livelihoods and food security (Nyhus & Sumianto, 2000; Kaswamila *et al.*, 2007; Barirega *et al.*, 2010; Fairet *et al.*, 2012), leading to attacks on elephants in response to the crop losses (Zimmermann *et al.*, 2009; Davies *et al.*, 2011). In southern Africa, given that both human and elephant populations are ever-increasing and causing spatial land use overlaps between the two parties (OôConnell-Rodwell *et al.*, 2000; Cumming & Jones, 2005; Warner, 2008; Pinter-Wollman, 2012), crop-raiding is likely to

remain a major impediment to building local support for elephant conservation by conservation bodies.

Botswana, like many other elephant range countries, still faces challenges with regard to reducing the impacts of elephants on habitat and human livelihoods (DG Ecological Consulting, 2003). Subsistence farmers living in Botswanaôs rural north have, for many years, struggled with elephants that often raid their fields and damaging crops (see for instance, Envik, 2000; NRP, 2006; Warner, 2008; Gupta, 2013). The Okavango Delta is one of northern Botswanaôs HEC hotspot areas as well as UNESCOôs World Heritage Site: it is a crucial conservation area that not only provides home to some of the Worldôs vulnerable species like elephants (Blanc, 2008), but also provides various livelihoods for the people living in and around it (Mendelsohn & el Obeid, 2004; Kgathi *et al.*, 2006). Thus, there is need to integrate conservation, agriculture and rural livelihoods, and address challenges of these priorities simultaneously to effectively achieve sustainable development (Adams *et al.*, 2004; Scherr & McNeely, 2008; Fungo, 2011).

In the Okavango Panhandle region, conflict between subsistence arable farmers and elephants is becoming increasingly frequent and widespread in the recent years (see for instance, Mosojane, 2004; NRP, 2006; Songhurst & Coulson, 2014). It has been estimated that the annual potential loss of harvests to elephants in agricultural areas of the eastern Okavango Panhandle is about 40% (Mosojane, 2004). In the 2004/2005 growing season, NRP (2006) also noted that a substantial number of fields (more than one third) were completely raided by elephants. Essentially, crop-raiding by elephants is a major cause of concern for the government and subsistence farmers in particular.

Surprisingly, crop damage by elephants remains unabated even when several intervention measures to combat it are already in place (see, for example, Osborn & Parker, 2003). Farmersô traditional deterrents such as drum beating, shouting and guarding as well as lighting fire are believed to be ineffective in repelling elephant crop-raiding because elephants easily habituate to them (OôConnell-Rodwell *et al.*, 2000; Hoare, 2001b). Nevertheless, Osborn (2002) remarked that certain traditional methods can perform well when used systematically. Within the context of elephant depredation, problem animal control (PAC) activities employed by wildlife authorities have also achieved little in reducing crop loss. According to Osborn and Parker (2003), the persistence of elephant raiding is a result of technical faults with mitigation measures, lack of commitment of the farmers and limited resources among other things. Osborn and Parker (2003) go on to say that ñOne of the main causes of failure may be due to the centralized nature of órreaction teamsô and the logistics of patrolling lengthy boundaries between agriculture and elephant habitatò (p. 2). From these remarks, one could infer that most conflict resolution intervention strategies offered by wildlife/conservation authorities are non-participatory (or centralised in nature).

However, given that local conditions can limit the ability of wildlife authorities to combat elephant crop-raiding (Osborn & Parker, 2003), actively involving farmers in key decision-making processes regarding HEC management within their areas can reduce external assistance and move them toward becoming independent in addressing the problem (Osborn & Parker, 2002). Recently, there has been growing evidence suggesting that empowering local people in addressing HEC is the most effective and sustainable way to combat crop-raiding (OôConnell-Rodwell *et al.*, 2000; Jackson & Wangchuk, 2001; Osborn & Parker, 2003), and improve local peopleôs food security, tolerance of elephants, and support for elephant conservation (Naughton

et al., 1999; Messmer, 2000). This involves the use of low-tech mitigation strategies that are humane toward elephants, and make use of cheap, locally available materials (Osborn & Parker, 2003; Osei-Owusu & Bakker, 2008). In response to this, a number of African elephant range countries, including Botswana, are increasingly embracing the concept of community-based HEC management.

In 2009, the government of Botswana, through the management of the Department of Wildlife and National Parks (DWNP), introduced the concept of community-based conflict management into elephant hotspot areas (such as the eastern Okavango Panhandle) to empower communities in interacting with elephants and reducing HEC activities themselves. DWNP initiated chilli pepper and beehive fence trials to test their effectiveness in deterring crop-raiding elephants from entering farmersô fields in the villages of Seronga, Gunotsoga, Eretsha, Beetsha and Gudigwa (see Figure 3.1). Although these efforts have received growing attention and are commendable, not much is known about the levels of innovation uptake among subsistence arable farmers, and the factors influencing their adoption of the deterrent innovations. This is despite the great potential of the initiatives in addressing sustainable development concerns. Against this background, it is necessary to examine factors influencing the adoption behaviour and uptake levels of ECDIs among small farmers.

In several studies that empirically tested the efficacy of some of the elephant deterrent techniques, local perceptions of effectiveness, labour and resource requirements of the tried methods were reported to have stopped some farmers from participating further in the trials (OôConnell-Rodwell *et al.*, 2000; Sitati & Walpole, 2006; Graham & Ochieng, 2008; Hill & Wallace, 2012). Most of these studies, however, focused primarily on performance of the techniques, and did not quantify their uptake among farmers. Graham and Ochieng (2008) who

partly investigated the levels of elephant deterrents uptake among Kenyan small farmers found that response by the farmers was not sufficient. This finding was attributed to limited labour and resources, farmersô age and local politics as hurdles to adoption. Although the results of the Kenyan study (Graham & Ochieng, 2008) may be useful in informing policy and providing practical guidance for improving and encouraging adoption of novel elephant deterrents in Botswana and the in Okavango Panhandle region, research has shown that factors influencing innovation adoption represent, to some extent, the location in which adoption was studied (Nkonya *et al.*, 1997; Sechrest *et al.*, 1998). As such, it becomes necessary to undertake context-specific studies to examine and understand farmersô adoption behaviour.

As a result of limited research on ECDIs adoption in Botswana, a baseline study was carried out within communities of the western Okavango Panhandle (Mmape, 2012). The study evaluated the use of chilli pepper as elephant deterrent strategy and the factors impacting its adoption. This study reported a low level of chilli pepper uptake among farmers (40%, N = 100), and found farmersô low levels of education, income and inadequate contact with extension agents, as well as limited supply of production inputs to have impeded adoption. While the pilot studyôs findings highlighted some important factors to consider when addressing the constraints to the adoption of ECDIs, a more comprehensive study is needed for a greater understanding of the factors that influence adoption of ECDIs, and identifying priority factors to be pursued in support of ECDIs adoption.

The literature on innovation adoption has shown that several factors interact to influence potential adoptersô decisions of any innovation. Thus, risk orientation of the decision-maker, their subjective evaluation of the ECDIs, socioeconomic and demographic characteristics, and contextual institutional factors as well as innovation-specific characteristics are all important

determinants of adoption behaviour (Shapiro *et al.*, 1992; Sitkin & Pablo, 1992; Adesina & Zinnah, 1993; Wejnert, 2002; Rogers, 2003; Haider & Kreps, 2004; Hornik, 2004; Pannell *et al.*, 2006; Prager & Posthumus, 2010; Ovwigho, 2013). Prior to introducing any new practice into any particular community, a thorough consideration of these factors and others can reduce the risk of impediments to the adoption process.

Consequently, investigation into some of the factors influencing the adoption behaviour and uptake levels of ECDIs among subsistence arable farmers in the eastern Okavango Panhandle, Botswana is sought. The following questions are addressed in the study: (1) What are the demographic and socio-economic attributes of farmers in the Okavango Delta, Botswana? (2) What are the relationship existing between farmersô psychosocial dispositions toward ECDIs and the adoption of these innovations in the study area? (3) How do institutional factors affect adoption of ECDIs in the area? (4) How do the characteristics of ECDIs affect adoption of ECDI by farmers in the area? (5) What is the level of farmersô adoption of introduced ECDIs in the study area?

1.5. Study Objectives

The key thrust of the thesis was to determine factors influencing the adoption and use of two introduced ECDIs in the Okavango Delta, Botswana. Based on the main objective, four specific objectives guided the thesis, which are to:

1. determine the relationship between farmersô demographic and socio-economic characteristics and their adoption of ECDIs in the Okavango Delta,
2. determine the relationship between farmersô psychosocial dispositions toward ECDIs and their adoption of ECDIs,

3. determine the effect of institutional factors on farmersô adoption of ECDIs
4. determine the effect of ECDIs characteristics on farmersô decisions to adopt these innovations; and
5. assess levels of adoption of the two ECDIs among subsistence arable farmers in the Okavango Delta, Botswana.

1.6. Research/Hypothesis

Literature on factors affecting innovation adoption abounds in agricultural innovations adoption studies. Although the studies provide useful insights on the adoption factors, they also represent to some extent the unique singular characteristics of each of the innovations (Sechrest *et al.*, 1998). Based on this conception, coupled with very few studies addressing uptake of ECDIs, hypotheses of the study were set in the null form:

1. There is no significant relationship between farmersô demographic and socio-economic characteristics and the adoption of ECDIs.
2. There is no significant relationship between farmersô psychosocial characteristics and adoption of ECDIs.
3. There is no significant relationship between institutional factors and adoption of ECDIs
4. There is no significant relationship between characteristics of ECDIs and adoption of the innovations.

1.7. Significance of the Study

This study examined the link between farmersô demographic, socio-economic, and psychosocial characteristics, innovation characteristics, variable of institutional context and adoption of ECDIs. It did so by identifying opportunities for and impediments to adopting the deterrent innovations. It also addressed some of the key issues that poor, rural people face in their innovation adoption efforts. The study engendered data on factors influencing adoption of ECDIs in the eastern Okavango Panhandle and will be used to assist policymakers in formulating a multi-level approach to strengthening extension systems and ECDIs adoption. The goal is to foster human-elephant coexistence, protect biodiversity while also improving rural food security.

1.8. Definition of key Concepts and Terms

Innovation: An idea, practice, or object perceived to be new by an individual or by an organisation (Rogers, 1995, 2003; Straub, 2009). The perception of novelty is a fundamental aspect of an innovation than its time of existence within a particular population. As Rogers (2003) points out, an innovation can be intangible (or abstract), concrete (tangible) or both. In this study, chilli pepper and beehive fence constitute both the information (software) and object (hardware) components, and are viewed by the Okavango Delta communities as new practices of deterring crop-raiding elephants. According to Straub (2009), innovation does not necessarily mean better, or more beneficial than current practice(s).

Adoption: The decision taken by an individual (or an organisation) to utilise a new practice as the best course of action available (Rogers, 2003; Pannell *et al.*, 2006; Parminter, 2011). For this application, adoption was an individual farmerôs decision to incorporate either chilli pepper

or beehive fence (or both) into their on-going arable farming practice as the best ECDI(s) available to wade off elephantsô destructive tendencies. According to Rogers (2003), innovation-decision process ñcan just as logically lead to a rejection decision as to adoptionò (p. 177). He goes on to say that each stage of the innovation-decision process is a possible rejection point. Thus, factors that potentiate adoption may as well impede continued use of the innovation.

Rejection: The decision not to adopt an innovation (Rogers, 2003). An individual may know about the existence of a new idea but never bother to discover more about it or can stop at some point of the learning process for various reasons, leading them to not adopting the innovation at all. Rejection in this study denotes non-adoption of either one or both of the introduced ECDIs.

Adoption level: The extent of innovation use within a target population. Drawing upon Ovwighoôs (2013) framework for measuring adoption, the levels of use of ECDIs among subsistence arable farmers were assessed by the summation of the numerical values of ôYesô responses. In other words, it is the total number of adopters.

Discontinuance: The decision to stop using an innovation after having previously adopted it (Rogers, 2003). According to Oladele (2005), discontinuance is as important as adoption. The factors that help adoption may affect adoptersô continuous utility of innovation. This is so because discontinuance can serve as an important indication of an un-synchronised innovation into farmersôon-going decision-making process.

Cosmopoliteness: Jeffres *et al.* (2004) defined cosmopoliteness as ó… the extent one is oriented toward the community in which one lives or is oriented beyond that toward a larger context.ôIt describes how one is exposed to or is conscious of their environment. For this study, the concept

is measured on the basis of how many times they have gone outside of their immediate community to seek for information on agricultural innovations (including ECDIs).

1.9. Structure of the Thesis

The thesis begins with a general introduction in chapter 1, and then in chapter 2 literatures relevant to the study is reviewed. While the methodology section is presented in chapter 3, study results are outlined in chapter 4. Chapter 5 discusses the study results, providing conclusions and recommendations for both for research and practice.

CHAPTER 2

LITERATURE REVIEW

2.1. Overview

This chapter explores the literature that is relevant to understanding the adoption behaviour and analysis of the study results. It is organised into sub-sections, which looks into the following: Usage of chilli pepper and beehive fence: global perspective; introduction in Botswana; concept of adoption behaviour; theoretical approach; and conceptual framework.

2.2. Use of Chilli pepper and Beehive fence: A Global perspective

Africa and Asia are faced with human-elephant conflict (HEC)ð a major threat to rural livelihoods and food security, and to elephant survivalð and are now having to deal with the increasing pressure. In many parts of these regions, a range of strategies aimed at reducing HEC have been tried, including chilli-based methods and beehive fence.

Chilli pepper: Following Osbornôs doctoral studies in the mid-1990s in which he investigated the ecology of crop-raiding elephants in Zimbabwe (Osborn, 1998), the idea of using capsicum (chilli pepper) based elephant deterrents was founded, although the idea has roots in the United States of America where it was being explored on bears and other predators at the time (see Hunt, 1985; Parker & Anstey, 2002 for examples). *Capsicum* spp. have a resin that contains capsaicin, a substance that makes the peppers so hot and causes nociceptive stimulation of the trigeminal system (Mason *et al.*, 1991; Rasmussen, 1994 *in*; Osborn, 2002). This burning sensation caused by capsaicin is used to control the behaviour of elephants when it comes in contact with mucous membranes of the animals. In their 1995 study, Osborn and Rasmussen observed that elephants were to be quick to respond to capsicum oleoresin spray in the Hwange

National Park, Zimbabwe (Osborn & Rasmussen, 1995). Then several studies field testing the performance of chilli-based methods were conducted in numerous countries facing HEC (see, for instance, Osborn, 2002; Sitati & Walpole, 2006).

In Zimbabwe, for example, Osborn (2002), Osborn and Parker (2002) and Parker and Osborn (2006) further explored the effectiveness of this strategy, and generally found that elephants spent shorter time in crop fields when chilli-based methods were used compared to traditional deterrents. Similar studies have been carried out in Kenya (Sitati & Walpole, 2006; Parker *et al.*, 2007; Graham & Ochieng, 2008; Graham *et al.*, 2009), Mozambique (Parker & Anstey, 2002), and in Indonesia (Hedges & Gunaryadi, 2010). Although these studies have collectively yielded mixed results to date, they have nonetheless acknowledged chilli pepperôs potential in reducing crop-raiding incidences caused by marauding elephants.

Chilli pepper is multiform in nature. It can be used either as: (*i*) hand-held pepper sprays (aerosols) or smoke canister bombs fired from simple mortar-like launchers (Osborn, 2002; Parker *et al.*, 2007; Hedges & Gunaryadi, 2010), (*ii*) chilli ógreaseô (or pepper grease) fence (ground chillies mixed with used grease or oil) which is applied to cloth or rope fence around crop fields (Parker *et al.*, 2007), or (*iii*) chilli-dung briquette: elephant or cow dung is mixed with ground chillies and then sun-dried. The bricks are placed along the field boundaries and upon sensing elephants approach at night, they are burnt to produce a pungent smell that deters elephants from entering a field. Alternatively, chillies can be added to fire (as chilli heap) to produce a noxious smoke that wade off elephants (Osborn & Parker, 2002; Parker *et al.*, 2007).

Figure 2.1: Chilli-grease fence on a farmerôs field in Seronga (Photo by Sekondeko R. Noga)

Beehive fence: In the same vein, the use of African honey bees (*Apis mellifera scutellata*) to stop crop-raiding elephants from entering crop fields has been considered in Kenya. Beehive fence employs elephantsô natural bee avoidance behaviour to stem crop-raiding incidences (King *et al.*, 2011). While the buzzing sounds of the disturbed African honey bee (*Apis mellifera scutellata*) scare elephants away (King *et al.*, 2007), elephantsô alarm ócallô warns family members to withdraw from a possible bee threat (King *et al.*, 2010). The work which has been underway since 2002 (Vollrath & Douglas-Hamilton, 2002), has made strides in investigating the behaviour of elephants in response to encountering African honey bees. Following Vollrath and Douglas-Hamiltonôs 2002 work, King *et al.* (2011) did further trials to

ascertain whether indeed elephants would avoid a beehive fence. The study results showed a significant difference in the number of elephants which successfully raid crops between fields using beehive fencing and those that used a natural thorn fence, indicating that beehive fence is effective in deterring crop-raiding elephants. However, this finding is not without criticism, but would not be explored further in this current work.

In constructing the beehive fence, hives are hung every 10 meters around field boundary and linked together through an interconnecting wire such that when one hive or the connection wire is touched by an elephant, the whole fencing will swing at once and discharge bees (king, 2014).

Figure 2.2: Beehive fence on a farmerôs field in Gunotsoga (Photo by Sekondeko R. Noga)

Generally, these (chilli pepper and beehive fence) novel elephant deterrents are believed to be cost-effective as many of the materials used are locally available, and are simple to implement by most subsistence farmers (Osborn & Parker, 2003; King *et al.*, 2011). Also, the innovations are non-consumptive, an essential facet of the deterrents stressed by conservationists for the preservation of elephants and other natural resources. Although more attention is being paid on these strategies, conflict between subsistence arable farmers and elephants is continuing and growing. The reason could be that the mitigation measures currently in use (including chilli pepper and beehive fence) are either not effective in stemming out elephant crop-raiding, or their uptake and use by farmers is insufficient. On the point of innovation adoption, there is a paucity of published studies examining this subject (Graham & Ochieng, 2008).

2.3. Introduction of ECDIs in Botswana: Institutional and Implementation Arrangements

Responding to the recommendations of a consultancy work carried out by Natural Resources and People (NRP) on HEC, through the Okavango Delta Management Plan (ODMP) (NRP, 2006) together with those from the Kavango-Zambezi Transfrontier Conservation Areaôs (KAZA TFCA) pre-feasibility study (Hanks, 2006), the government of Botswana, through the DWNP and supported by the Global Environment Fund (GEF) World Bank funding, has undertaken to address HEC management challenges and their attendant problems. As such, DWNP has several initiatives underway in elephant hotspot areas of northern Botswana aimed at managing and reducing the impacts of HEC, particularly crop-raiding since 2007.

As part of the mitigation strategy, the DWNP set up Village Project Committees (VPCs) in each trial community with the mission to diffuse knowledge about the innovations and then train other farmers on how to properly implement chilli pepper (which only comprised three components: chilli grease fence, chilli dung briquette, and chilli heap) and beehive fence. A

reconnaissance survey carried out in the study area showed that VPC members were (and still are) provided with hands-on technical training and knowledge in the use of ECDIs to enable them carry out their roles effectively and consistently. According to the DWNP, incorporation of local people in the implementation of the ECDIs trials was meant to encourage ownership of, increase receptivity to, and consequent adoption of the ECDIs. Although supplies are limited, DWNP procures supply equipment for ECDIs from abroad, especially chilli pepper and provides them to farmers free-of-charge as incentive for adopting the deterrent innovations.

In the eastern ODP, one focal officer of DWNP (herein referred to as extension agent throughout in this study) is tasked with implementing and coordinating the pilot project, covering the villages of Seronga, Beetsha, Eretsha, Gudigwa, and Gunotsoga. Over the past several years, considerable efforts have been made to promote chilli pepper and beehive fence as important and effective techniques in preventing elephant crop-raiding. For the deterrent innovations to have an impact on reducing crop-raiding incidences in the study area, however, farmers must adopt and sustainably apply them into their on-going arable farming practices. However, despite the importance of the community-based interventions, research on levels of adoption among subsistence farmers and the factors influencing adoption or otherwise is limited.

2.4. The Concept of Innovation Adoption Behaviour

Since its founding in sociology, research on the adoption and use of innovations has spread over many disciplines. As a consequence, several conceptual and/or constructs definitional issues in innovation adoption studies arose across many disciplines. This plurality in definitions manifest itself in the use of a variety of concepts such as adoption, rejection (non-adoption), resistance, acceptance, approval, and others, when referring to behavioural and social change (Nabih *et al.*,

1997). As Nabih *et al.* (1997) assert, adoption and rejection have been the criterion concepts in innovation research and theory. Traditionally, adoption behaviour was assumed to have a binary effect of either adoption or non-adoption (Dimara & Skuras, 2003). Robertson, 1971 (cited in Nabih *et al.*, 1997) described the former as the acceptance and continued use of an innovation. For Rogers (2003), adoption is a decision of ñfull use of an innovation as the best course of action availableò (p. 177). By defining adoption in this way, Robertson effectively acknowledges that not every innovation subscription results in adoption. Moreover, acceptance alone is not sufficient for adoption. This consideration is however lacking in Rogersô (2003) definition. Instead, he assumes that acceptance of (Nabih *et al.*, 1997), and exposure to innovation translate into adoption.

Evidently, the conceptual problems underlying behavioural measure arise due to the use of different concepts to refer to same behaviour. According to Bohlen 1964 (cited in Nabih *et al.*, 1997), innovation acceptance and adoption, for example, are not synonymous in that there is time difference in their performance ï acceptance (which is a mental status or intent) precede actual adoption, indicating that acceptance is only a determining factor of adoption. Clearly, there is no standard definition of adoption and hence it varies with the innovation being adopted.

One more conceptual debate growing out of the adoption literature concerns the theoretical relationship between new idea and new practise or object. By introducing the concept of symbolic adoption, some scholars believed that adoption of a new idea (referred to as symbolic idea) and of an object or practice cannot occur at the same time (Beal *et al.*, 1966; Bohlen, 1968; Rogers, 1968). That is, they happen independently of each other. Alternatively, Klonglan and Coward (1970) considered symbolic adoption as part of the adoption process irrespective of

the nature of the innovation being adopted. In this way, all innovations (whether abstract or concrete) are assumed to involve an information component, which always precede adoption of a new practice (Lionberger, 1960).

Wilkening (1956) points out that ǒé adoption of a new practice requires several different kinds of informationé from initial knowledge about the innovation to an understanding of how it can be made more effective after it is adoptedô (p. 362). This description implies a sequence in the way information about an innovation is learnt. Thus adoption is a learning process which happens over time (Abadi Ghadim & Pannell, 1999). According to Rogers (2003), once an information deficit is fulfilled, typically through a knowledge-persuasion-decision-implementation-confirmation passage, adoption is bound to occur. However, even when knowledge of an innovation is essential and compulsory, information alone is not enough nor does it always translate into adoption (Lionberger, 1960). There are other equally important factors that can help or inhibit innovation adoption.

Particularly, the adoption of new practices is affected by at least five factors: 1) socioeconomic characteristics of the adopting unit; 2) personality variables; 3) perceived attributes of the innovation; 4) nature of the client system; and 5) the extent of the extension agentsô effort (Lamble, 1984 *in* Rollins, 1993; Rogers, 2003). According to Rollins (1993) and Rogers (2003), a major function of extension agency/agents should be to facilitate adoption or to influence the level of innovation diffusion by their clients. But in order to effectively carry out this, extension agents must first understand the unique characteristics that describe their social system (Rollins, 1993; Sechrest *et al.*, 1998).

2.5. Factors affecting innovation adoption

Theoretical and empirical studies have shown how an individualôs innovation-decision is influenced by multi-interactive factors, such as demographics, socioeconomic, and psychosocial characteristics, innovation-specific characteristics, and variables of institutional context (Adesina & Zinnah, 1993; Agarwal & Prasad, 1997; Abadi Ghadim & Pannell, 1999; Rogers, 2003; Haider & Kreps, 2004; Hornik, 2004; Pannell *et al.*, 2006; Parminter, 2011).

In diffusion research, an individualôs innovativeness and socioeconomic status (including access to change agents) play a central role in becoming aware that an innovation exists in their social system (Agarwal & Prasad, 1998; Rogers, 2003; Hornik, 2004). That is, they can determine oneôs information-seeking behaviour (Agarwal & Prasad, 1998). However, even when an individual is enthused to acquire information and the information is readily accessible, some scholars have argued that its use can still be limited (Neelameghan, 1981; Wozniak, 1993; Opara, 2010). Without intellectual capacity and perhaps experience with previous innovations, individuals are less likely to understand information on innovation and so is adoption procedures (Wozniak, 1993; Opara, 2010). Hence, education and experience stretch oneôs intellectual capacity which enables more efficient gathering and interpretation of information (Wozniak, 1993; Abadi Ghadim & Pannell, 1999; Rogers, 2003). Thus, people who have more of the characteristics previously mentioned are more likely to adopt a new behaviour (Rogers, 2003; Hornik, 2004).

Once potential adopters become knowledgeable about an innovation, they develop unique perceptions towards it which, in turn, influence their adoption decisions (Rogers, 2003; Straub, 2009). Rogers (2003) posits that people with more favourable perceptions of the innovation are likely to adopt the innovation more rapidly. Even adverse perceptions toward an innovation,

however, can still be altered. Several models suggest change agents (Rogers, 2003; Haider & Kreps, 2004), learning by doing (Abadi Ghadim & Pannell, 1999), and social pressure/mandated versus voluntary use of innovation (Fishbein & Ajzen, 1975; Wejnert, 2002) as possible moderators of perceptions toward innovation.

Basically, DOI theory assumes that the extent of change agent effort in contacting potential adopters play a central role in the diffusion and adoption of innovations (Rogers, 2003; Haider & Kreps, 2004). It is, therefore, hypothesised that farmers who are in frequent contact with extension agents accumulate more information, and are more likely to have favourable perceptions toward ECDIs, thereby increasing their probability of innovation adoption.

Again, individualôs demographic situations (gender, age, family size and ethnicity) have a significant bearing on their decision to adopt innovation. Although people may become skilled with time, the physical strength of older people and how they view their world may as well shift, which might constrain innovation adoption (Mazvimavi & Twomlow, 2009). Besides, gender ï or age ï specific roles, as may be set by an individualôs societal culture, may on itself create labour shortages which, in turn, influence adoption of certain innovations (Loomis & Beegle, 1950; Sommers & Napier, 1993; Wejnert, 2002). In each case, it is suggested that people who have more or less of the characteristics are more likely to adopt a new practice. Similarly, Sommers and Napier (1993) argued that people who are from the same race/ethnic group tend to understand each other better than those who are of different descent.

The perceived attributes of innovations model assumes that the underlying characteristics of innovation inevitably affect the innovation ï decision process (Feder & Umali, 1993; Guerin & Guerin, 1994; Rogers, 2003). Based on these characteristics, some innovations easily get

adopted while others do not. Perceived compatibility, implementation cost, complexity, trial-ability and effectiveness are hypothesised as the characteristic of ECDIs, which could influence their level of adoption (Adesina & Zinnah, 1993; Rogers, 2003). Although it is acknowledged that preventive innovations may pose an adoption challenge due to their low effectiveness (Rogers, 2002), it is predicted that ECDI perceived effective in deterring crop-raiding elephants than the current practice, compatible with farmersô culture or past experience, ease to use and is cost-effective would be readily adopted than the other (Adesina & Zinnah, 1993; Rogers, 2003; Pannell *et al.*, 2006).

2.6. Theoretical Framework

The theoretical foundation of this thesis is rooted in Rogersô (2003) Diffusion of Innovations (DOI). Although the origins of DOI can be traced to Ryan and Grossôs (1943) study on diffusion of hybrid corn in two Iowa communities, the theory was formalised by Everett M. Rogers in 1962 in his first edition book, *`Diffusion of Innovations'* (Rogers, 1962). Diffusion describes the process through which new ideas, practices or objects are spread into and taken up by a social system (Rogers, 2003; Rogers *et al.*, 2005). This process includes both the planned and spontaneous spread of innovations (Rogers, 2003). For Rogers (2003), diffusion ñis a special type of communication, in that the messages are concerned with new ideasò (p. 5), here in this case, introduced elephant crop-raiding deterrent innovations (ECDIs). Rogers and Kincaid (1981) have argued that communication is a two-way process through which participants not only exchange information, but also create and share views on certain events, and this can either bring them together or drive them apart. Thus, diffusion is a dynamic learning process based on the constant interaction (both formal and informal information

exchange) of community members with a view to reaching a common understanding (Rogers, 1995; Abadi Ghadim & Pannell, 1999).

In addition, diffusion is also thought as a form of social change in that change occurs in the structure and function of a given community (Rogers, 2003). That way, invention, delivery, and adoption (or rejection) of new ideas impose change on an individual or the entire community (including decisions about ECDIs). DOI postulates characteristics of an *innovation*, the nature of *communication channels*, the *social system*, and the passage of *time* as critical elements of the diffusion process (Rogers, 2003).

***The Innovation*:** Rogers (2003) defined an innovation as ó an idea, practice or object that is perceived as new by an individual or other unit of adoptionô (p. 12). Perceivable newness of an innovation is more significant than itôs pre-existence within a population (Rogers, 2003). This embrace change in crop protection approaches, such as the use of chilli pepper and beehive fence to deter raiding elephants or a new idea of agricultural processing (Straub, 2009). DOI postulates that certain innovation characteristics predispose its adoption: relative advantage, compatibility, complexity, trial-ability, and observability (Rogers, 2003). *Relative advantage* is a perceivable profitability of a new idea or practice than its precursor (Rogers, 2003). It hinges on individualôs unique set of goals and the institutional, economic and social context where the innovation will be used (Pannell *et al.*, 2006). Thus innovations perceived to be better will be adopted more rapidly than others.

However, it is believed that relative advantage is a challenge for preventive innovations, such as chilli pepper and beehive fence. This is because preventive innovations are low in relative advantage (Rogers, 2002). *Compatibility* means ñthe degree to which an innovation is perceived

as consistent with the existing values, past experiences, and needs of potential adoptersò (Rogers, 2003, p. 240). Innovations that are in agreement with an individualôs belief systems or schema will be readily adopted. *Complexity* refers to how difficult to understand and use an innovation is (Rogers, 2003). Pannell *et al.* (2006) and Rogers (2003) reckon that complexity reduces innovationôs relative advantage, and ultimately its rate of adoption. On the one hand, *trial-ability* means the degree to which innovations could be tried out in small bits. Öhlmér *et al.* (1998) posit that trial-ability enhance adoption. Trial-ability of an innovation offers potential adopters the opportunity to find out how it works under their conditions (Rogers, 2003). In other words, trialling provides information that reduces uncertainty about the relative advantage of (Tonks, 1983), and the skills needed to apply the innovation (Pannell *et al.*, 2006).

Observability, on the other hand, ñis the degree to which the results of an innovation are visible to othersò (Rogers, 2003, p. 258). The observability of results from an innovation is positively related to adoption (Rogers, 2003), due to its influence on trial-ability (Pannell *et al.*, 2006). In addition, ñobservability leads to social thresholdð the point when an innovation becomes so pervasive in a culture that even those who would not normally adopt consider adoption of an innovationò (Straub, 2009, p. 631). Thus the relative advantage, compatibility, complexity, trial-ability and observability of an innovation may, singly or combined influence its adoption or rejection.

***Communication channels*:** To create understanding about an innovation, DOI theory proposes communication channels through which information is diffused. Mass media and interpersonal communication are conceptualized as the two key communication channels (Rogers, 2003) by which messages about new ideas or practices can be shared between innovation sources and its recipients. The theory as well claims that mass media channels (including television, radio,

opinion leaders and newspapers) are more pivotal at knowledge stage while interpersonal channels (between friends, neighbours, researchers, and so on) are significant at persuasion stage.

Even though Rogersô arguments are premised on the notion that mass media create awareness-knowledge and interpersonal networks are for behaviour change, Hornik (2004) is of the opinion that behaviour change can be influenced by any or no source, citing many other factors that can explain the same. Instead, Hornik (2004) buttresses deliberate organization of social networks where the primary purpose is to deliver a material productð distributional role than persuasive. Nonetheless, empirical evidence indicates that interpersonal communication networks are crucial influences in the adoption process (Benor & Harrison, 1977; Birkhaeuser *et al.*, 1991; Anderson & Feder, 2004; Parminter, 2011).

***Time*:** DOI theory is outlined through the context of time. The theory conceptualizes that some individuals adopt an innovation earlier than others, and that individuals have different personal characteristics that make them to adopt an innovation earlier or later than others (Rogers, 2003). It is in this light that Rogers (2003) categorized adopters into groups based on the relative amount of time it takes a group of people to adopt. This diffusion curve (also known as an S shape or normal curve) denotes that there is a small percentage of early adopters (at the beginning of the diffusion process), a large group of mainstream adopters (as diffusion proliferates), and finally a small percentage of late adopters, as the rate of diffusion slows down (Rogers, 2003; Straub, 2009).

Accordingly, based on the grouping, there are analogies in personality, socio-economic situations, and communication behaviour amongst the distinct adopter groups. Early adopters

tend to have higher socioeconomic status, venturesome, have higher upward mobility within their social culture, less dogmatic, have a more favourable attitude toward change, highly interconnected through interpersonal networks in their social system, intelligent and have more contact with change agents. However, personal innovativeness is not rigid, and equally applied to every adoption decision (Pannell *et al.*, 2006). Thus innovators (or early adopters) of one innovation may possibly be laggards of another innovation depending on, for example, perceived benefits in implementing the innovation.

***Social system*:** This refers to a community of individuals governed by certain elements and processes upon which the system relies for its perpetuity and sustenance (Loomis & Beegle, 1950). Elements such as roles, ranks, norms, mores, traditions, sanctions, facilities, and so on, and processes such as socialization, boundary maintenance, social-cultural or systemic linkage and communication serve as frameworks or scaffolding on which the society is built. Whether an individual who is a member of the social system adopts an innovation would depend on these key guidelines and components of the society.

Essentially, the spread of an innovation is postulated to end in its adoption (or rejection) by a target social system. But the decision whether or not to adopt an innovation is by no means a straightforward matter: it involves a series of actions, choices, and considerable evaluation of the innovation (Wilkening, 1956; Rogers, 2003; Parminter, 2011). Here, individuals engage considerably in information-seeking, discussion, analysis, and reflection over time before arriving at a particular adoption decision (Pannell *et al.*, 2006). According to Rogers (2003), there are five main stages in the innovation-decision processð a mental process through which an individual passes from first (1) *Knowledge* of an innovation, to (2) *Persuasion*, to a (3) *Decision*, to (4) *Implementation* of the new idea, and to (5) *Confirmation* of this decisionð and

that these stages have different conditions that can increase or decrease the likelihood of innovation adoption. The 5-Step process is explained below:

Knowledge occurs when an individual becomes exposed to the new idea and develops an understanding of it. The information sought here is assessed against the goals of the decision-maker (Pannell *et al.*, 2006) and determines the next course of action ï cessation or search for further information. This stage is believed to be influenced by an individualôs innovativeness, socioeconomic status, and access to external information (Midgley & Dowling, 1978; Hirschman, 1980; Rogers, 2003). *Persuasion* is when an individual gains further knowledge (from selected information sources) about the innovationôs salient characteristics (including cost of implementing the innovation, its compatibility, complexity, trial-ability, and effectiveness) to make a personal judgement, the result of which is a favourable or unfavourable attitude toward the innovation (Rogers, 2003; Straub, 2009). Here, perceived characteristics of innovations, social and information networks are all important influences on the probability of proceeding to the next stage (Adesina & Zinnah, 1993; Rogers, 2003; Berman, 2007).

At the *Decision* stage, an individual engages in activities that lead them to adopting or rejecting the innovation. Trialling of the innovation on a partial basis or evaluating trials of near-peers who have already adopted the innovation contribute substantially to adoption decision and skill development (Rogers, 2003; Pannell *et al.*, 2006). Thus trialling is a way of reducing uncertainty inherent with the adoption decision (Rogers, 2003). *Implementation* occurs when an individual puts the innovation into use. Unlike the mental evaluation of innovation associated with the preceding stages, implementation stage involves overt behaviour change as the innovation is put into practice (Rogers, 2003). Further trials done here are meant to confirm the innovationôs applicability. Also, the innovation may be modified (or re-invented) to fit the

adopterôs conditions (Rogers, 2003; Pannell *et al.*, 2006). At the *Confirmation* stage, an individual confirms their earlier decision to use the innovation or reverse it when they receive conflicting messages about the innovation or when trial results are not sufficient to justify continued use (Rogers, 2003; Haider & Kreps, 2004; Pannell *et al.*, 2006). Thus, previous experience and needs of the potential adopter are more likely to be important influences of decision at this stage.

The time of innovation adoption based on the DOI theory is premised on the notion that some individuals are endowed with greater innovative disposition, and will adopt an innovation earlier than those who are less predisposed (Rogers & Shoemaker, 1971; Midgley & Dowling, 1978). That is to say, some people adopt innovation relatively earlier than other members in a social system. However, an individualôs time of innovation adoption can also be influenced by the decision makerôs socioeconomic circumstances, their risk assessment, their beliefs about the benefits of adopting an innovation (such as preventing elephant crop-raiding), normative influence, and so forth (Pennings & Garcia, 2005; Pannell *et al.*, 2006). But the variance in adoption times between members of a given social system means that they can be organised into adopter categories depending on how long it takes for them to start using a new idea (Martínez & Polo, 1996; Rogers, 2003). According to the DOI theory, adopters fall into five categories: Innovators, Early Adopters, Early Majority, Late Majority, and Laggards (Rogers, 2003). Innovators are individuals who first try an innovation in a social system. People in this group are generally believed to be more venturesome, cosmopolite, educated, high risk-takers, have substantial financial resources, and are self-motivated (Rogers & Shoemaker, 1971; Rogers, 2003; Haider & Kreps, 2004). They are viewed as gatekeepers of an innovation to the group of people they lead.

In contrast, early adopters tend to be more integrated into the local social system (making them localites) than are innovators (who are highly cosmopolite) (Rogers, 2003). As well, they are typically well-educated people, though are relatively risk-averse under uncertainty as compared to innovators (Rogers, 2003). But due to the close relationships they have with peers, early adopters are usually respected in most social systems. As such, they seem likely to hold leadership roles and provide advice and information about an innovation to many in the social system (Rogers, 2003; Sahin, 2006). For this study, the researcher established that DWNP used VPC members as role models (or local informal opinion leaders) to diffuse and train other farmers on how to implement ECDIs. In general, VPCs were used to promote behaviour change: that is, adoption of ECDIs. In view of that, opinion leaders are influential members of a social system about a given subject-matter (Rogers, 2003; Tolba & Mourad, 2011). Thus, their perceptions and attitudes toward an innovation can play an essential role in influencing other individualsô view of the innovation or overt behaviour, especially that they are at the centre of interpersonal communication networks (Tolba & Mourad, 2011).

Members of the early majority typically adopt an innovation after the early adopters (Rogers, 2003). According to Rogers (2003), early majority have a lot of contact with other members of the social system but rarely occupy positions of opinion leadership. He, however, argues that early majority provide an important interpersonal network link in the diffusion process. Even so, early majority usually deliberate for some time and may require evidence of innovationôs effectiveness before completely deciding to adopt it (Rogers, 2003; Haider & Kreps, 2004; Sahin, 2006). Like the early majority, the late majority constitute one-third of the social system. Individuals in this category are typically skeptical about an innovation, have relatively scarce resources, and are thus reluctant to adopt until the innovation has been adopted by the majority

(Rogers, 2003). Here, adoption is mainly due to economic necessity and strong social pressure (Rogers, 2003). In overall, however, the late majority adopt an innovation largely because most of their peers have done so and feel the need to conform. Laggards are skeptics who adopt an innovation after a relatively long time when the innovation is possibly well established within the social system (Rogers, 2003). They tend to be the least educated, cosmopolite, have little, if any, opinion leadership, and their local circle of peers consist mainly of others of similar socioeconomic and social status (Rogers & Bhowmik, 1970; Rogers, 2003; Sahin, 2006). Because of their precarious economic position and limited contact with change agents (to be discussed next), laggards become extremely suspicious not only of innovations, but also of change agents, and they require the greatest evidence of innovationôs success before adopting it or they will adopt the innovation only when they absolutely have to (Rogers & Shoemaker, 1971; Rogers, 2003; Sahin, 2006).

As widely acknowledged, understanding the adoption process (which portrays an individualôs stage of change) is critical to effectively spread and gain innovation adoptions (Haider & Kreps, 2004; Kratochwill, 2005; Dearing, 2009). To this effort, the DOI theory stresses the importance of professional change agents (such as DWNP staff) in persuading target groups (via interpersonal channels of communication) to adopt an innovation (Rogers, 2003). In fact, much social change (such as the adoption of ECDIs) that is based on the DOI theory is due almost entirely to an externally applied force: that is, the change is induced by factors outside the targeted system, for instance change agents or mass media (Kincaid, 2004; McRoberts & Franke, 2008). This can be seen in how Rogers (2003) defines what a change agent is: ñan individual who influences clientsô innovation-decisions in a direction deemed desirable by a change agencyò (p. 27). Deducing from this definition, a change agent is an employee of a

certain organisation who initiates, facilitates or supports change in a community to which are external or operate in. Acting the script, attempts to mitigate human-elephant conflict (HEC), particularly crop-raiding in elephant hotspot areas of northern Botswana (such as the Okavango Delta) were initiated by and centralised in the DWNP. Thus, for this study, DWNP is the change agency and the extension staff working on its behalf and involved in the promotion of ECDIs among five rural communities in the eastern Okavango Panhandle (see Figure 3.1) are the change agents.

The DOI theory identifies seven main roles that a change agent need to perform in the process of introducing an innovation into a social system, which is to: (1) develop a need for change, (2) establish an information exchange relationship, (3) diagnose problems, (4) create an intent to change, (5) translate an intent into action, (6) stabilize adoption and prevent discontinuance, and (7) achieve a terminal relationship (Rogers, 2003). But the success of the change agent in achieving widespread adoption is contingent on the outreach efforts of the agent, their client orientation (as opposed to that of the agency they represent), program compatibility with clientsô needs, their empathy with clients, their degree of homophily with clients (the higher the social status, social participation, formal education and cosmopolitanism of the client, the better their interaction), their credibility in the clientsô eyes, their utilization of opinion leaders, and the development of clientsô skills to evaluate innovations (Rogers, 2003; Hartwich & Halgin, 2008).

In reality, change agents are rarely homogenous with their client system in terms of status and information endowments, and thus exhibiting an interaction that is mainly vertical and persuasive in nature (Dearing & Kreuter, 2010). Due in part to the heterogeneity between the two parties, ñé extension agents have limited power to influence farmers, because that

influence depends on farmersô willingness to trust the extension agentsô intentions and on the agentsô ability to help farmers achieve goalsò (Monge *et al.*, 2008, p. 15). As a consequence, change agents often use opinion leaders in diffusion activities, especially to jump-start the process (Rogers, 2003; Dearing, 2009). Here, the role of the change agent would be to influence the attitudes and behaviours of opinion leaders towards the new practice in a direction promoted. Agreed that opinion leaders have great influence on their peer-followers, are accessible, credible, and operate consistently across members in a local social system, it is presumed that a trickle-down effect will occur in their day-to-day interaction with other members (Wejnert, 2002; Rogers, 2003; Dearing, 2009). Therefore, identifying people that serve as sources of example, modelling, and advice within the adopting unit is very crucial for efficient and effective diffusion processes (Dearing, 2009). In the study area, DWNP used Village Project Committee (VPC) members in each trial community to diffuse and train other farmers on how to implement the mitigation measures. However, opinion leaders are there not to take on the role of change agents. Pereles *et al.* (2003) argued that the role of opinion leaders is an informal one, and asking them to advocate, persuade, promote, or educate their peers within the social system in ways they ordinarily would not is in some way formalising their role to that of change agents, thus risking their credibility within the system. But successful innovation diffusion and adoption demands change agents and opinion leaders to undertake collective concerted actions and efforts (Le Anh Tuan *et al.*, 2010).

Although the DOI theory is an important theoretical foundation for predicting and explaining innovation adoption in a social system, it is not without some concerns and criticism which are said to moderate its potential (see for instance, Hornik, 2004; Kincaid, 2004; Bucchi, 2008; Straub, 2009; White, 2009). According to Straub (2009), the theory is primarily descriptive

rather than prescriptive, and as such it does not tell how to facilitate adoption but rather how adoption occurs. Most importantly, the theory takes a more top-down approach which utilises expert input as determinant of social change in most social systems, leading to a pro-innovation bias (Kincaid, 2004). However, Sechrest *et al.* (1998) have argued that innovation strategies that involve stakeholders early on in the research and development (R&D) and transfer processes will create a synthesis between researcher, extension agent, and farmer knowledge that will better solve farmersô real problems. Thus the lack of participatory processes and appropriate engagement fora do engendered innovation diffusion failure and low adoption intensity s. This view is corroborated by Walker (2007). Notwithstanding the limitations just discussed, the DOI is useful when investigating factors influencing an individual (or organisation) to adopt (or reject) a new practice. The theory is handy in development practice where adoption of innovations will supposedly improve rural livelihoods and well-being.

2.7. Conceptual Framework

The conceptual framework (graphically illustrated on Figure 2.3) drew largely on Diffusion of Innovations (DOI) theory. Essentially, the theory stresses the factors influencing the decision an individual makes about an innovation during the adoption decision process. Thus, the factors and the interconnection between them was largely framed on Rogersô (2003) innovation-decision process. Based on the individual adoption-process, the current research model (in Figure 2.3) indicates that innovation adoption behaviour can be seen through an individual adopting or rejecting an innovation. Once adopted, the innovation is used continuously or discontinued at some point in time. But in the event that it is rejected, the innovation is forever rejected or is later adopted after further consideration.

According to this framework, a personôs adoption behaviour is a product of the characteristics of the social and innovation unit and normative pressures and beliefs. Taken together, characteristics of the social and innovation unit (such as certain variables of socio-economic, demographic, and psychosocial context, institutional factors, and innovation characteristics) interact between and amongst each other to influence a particular behaviour and performance, which is consistent with the innovation decision model proposed by Rogers (2003). The framework also assumes that adoption (or not) may be the result of increasing social normative pressure or relevant othersô belief that one should or should not perform such behaviour (Ajzen, 1991; Lozeau *et al.*, 2002; Rogers, 2003).

Normative pressure concerns what an individual óshouldô or expected to do by oneôs social network (Ajzen, 1991). That way, the individual conforms to group behaviour or what the group wants. In the same vein, normative beliefs are concerned with the probability that significant others will approve or disapprove execution of a given behaviour (Ajzen, 1985; Ajzen, 1991). As a consequence of this, performance of the behaviour is largely influenced by the judgment of influential people or groups. The current model assumes normative pressure and beliefs to come from informal opinion leaders (such as community leaders ï *dikgosi* and VPCs), social networks of individual farmers (including peers, family members, and so on) and from gatekeepers such as farmers who have already adopted ECDIs. Nonetheless, normative pressure and beliefs were not measured and taken into account in the analysis.

Besides, the framework postulates prior conditions (see Figure 2.3)ð which are location-based conditions already prevailing before introduction of innovationð to affect social and innovation related variables, which in turn, influence adoption behaviour. Adoption behaviour may be

sustained or discontinued. Individuals who may have initially rejected the innovation may later adopt it, thereby adding to the existing adopters.

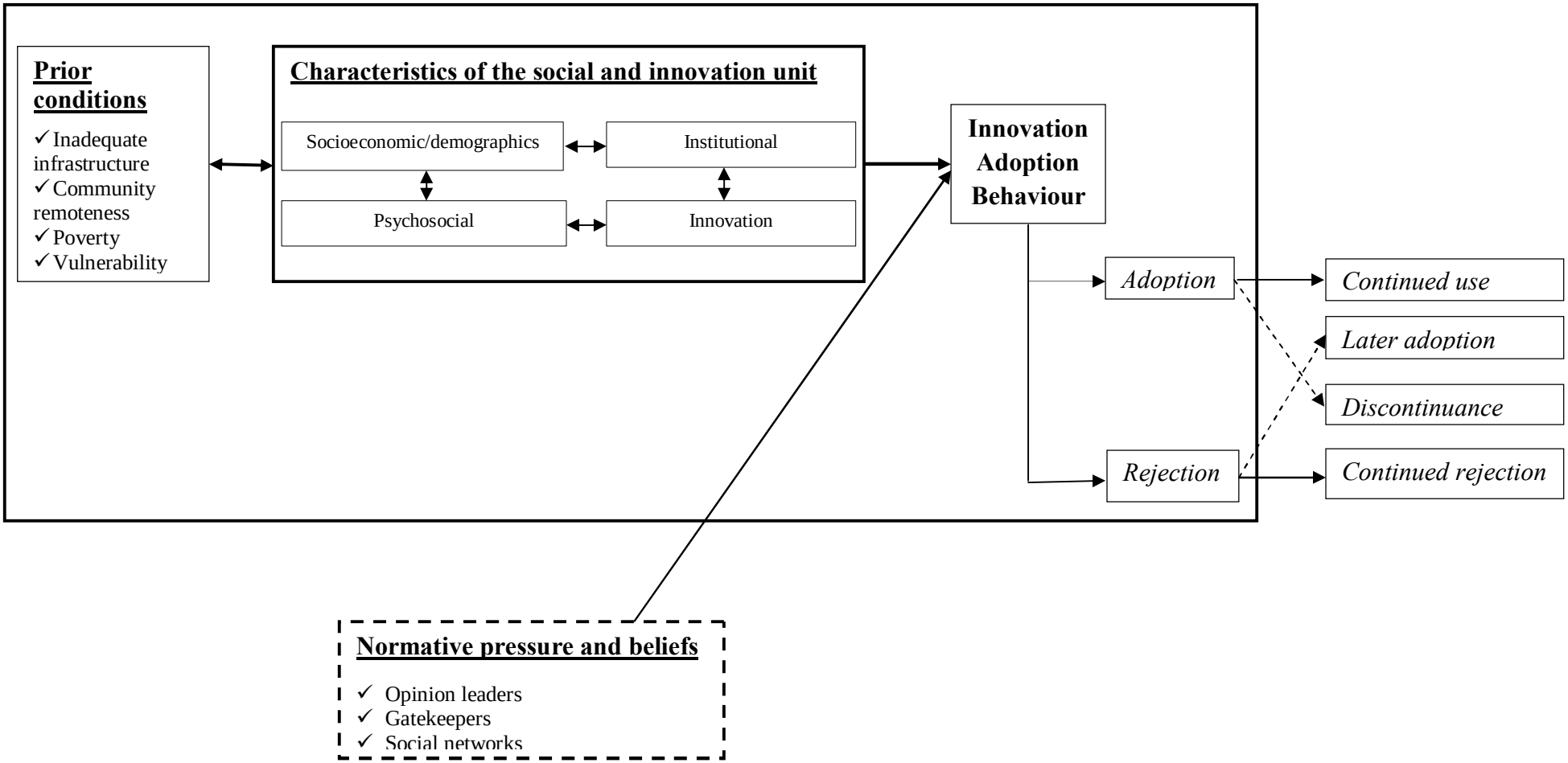

Figure 2.3: The innovation adoption framework

Source: Adapted from Rogers (2003).

CHAPTER 3

METHODOLOGY

3.1. Overview

This chapter describes the overall study area, and then discusses the study design and data analysis techniques that frame the study. Here, also the methodological issues are considered involving the concept of triangulating (or mixing) data sources in order to counterbalance inherent biases of a single method.

3.2. Study Area

The study was conducted in five villages of Gudigwa, Beetsha, Eretsha, Gunotsoga and Seronga within the Okavango sub-district (located in the Ngamiland district), north-western Botswana (Figure 3.1) between February and June, 2015. The district is famous for its rare inland Delta, the Okavango Delta (Ramberg *et al.*, 2006). The Delta is characterized by large bodies of open water that support a dazzling array of wildlife and vegetation species (Mendelsohn & el Obeid, 2004). The Okavango River which reaches the upper Okavango Delta (the Panhandle) from the upland plains of Angola is a vital source of livelihood for riparian community people (Kgathi *et al.*, 2006).

The 2011 national census documented 16,306 people in the Okavango sub-district (Central Statistics Office, 2011a), most of which live in villages and settlements spread along the Okavango River. Population sizes within studied sites range between 630 and 2700 people (see Table 3.1) of diverse ethnic groups and livelihood strategies. Gudigwa, which is the remotest village of the Okavango sub-district, is home to almost entirely BaSarwa (Taylor, 2002). Historically, BaSarwa were (and still are) hunter-gatherers (Taylor, 2002) who, because of the

disturbance of their traditional socio-cultural, economic and political lifestyles have since adopted new livelihood strategies, especially crop and livestock farming as well as wage labour in tourism (Mbaiwa, 2005). Conversely, Eretsha has two ethnic groups, the HaMbukushu and BaYei who pursue various livelihood activities, predominantly farming. Beetsha is composed mainly of HaMbukushu and bits of BaKgalagadi and BaSarwa, while Gonutsuga is home to the BaYei ethnic group. Seronga village, which can be described as the capital of the eastern side upper panhandle villages (of the Okavango sub-district) on the account of extra population and economic activities, is comprised of a combination of the above-mentioned ethnic groups.

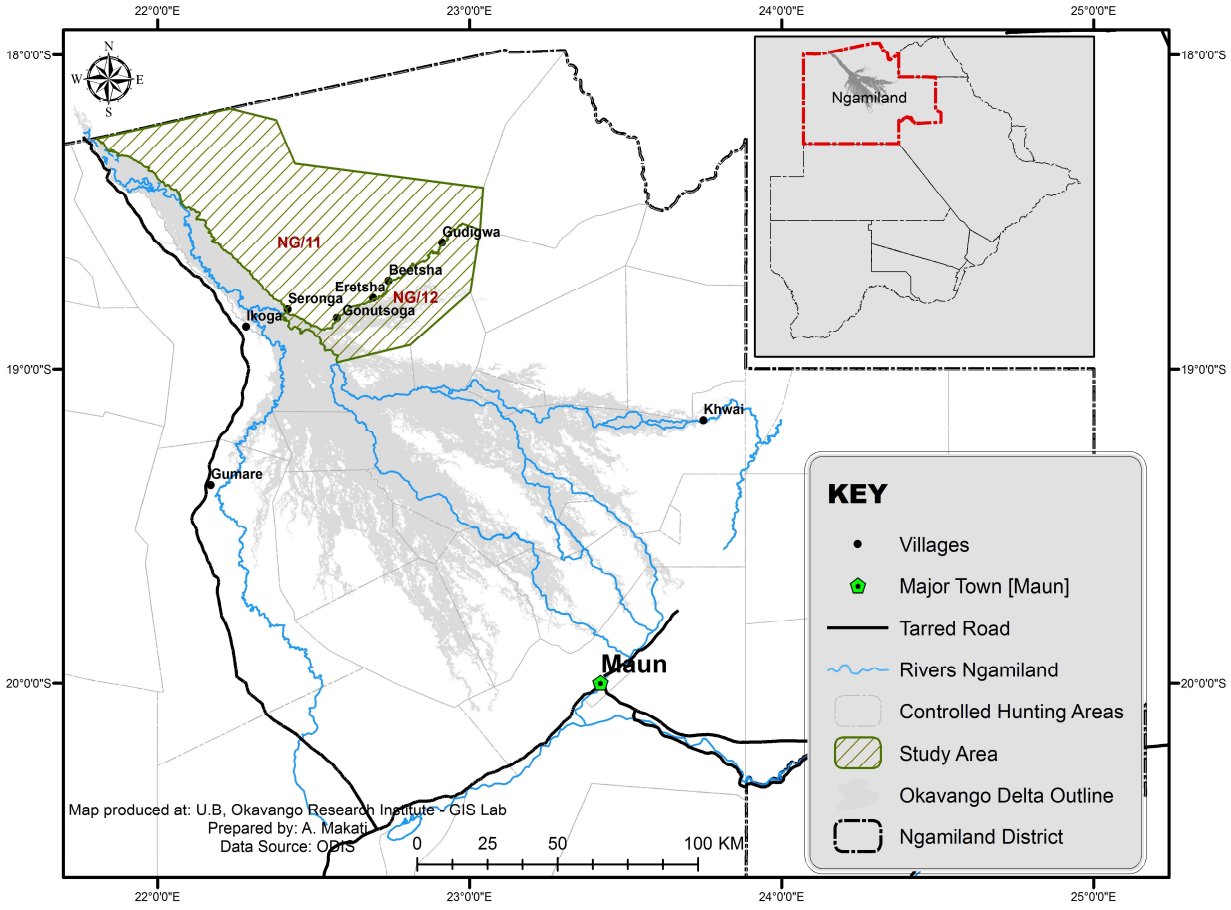

Figure 3.1: Map of the Okavango Delta showing study villages and elephant range (NG11 and NG 12)

Given the remoteness of the villages from towns and cities, and hence fewer economic activities, subsistence agriculture is thus central to their livelihood strategies (NPR, 2007; Motsholapheko *et al.*, 2011). Crop farming mostly occurs near or not far from the Okavango River (Tawana Land Board, 2005; VanderPost, 2009), with elephants roaming freely everywhere. As a result, subsistence crop farmers are always in conflict with crop-raiding elephants. According to Songhurst and Coulson (2014), this conflict may be due to that crop fields are constructed into or near elephantsô traditional pathways. However, wildlife censuses of 2011 (Chase, 2011) and 2012 (DWNP, 2012) show that elephant population of the Okavango Delta has increased from 14 000 to above 15 000 individuals, which further complicates the problem.

The recognition of the Okavango Delta as an elephant hotspot area (ODMP, 2002) together with the agreement by Kavango Zambezi Transfrontier Conservation Area (KAZA TFCA) member States to mitigate HEC in the region (Hanks, 2006) has put pressure on governments and wildlife managers to address the conflict. Thus, HEC have continued to receive attention in Botswana from the government, wildlife managers, and non-governmental organisations (NGOs). A series of initiatives has been underway in the Okavango Delta to address the conflict, particularly crop-raiding. Here, a research is needed to understand progress that has been made since the introduction of the ECDI initiative and what challenges and opportunities have been encountered. The studied communities were therefore selected based on their participation in a pilot project testing the effectiveness of introduced ECDIs in order to explore the adoption behaviour of subsistence farmers, and the factors that may be influencing their adoption decisions.

3.3. Research Design

This descriptive, cross-sectional survey investigated factors influencing adoption of ECDIs in five rural communities on the eastern side of the Okavango Delta Panhandle. The data collected relate to a specific point in time, obtained from multiple information sources (Berg, 2004; Johnson & Christensen, 2013). The study design was crucial to collecting a myriad of information within a relatively short time period, especially given the strict time and economic constraints within which the study was conducted (Levin, 2006). A mixed-methods *explanatory sequential* design was used to collect data, where quantitative data were collected first based on the hypotheses and DOI theory; after this, an in-depth qualitative data were gathered to explain (or connect to) the results of the former (Ivankova *et al.*, 2006; Wisdom & Creswell, 2013). In this thesis, priority was given to qualitative data collection and analysis based on the purpose of the study to determine and explain the factors that influence farmersô adoption decisions of ECDIs (Morgan, 1998; Ivankova *et al.*, 2006). The triangulated data provided stronger substantiation of concepts and hypotheses (Creswell & Plano Clark, 2007).

In the quantitative survey, the aim was to determine (selected) predictive factors influencing subsistence arable farmersô adoption or non-adoption of ECDIs. A structured interview schedule was developed—designed with close-ended and linked open-ended questions to complement each otherð for quantitative data collection. The core survey items reflected some composite variables, representing a range of intrinsic and extrinsic factors to farmerôs adoption of ECDIs: farmer demographic and socioeconomic background, their psychosocial characteristics, innovation-specific characteristics, institutional support services, and adoption of ECDIs. These factors were identified through the analysis of the related literature, diffusion-adoption theories

and/or models, particularly Rogersô diffusion of innovations (DOI) theory (Rogers, 2003), and a reconnaissance survey of the study area.

In the qualitative phase, the goal was to have a rich understanding of the meaning participants give to their experiences, feelings and perceptions about the matters being studied, in this case, factors influencing adoption or non-adoption of ECDIs in the study area (Creswell *et al.*, 2003; Charmaz, 2006). Typically, qualitative research is rooted in interpretive paradigm which ñé is concerned with how the social world is interpreted, understood, experienced, produced or constitutedò (Mason, 2002). It posits that each personôs reality is unique, providing unique insights into why they behave in the manner they do, and that the reality can be understood most effectively through or from the perspectives of that individual by observing them and/or listening to their accounts (Creswell *et al.*, 2003). Accordingly, interpretivism is based on naturalistic approach and as such, it strives to situate an investigator as close as possible to the researched in order to gain access to them and describe context-bound, personal experiences (Sullivan & Ebrahim, 1995; Gelo, 2012).

Agreed that different people, based on their lived experiences and their particular social positions, can interpret the same event or situation differently and act in conflicting ways (Sullivan & Ebrahim, 1995), multiple respondents were considered in this study to allow for comparison and contrast between them, and have a deeper and pluralist perspective about the investigated phenomenon (Meyer, 2001). Hence, data collection methods that get a researcher close to the researched, such as key informant interview, observation and focus group discussion (FGD) were used to elicit responses (Denzin & Lincoln, 2005). The use of multiple methods also increased the robustness of data and added rigor to the research towards addressing research

objectives (Creswell & Plano Clark, 2007; Bulsara, 2015). The obtained data were then used to explain quantitative data that were tested in the first phase (Creswell *et al.*, 2003).

3.4. Ethical considerations

Prior to the commencement of the research, community entry protocol was observed because it is a common practice in Botswana to consult and seek consent from community leadership such as village *dikgosi* before conducting any study in their area of jurisdiction. This was done in an effort to explain the purpose and goal of the study and to also build mutual understanding and trust with the people in order to motivate them to participate in the study and truthfully respond to research questions. Besides, individual consent was sought from all respondents (see informed consent in APPENDIX A), including explaining to them the purpose and why they were requested to take part in the study. Moreover, respondents were informed that their participation was voluntary and were free to withdraw from it anytime they felt so without necessarily having to give explanation. Overall, the studyôs protocol was approved by the Ministry of Environment, Wildlife and Tourism, and by the Ethics Committee of the University of Botswana.

3.5. Sample design and selection

In selecting the samples in the study area, the concepts of target (or theoretical) population, accessible population and selected sample were utilised. Gliner and Morgan (2000) defined theoretical population as all participants of theoretical interest to the researcher and to which they would like to generalise, while accessible population is a subset of the target population and provides a sampling frame or is the population from which a sample can be drawn. Conversely, selected sample refers to a group of participants selected from the accessible population (Gliner & Morgan, 2000). Drawing upon these descriptions, the entire population of the eastern Okavango Delta Panhandle served as the theoretical population. The people are frequently in

conflict with wild animals, particularly elephants (NPR, 2007; Songhurst, 2012; Songhurst & Coulson, 2014). Furthermore, majority of the people living on the eastern fringes of the Okavango Panhandle are relatively poor (about 47.3% live below poverty datum line), where up to 29.3% of the population is unemployed (Central Statistics Office, 2011b). And thus subsistence agriculture is an important and widespread livelihood strategy in the area (NRP, 2006; Motsholapheko *et al.*, 2011).

The accessible population comprised five villages participating in a pilot project initiated by the Department of Wildlife and National Parks (DWNP) aimed at testing the efficacy of chilli pepper and beehive fence in preventing elephant crop-raiding. A multilevel sampling design was used to select more samples/sub-samples from the accessible population and compared their responses on the factors influencing adoption of ECDIs in the study area (Onwuegbuzie & Leech, 2007). The sampling design typically uses probability and purposive sampling techniques on different levels of the study [such as subsistence arable farmers, village project committee (VPC) members and professional extension agents] (Onwuegbuzie & Collins, 2007). This thesis focused on an individual arable farmer and was as such used as unit of analysis. However, due to the lack of farmerôs associations and/or difficulty in accessing farmer database in the study area, households were used as ópoint of entryôto the individual arable farmers. Thus, the 2011 national census enumeration area (EA) maps were used to verify the number and location of households in the villages. A list of all households in each of the study villages was compiled. Then the total number of listed households for each of the villages was used to calculate the sample size (see Table 3.1).

Table 3.1: Population size, and the number of listed and sampled households by location

Village	Population size	Number of listed households	Number of selected households at 30%
Seronga	2,674	608	182
Gunotsoga	635	144	43
Eretsha	720	164	49
Beetsha	941	214	64
Gudigwa	725	165	50
Total	**3,864**	**1,487**	**388**

Source: Central Statistics Office (2011a)

From the list of all households in the individual villages, a total simple random sample of 388 arable farmers was drawn at 99% confidence level and with a margin of error of 4.47. The required sample size in each village was the equivalent of 30% of the accessible households. According to Balnaves and Caputi (2001), Social Science research typically considers a sample size of 5% to be sufficient to perform basic statistical analysis.

Also, additional cases were added to explore further important quantitative results obtained through interview schedules as well as to rival explanations (Devers & Frankel, 2000). Thus, a critical sample involving 10 male and female arable farmers (five for each) with órich experienceô and strong opinions toward ECDIs (Marshall, 1996b) was organised to participate in focus group discussions (FGDs). The sample was identified through the help of village project committee (VPC) members in each village.

Furthermore, a key informant sample comprising two DWNP staff and five VPC chairpersons from the respective study communities were purposively selected for the survey. This set of people, known as key informants, are believed to have particular knowledge or expertise regarding the deterrent innovations being promoted (Marshall, 1996b), and they also occupy special positions of responsibility and influence in their communities or those in which they operate (Marshall, 1996a). DWNPôs problem animal control (PAC) unit is the implementing or

extension agency, and its staff who are in charge of implementing the pilot project at local level have the onus of pushing the adoption of ECDIs (World Bank, 2009). Of the two PAC unit staff, one is the project coordinator based in Maun DWNP office, while the other is based in the Seronga office and is the project leader (or focal person) in the study area.

On the other hand, VPC chairpersons (and the entire committee members) have influence on the implementation of the mitigation measures, especially given that the committees were set up with the mission to diffuse ECDIs and train other farmers on their proper implementation. And because they are part of the affected communities, VPC members have strong social ties with the rest of their community members, and thus can greatly affect adoption decisions of ECDIs (Pereles *et al.*, 2003; Dearing, 2009). Essentially, VPC chairpersons offered juxtaposition of extension agentsô perceptions.

3.6. Reliability and validity tests of the instruments

A reconnaissance survey was first carried out in December 2014 with a view to ensuring adequate planning and informed decision-making to guide and improve the main survey efforts (Denzin & Lincoln, 2005; Creswell & Plano Clark, 2007; Creswell, 2013). Overall, the preliminary information obtained was used to construct valid questions in the interview schedule, key informant and FGD guides. Besides, the content and adequacy of the interview schedule, key informant and FGDs guides were judged by a panel of experts in social sciences at the Okavango Research Institute before data collection.

Alternatively, internal consistency of the different multi-item scales measuring the constructs perception, fatalism and risk-aversion tendencies were checked using Cronbachôs coefficient alpha (Cronbach, 1951; Peterson, 1994). It defines the extent to which items in the scale hang

together (Cicchetti, 1994). In each case, farmers were asked to rate their level of agreement (approval) or disagreement (disapproval) against a set of survey items measured on a 5-point Likert-type scale (Likert, 1932). This was important in reducing the somehow unreasoned and dishonest responses. The scales composed of eight (8) Likert items as expressed in the literature, and were equally constructed as favourable and unfavourable towards each constructs. For the scale to be internally consistent, Cronbachôs coefficient alpha should be equal to .70 or above (Cicchetti & Sparrow, 1990: In Cicchetti, 1994).

Even so, there is still controversy around the ideal estimates of alpha for scales used in behavioural sciences. Streiner (2003) argued that attainment of high values of alpha do not guarantee internal consistency. As he contended, test length can affect internal reliability of a scale. Thus, scales with 20 items or more are bound to meet internal consistency (Streiner, 2003). All things considered, Cronbachôs coefficient alpha values of 0.60 and above were accepted for this study. In checking for the internal reliability for each multi-item scale, the Cronbachôs coefficient alpha on perceptions about chilli pepper and beehive fence are 0.70 and 0.74, respectively. While test for internal consistency for risk-aversion produced an alpha value of 0.61, it was 0.64 for fatalism.

3.7. Variables and measurement

Using the existing theoretical and empirical models of innovation diffusion and adoption, a deductive approach of scale development was used (Clark & Watson, 1995; Getty & Thompson, 1995). Deductive approach suggests, based on theory and/or conceptual framework, relationships between concepts under study (Getty & Thompson, 1995). As such, items to a new scale (each of which represent a single concept/construct to be examined) should be derived from pre-existing scales which have been validated both theoretically and empirically (Adger *et al.*, 2004). In light

of this, instrument scales and the research items that constituted them were drawn from innovation-diffusion-adoption literature (Likert, 1932; Adesina & Zinnah, 1993; Abadi Ghadim & Pannell, 1999; Boahene *et al.*, 1999; Rogers, 2003; Haider & Kreps, 2004; Graham & Ochieng, 2008; Singha *et al.*, 2012; Ovwigho, 2013) from which sixteen predictor variables were then selected (see Table 3.2).

Information to be collected was characterised in four categories in accordance to Singha *et al.* (2012) being: (a) farmersô demographic and socio-economic status (i.e., age, gender, family size, education level, income, and contact with extension personnel, cosmopoliteness and land holding); (b) psychosocial variables (such as perceptions, fatalism and risk-aversion); (c) institutional variables (i.e., government support, extension capacity and extension delivery strategies); and (d) innovation characteristic (Table 3.2).

As regards perceived characteristics of ECDIs, farmersô responses on innovation compatibility, cost of and complexity in implementation, trial-ability, and effectiveness were measured on a three-point rating scale in which 1 on the one end indicated an unfavourable perception, and 3 on the other end represented a favourable perception. On the contrary, farmersô psychological disposition relating to risk-aversion, fatalism and perceptions about the use of chilli pepper and beehive fence as ECDIs were measured using a five-point Likert scale (see Table 3.2). As such, the scale measured the level of approval or disproval, agreement or disagreement to the subject-matters.

Table 3.2 Variables and their measurement

Age	Grouped into age categories with order e.g., 20-29, 30-39, and so on
Gender	Which is a dummy variable, was assigned 0 for male and 1 for female
Family size	Number of relatives who depend on the farmer for their livelihood. It measured the level of social obligation that the farmer has to meet
Ethnicity	Ethnic group to which the farmer belongs
Education	Highest level of formal education
Income	Amount of the farmerôs income (from arable farming and non-arable farming activities)
Contact with extension agents	Number of times the farmer was visited by extension agent per quarter
Cosmopoliteness	The number of times a farmer has travelled out of his/her immediate community to other communities, towns or cities to seek for agricultural information in the last 5 years
Land holding	Yes or No dichotomy
Fatalism	An individual's affinity towards resignation to fate, which was be measured on a 5-point Likert scale type
Risk-aversion	The tendency of an individual not wanting to dabble into some new and unknown ventures, which was measured on a 5-point Likert scale
Perception	Evaluative response on feelings, opinions, etc. towards deterrent measure measured on a 5-point Likert scale type
Government support	It was measured using open ended and close ended questions and measured the commitment by government in extension services.
Extension capacity	Number of available extension personnel, measured by Yes or No dichotomy to assert or decry the manpower
Extension delivery strategies	Mode of innovation dissemination
Institutional relations	It was measured using open ended and close ended questions
Innovation characteristics	3-point scale of innovation characteristics in terms of their effectiveness, trial-ability, cost, compatibility & complexity
Adoption status (or behaviour)	A farmersô adoption behaviour was measured using an adoption index: which is the number of innovations adopted by the farmer divided by the number of innovations introduced to him or her by the Extension agency. Thus, a farmer who adopted both the ECDIs was given an index of 1, while those who adopted only one had an index of 0.5. Farmers who had not adopted any at all had an index of zero.
Adoption level	Measured by the total number of adopters

3.8. Data collection

Overall data collection was two-fold: relevant literature, official statistics and Web information as well as government reports served as secondary data. Such data served as the foundation upon which the current study was built. On the other hand, structured interview schedules, key informant interviews, focus group discussions (FGDs) and field observations were used as the methods of primary data collection. In this study, primary data collection was conducted in two phases. Phase one involved a reconnaissance study and the latter dealt with the main survey in which data collection was subsequent. The reconnaissance study was carried out to develop initial insights, guide and improve the main data collection efforts (Denzin & Lincoln, 2005; Creswell & Plano Clark, 2007; Creswell, 2013). Discussions with two staff members from DWNP and *dikgosi* from the rural communities, which were studied, provided useful insights on the introduction and adoption of the mitigation measures. The outcome of the reconnaissance study was used to construct valid questions in the research instruments (i.e., interview schedule, FGD and key informant forms) for the in-depth survey. Next, a full survey comprising a comprehensive quantitative and an in-depth qualitative data collection was undertaken between February and July 2015.

Quantitative data collection, which involved the use of a structured interview schedule ï consisting of a series of closed-ended and linked open-ended questions, was conducted in the villages of Gudigwa, Beetsha, Eretsha, Gunotsoga and Seronga. The interview schedule was directly administered to all selected subsistence arable farmers by the researcher and two trained field assistants based at the University of Botswanaôs Okavango Research Institute. In line with the study objectives, the interview schedule comprised several, logically arranged sections which sought data on farmersô demographic and socio-economic background, their psychosocial

characteristics, innovation characteristics and institutional factors as well as farmersô adoption status of ECDIs. The data, which were mostly quantitative in nature, were used to determine the frequency of ECDIs adoption among the selected farmers, and for determining relationships between outcome and predictor variables (Aaker *et al.*, 2000).

Subsequent to the quantitative survey, qualitative survey was conducted. Although quantitative data can be handy in establishing relationship between the variables of interest, they are not adequate in understanding the way social realities are perceived by an individual, such as the behaviour of farmers in relation to ECDIs (Matveev, 2002). Qualitative methods, such as key informant interviews, FGDs and observational fieldwork, are believed to provide a ódeeperô understanding of social phenomenon, like peopleôs subjective experiences (Sofaer, 1999; Creswell *et al.*, 2003; Charmaz, 2006). These qualitative methods were, therefore, used to elicit rich, detailed qualitative data to be used in explaining data collected through quantitative survey (Morgan, 1998). Key informant interviews draw on the knowledge of subject-matter experts or people with first-hand knowledge on a particular subject, in this case, adoption of ECDIs in the Okavango Delta, Botswana (Huber & Power, 1985; Kumar, 1989; Marshall, 1996a). In this study, a total of 12 key informant interviews were held with extension agents from DWNP and some community leaders such as *dikgosi* and VPC chairpersons within the study area. In order to allow for in-depth investigation of issues as they arise in the interview, a semi-structured interview guide (see APPENDIX B ï 2) was used in collecting the data.

In addition to key informant interviews, five FGDs, one per community were conducted. The group discussions were held with purposively selected farmers who used chilli pepper or beehive fence or both to collect supplementary qualitative information on their views, experiences and beliefs on the introduced ECDIs, factors that influence their adoption of these innovations, as

well as their response to the role of DWNP in facilitating adoption of the innovations. The farmers were potential sources of rich information on these matters. Each FGD comprised 10 participants [5 males, 5 females]. According to Kitzinger and Barbour (1998), the discussion is focused because there is collective action by group members, such as debating a set of issues on the factors affecting delivery and adoption of ECDIs. In this way, group members bring to the discussions different perspectives, opinions, and understanding (Kitzinger & Barbour, 1998). Essentially, group interaction is the central component of FGDs and is used by the researcher to trigger thoughts and ideas among participants that could not emerge during individual interviews (Kitzinger & Barbour, 1998; Kress & Shoffner, 2007). In view of the diversity in discussantsô personalities, clear explanations of the purpose of the focus group were made just before discussions started to help participants to feel at ease, and thereby facilitating interaction between the group members (Kress & Shoffner, 2007; Vicsek, 2007).

Again, to circumvent possible dominance of one participant over others, discussants were given equal chance to speak, and those who appeared too quiet were motivated to provide their viewpoints on the topical issues raised (Vicsek, 2007). Open-ended questions were used to promote unrestricted but guided discussions among participants (Kress & Shoffner, 2007). A FGD guide was used to provide direction for the moderator during the discussions. All FGDs and key informant interviews were audio-recorded and transcribed verbatim (Dezinl and Licoln, 2003).

Interviews (with key informants, individual farmers and in FGDs) were complemented by detailed field observation notes written by the researcher, during and immediately after each interview. It involved documenting respondentsô behaviour and activities at their homes and crop fields. Also, the social, economic and institutional contexts in which the survey data were

produced were recorded to further contextualise respondentsô representation of ECDIs adoption behaviour. These data served as a check against respondentsô subjective reporting of what they believe and do as well as understanding the complexity of their behaviour and experiences (Mack *et al.*, 2005).

3.9. Data processing and analysis

Primary data collected through interview schedules were coded, entered, cleaned and screened for errors before beginning analysis. Data coding was done directly on the interview schedule (or pre-coded, except for open-ended questions which required post-coding), and it involved identifying, classifying and assigning numbers to each of the possible responses (Stinson *et al.*, 1996). Once qualitative data from key informant interviews, FGDs and observations were collected, the researcher read through all the responses and identified common themes in relation to factors influencing adoption of ECDIs; developed coding categories for the different themes identified, listed at least one category under each response, and assigned a number to each (quantifiable data) (Bradley *et al.*, 2007; Liamputtong, 2009). Subsequently, the data were entered into a spread sheet for IBM SPSS Statistics 24 computer programme. The data were then cleaned and screened.

Data cleaning and transformation were done manually (directly on the interview schedules) and/or by statistical software (i.e., SPSS) through analyses of the distribution (frequency of values) for each variable (Rahm & Do, 2000). Hence, duplicates, missing responses, miscodes, and outliers were detected and corrected. After that, normality checks [by both visual inspection of the frequency distributions (histograms) and Kolmogorov-Smirnov (K-S) test] were performed to ascertain whether the data meet the requirements for using parametric tests (Field,

2009; Tabachnick & Fidell, 2014). However, the assumptions for normality were found not tenable.

As a consequence, non-parametric tests such as logistic regression and Pearsonôs chi-square of independence were used to determine the relationship between adoption of ECDIs and farmersô demographical, socio-economical and psychosocial characteristics, as well as innovation-specific and institutional characteristics. In other words, the statistics were used to model farmersô decisions to adopt the mitigation measures. Several descriptive statistical analyses, such as frequencies, mean and mode, charts, and so forth were conducted to describe and summarise the data. The dependent variable was collapsed into a binary (or dichotomous) variable due to insufficient data on beehive fence and ódual adoptionô of the ECDIs (totally 0.8%). Thus, a farmerôs decision on ECDIs implementation was connoted as a discrete choice of whether they had adopted any of the ECDIs or did not at all. Accordingly, a õYesô response (indicating adoption) was assigned 1 point, while a ñNoò response (for non-adoption) was assigned 0 points. Testing of all the assumptions underlying the use of both the statistics (i.e., logit model and chi-square test of independence) were done before conducting them.

The digitally recorded FGDs and key informants interviews were transcribed and translated verbatim into English after repeatedly listening to the recordings. Using thematic analysis, themes (or patterns) within the qualitative data were identified (Braun & Clarke, 2006; Liamputtong, 2009). In this thesis, generation of themes within the qualitative data were interactive, that is, it took into account the relationship between theoretical knowledge and the research process (Braun & Clarke, 2006). Thus, themes were mapped to the DOI theory (Boyatzis, 1998) and analysed by using interpretive approach to understand the underlying processes that shape and give meaning to farmersô adoption behaviour towards ECDIs

implementation (Jonassen, 1991; Creswell *et al.*, 2003). And although interpretation of the relevant experiences, opinions and perspectives of respondents were based mostly on their prevalence as ómeasuredô by the number of different speakers who articulated them, attention was also focused on responses that provided pertinent and allusive information to uncovering the factors influencing farmersô adoption behaviour (Braun & Clarke, 2006).

CHAPTER 4

RESULTS

4.1. Overview

This chapter presents data analyses results pertaining to the factors influencing adoption of elephant crop-raiding deterrent innovations in the Okavango Delta of Botswana. It does so by providing conclusions to fundamental research hypotheses that shaped the study, namely: (1) There is no significant relationship between farmersô demographic and socio-economic attributes and the adoption of ECDIs; (2) There is no significant relationship between farmersô perceptions about ECDIs and the adoption of these innovations; (3) There is no significant relationship between institutional factors and the adoption of deterrent innovations; and (4) There is no significant relationship between ECDIs characteristics and their adoption by farmers. But first, the chapter begins by giving an outline of descriptive statistics, after which inferential data which tested the previously mentioned hypotheses are presented.

4.2. Socio-economic and demographic characteristics of farmers

In sum, 388 subsistence arable farmers from five rural villages on the eastern side of the Okavango Delta Panhandle, Botswana participated in the study. Majority (59%, n = 228) of the farmers were females (Table 4.1). Over half (52%) of the farmers were aged 50 years and above, with the highest age category of 60 years and above accounting for the highest proportion (33%) among all categories (Table 4.1). As seen in Table 4.1, the age category of 60 years and above appears most frequently. A few (18%) of the farmers have completed post-primary education, but 49% (n = 188) had not attended school at all. Farmersô family sizes were mostly between 2 ï 5 members and 6 ï 9 members, accounting for about 40% apiece. The mean family size was 7

persons (SD = 3.09) (Table 4.1). The majority of the farmers (~73%) had contact with extension agents only once per quarter, with very few (1%) meeting them always (Table 4.1). Regarding cosmopoliteness, about 90% (n = 349) of the farmers had never gone outside their immediate communities to seek agricultural information, but 0.5% (n = 2) had indicated to have sought for agricultural information more than five times in other localities or communities (Table 4.1).

Table 4.1 Demographic and socio-economic characteristics of the surveyed farmers

Variable	Item	Frequency	%	M (SD)
Gender	Male	160	41.2	
	Female	228	58.8	
Age	20 ï 29 years	29	7.5	
	30 - 39 years	85	21.9	
	40 - 49 years	73	18.8	
	50 - 59 years	74	19.1	
	60 years and above	127	32.7	
Education	None	188	48.5	
	Primary	38	9.8	
	Secondary	87	22.4	
	Tertiary	71	18.3	
Family size	Only one person	8	2.0	6.55 (3.09)
	Between 2 and 5 members	145	37.0	
	Between 6 and 9 members	177	46.0	
	Above 9 members	58	15.0	
Monthly income	BWPÒ100	192	49.5	
	BWP101 ï 500	127	32.7	
	BWP501 ï 1 000	46	11.9	
	BWP1 001 ï 5 000	23	5.9	
Contact with extension agents	Once/quarter	283	72.9	
	Twice/quarter	91	23.5	
	Thrice/quarter	10	2.6	
	Always	4	1.0	
Cosmopoliteness	Never	349	89.9	
	1 ï 2 times	34	8.8	
	2 ï 3 times	3	0.8	
	More than 5 times	2	0.5	

Source: Field survey 2015.

Most farmers (50%, n = 192) earned a monthly income of between BWP0 ï 100, with the highest monthly income in the range of BWP1001 - 5000. The modal income category was BWP0 ï 100.

In terms of ethnic groups, approximately 44% (n = 172) of the farmers identified themselves as BaMbukushu, almost 39% (n = 150) were BaYei, while 14.7% (n = 57) of them said they were BaSarwa (see Figure 4.1).

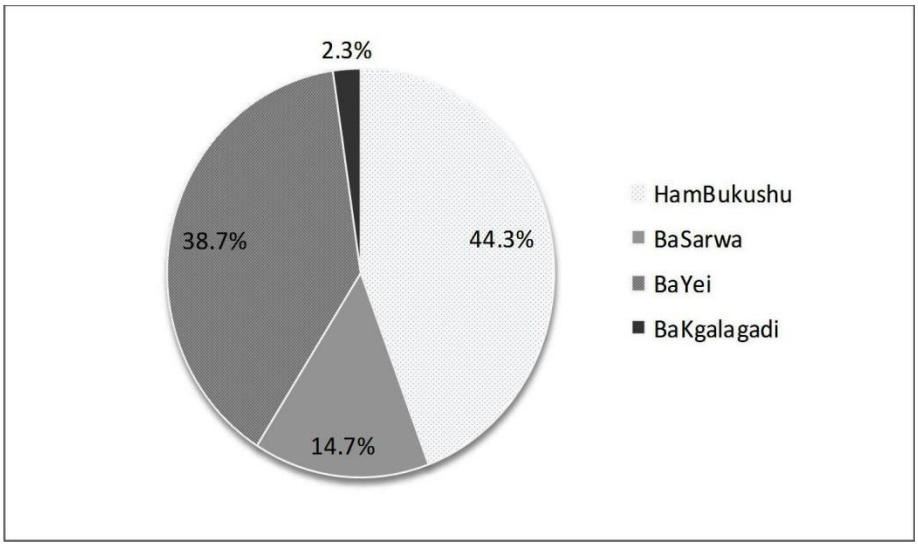

Figure 4.1: Relative proportions of farmers by ethnic groups

Seventy-five percent (n = 291) of the respondents owned arable land. The remaining respondents borrowed land from family members or neighbours during farming seasons (25%, n = 97) (Figure 4.2).

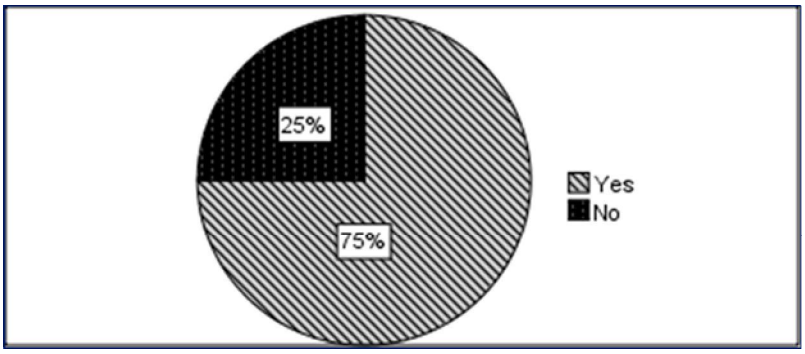

Figure 4.2: Proportion of farmers by land holding status

4.2.1. Test of Hypothesis 1

The study examined the relationship between a farmerôs adoption of ECDIs and his or her (selected) demographic and socio-economic variables. It was hypothesised that farmerôs gender, age, family size and ethnicity had no significant relationship with his or her decision to adopt ECDIs. Binary logistic regression was conducted to test the hypothesis, subsequent to verifying key assumptions underlying the analysis.

The logit model was statistically significant, χ^2 (6, N = 388) = 39.16, p = 0.00, indicating that the model was a good-fit for the data. In sum, the predictors accounted for 74% of the variance in the likelihood to adopt ECDIs, but with only ethnicity being statistically significant (Table 4.3). However, adoption frequencies are statistically significantly different only between BaSarwa and BaHambukushu. The log of the odds for a farmer of BaSarwa descent was negatively and significantly related to adoption of ECDIs (p = 0.000). BaSarwa were 0.15 times less likely to adopt ECDIs than BaHambukushu (Table 4.2).

Table 4.2 Logistic regression of farmersô demographics on the likelihood to adopt ECDIs

Predictor	**β**	**Wald**	***df***	**P-value**	**Odds Ratio (95% CI)**
Constant	0.95	4.08	1	0.04	2.57
Gender	0.02	0.01	1	0.93	1.02 (0.64, 1.63)
Age	ï 0.03	0.14	1	0.71	0.97 (0.82, 1.15)
Family size	0.06	2.41	1	0.12	1.06 (0.98, 1.15)
Ethnicity		34.23	3	0.00	
BaSarwa	ï 2.84	31.36	1	0.00	0.15 (0.08, 0.29)
BaYei	ï 1.20	0.97	1	0.33	0.77 (0.47, 1.29)
BaKgalagadi	ï 0.10	0.61	1	0.44	2.32 (0.28, 19.28)
(Base = BaHambukushu)					

Source: Field survey, 2015. *Note:* Cox & Snell R^2 = .10. Nagelkerke R^2 = .14

In the same way, logit model was fitted to the data to test the hypothesis that farmersô socio-economic characteristics had no significant relationship with their adoption of ECDIs. So the predictor variables were farmersô income, education, and contact with extension agents, cosmopoliteness and land holding. The logit model significantly predicted the probability of adoption, χ^2 (5, N = 388) = 18.58, p = 0.002, suggesting that the model is a good-fit for the data.

According to the model, the log of the odds of a farmer adopting ECDIs was negatively and significantly related to income (p = 0.019), and positively and fairly significantly correlated to education (p = 0.036) (Table 4.3). In other words, the higher the income, the less likely it is that a farmer would adopt ECDIs. Farmers who were in higher income categories were 0.74 times less likely to adopt deterrent innovations than those in lower ones. Furthermore, the probability of a farmer adopting ECDIs was higher than that of a farmer with lower education level. This statement is also confirmed by the positive coefficient (0.21) associated with the education. However, a farmer with higher education level is only 24% (or 1.24 times) likely to adopt ECDIs than a lower educated farmer (Table 4.3).

Also, the log of the odds of a farmer adopting ECDIs was negatively and significantly correlated to land holding (p = 0.014). That is to say a farmer who is without arable land would not adopt ECDIs or those that have borrowed from family members are less likely to implement the deterrent innovations. Thus farmers without or with borrowed arable land were 52% (or 0.52 times) less likely to adopt ECDIs. Hence broadly, these findings implied that some socioeconomic characteristics of farmers contributed significantly to the probability of adopting ECDIs. The presence of significant predictors meant that the hypothesis that farmersô socioeconomic characteristics have no significant relationship with adoption of ECDIs is in part not supported.

Table 4.3: Logistic regression of farmersô socio-economic characteristics for predicting their likelihood of adopting an ECDI

Predictor	**β**	**Wald**	***df***	**P-value**	**Odds Ratio (95% CI)**
Income	ï 0.30	5.50	1	0.02	0.74 (0.58, 0.95
Education	0.21	4.42	1	0.04	1.24 (1.01, 1.51)
Contact with extension agents	0.14	0.37	1	0.54	1.15 (0.73, 1.80
Cosmopoliteness	0.68	2.73	1	0.10	1.98 (0.88, 4.46)
Land holding	ï 0.66	6.05	1	0.01	0.52 (0.31, 0.88)
Constant	0.16	0.09	1	0.77	1.18

Source: Field survey, 2015

Note: Nagelkerke R^2 = .07.

4.3. Farmers' psychosocial characteristics

4.3.1. *Farmers' perceptions about the use of ECDIs*

The grand mean score for farmersô perceptions toward chilli pepper was 3.59 (SD = 0.69). As favourable perceptions are accorded the higher points on the Likert scale, the relatively high average value for the perception of chilli pepper meant that farmers would favour its usage as an

ECDI, all other things being equal. With regard to chilli pepper effectiveness, approximately 69% of the farmers affirmed that the innovation was effective in deterring raiding elephants, while 28.6% thought otherwise (Figure 4.3). Over 80% and approximately 54% of the farmers opined that ǒThe procedure for adopting chilli pepper innovation is clear and understandableé ô and that the innovation is not expensive implement, respectively.

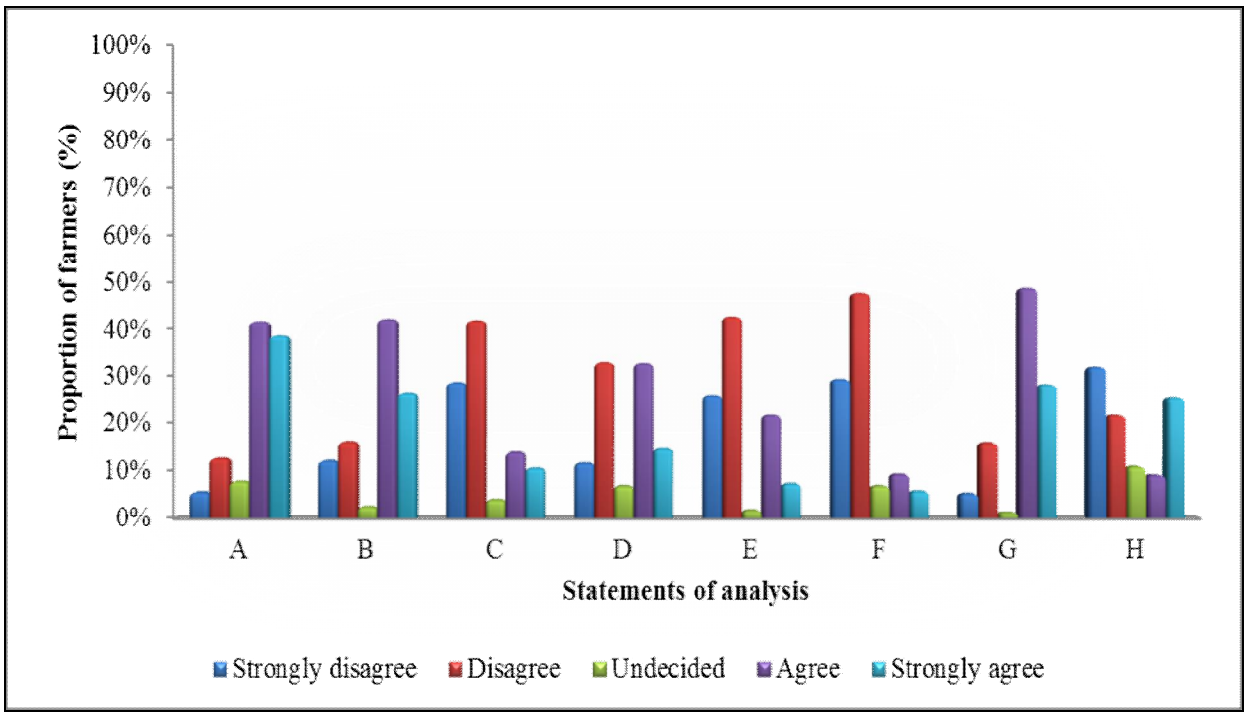

Figure 4.3: Farmers' perceptions about the use of chilli pepper as ECDIs

Note: **A** - The procedure for adopting chilli pepper innovation is clear and understandable to me. **B** - I find the innovation very effective in deterring elephants. **C** - The innovation is a waste of time. **D** - The input supply base for the innovation is satisfying. **E** - The adoption process of the innovation is full of drudgery and boring. **F** - I find traditional methods much more effective than the innovation. **G** - I think that using chilli pepper to deter elephants would fit well with the way I like to work. **H** - I find the innovation very expensive to implement.

Conversely, the computed grand average value for farmersô perceptions of beehive fence was 2.41 (SD = 0.81). The low average value ascribed to beehive fence innovation indicates that farmers did not favour its use as ECDIs. About 54% of farmers admitted that ǒthe innovation is a

waste of time,ô while 66.5% of them avowed that the innovation is full of drudgery and boring (Figure 4.4). Over 68% agreed to the statement ôI find the innovation very expensive to implement.ô In terms of beehive fence complexity, approximately 60% of the farmers remarked that the procedure for adopting the innovation is complex. While 66.5% of farmers indicated that ôThe adoption process of [beehive fence] is full of drudgery and boring,ô almost 60% of them asserted that the innovation is not effective in deterring crop-raiding elephants (Figure 4.4).

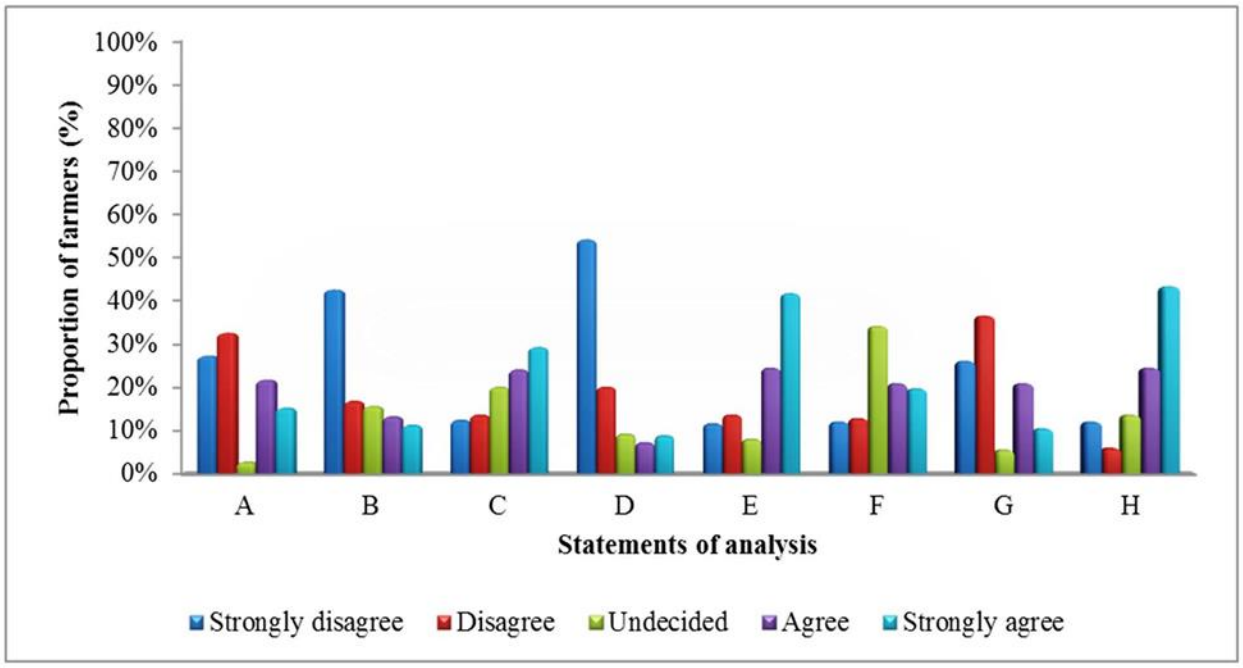

Figure 4.4: Farmersô perceptions toward the use of beehive fence as ECDI

Note: **A** - The procedure for adopting beehive fence innovation is clear and understandable to me. **B** - I find the innovation very effective in deterring elephants. **C** - The innovation is a waste of time. **D** - The input supply base for the innovation is satisfying. **E** - The adoption process of the innovation is full of drudgery and boring. **F** - I find traditional methods much more effective than the innovation. **G** - I think that using beehive fence to deter elephants would fit well with the way I like to work. **H** - I find the innovation very expensive to implement.

4.3.2. *Farmers' disposition of risk-aversion tendencies*

On average, the mean level of aversion to risks was 2.31 (SD = 0.75). As high risk-aversion tendencies were assigned the lower points on Likert scale, the relatively low mean value of risk-

aversion meant that farmers would generally not engage in risk-taking behaviour, other things being equal. The tendency in farmersô risk-aversion attribute is depicted in Figure 4.5. From this figure, although more than 67% of farmers agreed to the statement of ôI like to double my enterprise,ô 75.3% of them asserted that ôInvesting in new enterprise is something [they] don't do, since it is too risky.ô This viewpoint is also confirmed by 58.8% of farmers who contrasted the statement ôIf I believe an investment will carry a profit, I am willing to borrow money for itô (Figure 4.5).

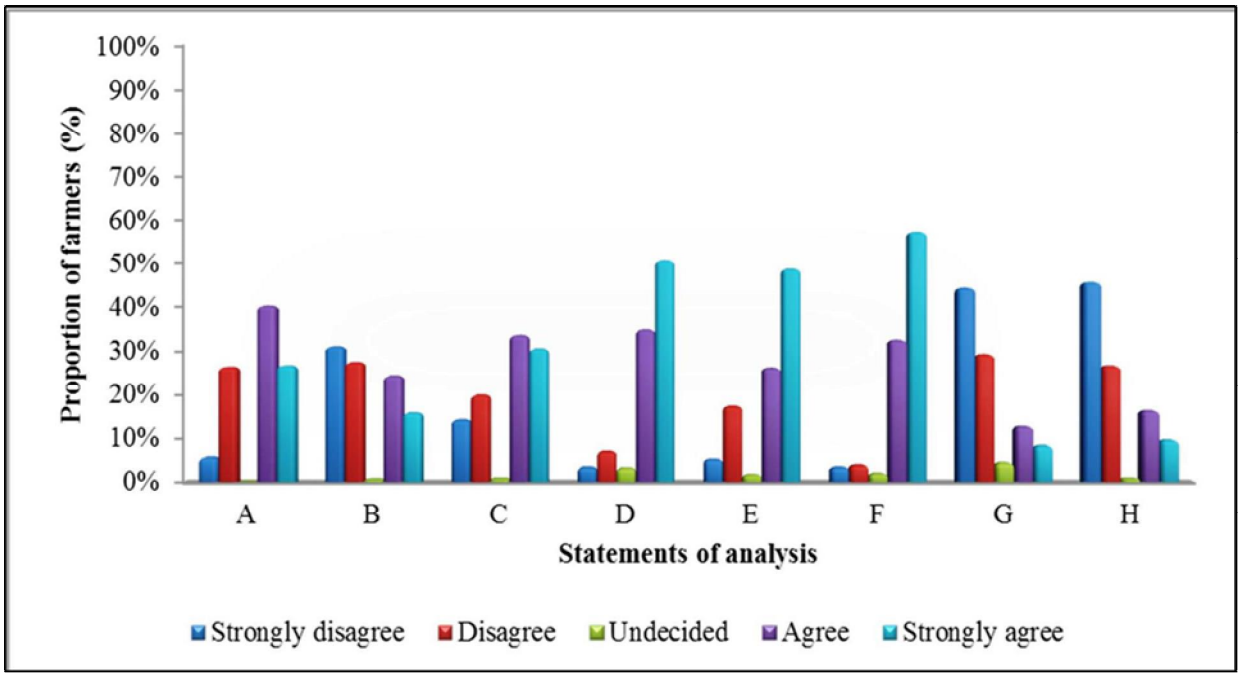

Figure 4.5: Distribution of farmers by risk-aversion attributes

Note: **A** - I like to double my enterprise. **B** - If I believe an investment will carry a profit, I am willing to borrow money for it. **C** - I don't like to invest in something that I have little knowledge about. **D** - I find it more important to invest safely and to get a guaranteed return than to take risks in order to possibly get a higher return. **E** - Investing in new enterprise is something I don't do, since it is too risky. **F** - I want to be sure my investments are safe. **G** - I am increasingly convinced that I need to take more financial risks if I want to improve my annual agricultural

harvests. **H** - I am willing to run the risk of losing money if there is also a chance that I will get better return from it.

4.3.3. *Farmers' fatalistic characteristics*

It is clear in Figure 4.6 that farmers in the study area are broadly not fatalistic. This disposition is shown in the overall mean value of 3.71 (SD = 0.70). Most farmers (72.9%, n = 303) affirmed that "Each person is primarily responsible for his/her success or failure in life." Moreover, 73% of farmers supported the idea that one needs to work hard if there are to be successful. This belief is underscored by 72.2% of farmers who disagreed with the statement "What will be will be" (Figure 4.6).

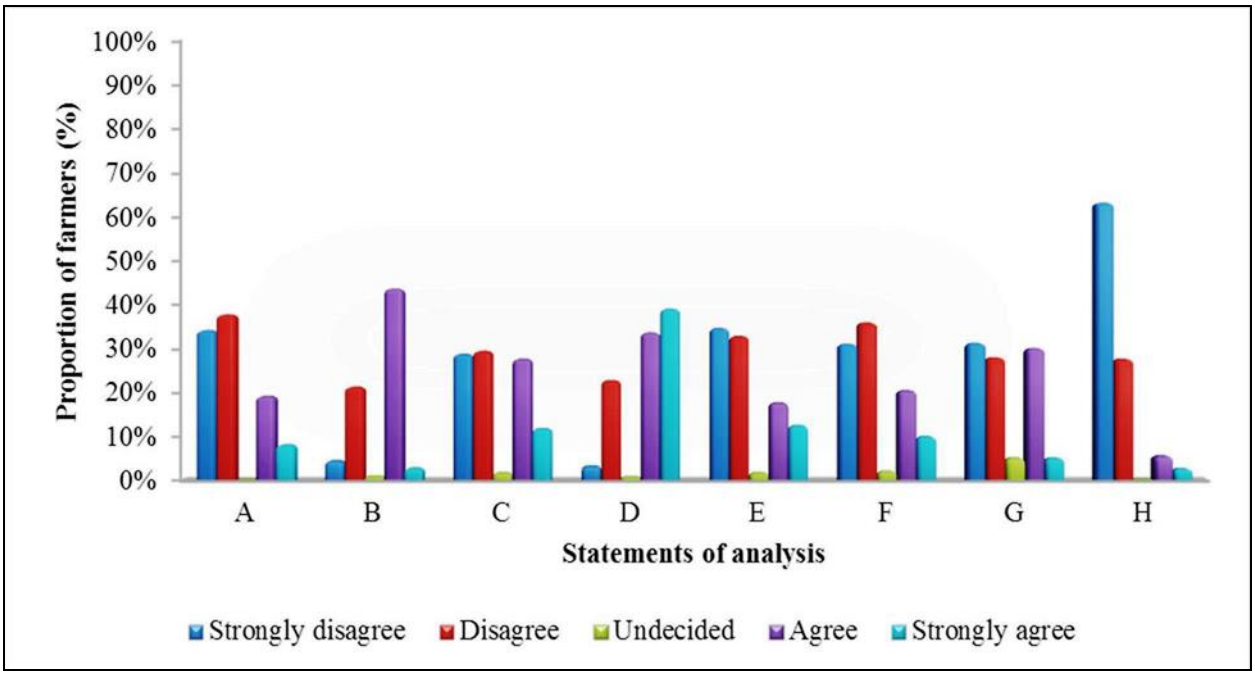

Figure 4.6: Distribution of farmers by fatalism attributes

Note: **A -** What will be will be**. B -** Each person is primarily responsible for his/her success or failure in life**. C -**One's success or failure in life is a matter of his/her destiny**. D -** To be successful, above all one needs to work very hard**. E -** If I just pray to God about my crop

protection, he will work it out**. F -** If God want me to survive, he will protect my crops against raiding elephants**. G -** I trust God, not elephant deterrents to protect my crops**. H -** I don't need to try to improve my crop protection measures because I know it is up to God.

4.3.4. Test of hypothesis 2

A logistic regression was performed to test the hypothesis ôThere is no significant relationship between farmersô psychosocial characteristics and adoption of ECDIs. The results are presented in Table 4.4. The omnibus test of model coefficient (with predictor variables included) was statistically significant, χ^2 (3, N = 388) = 27.55, p = 0.000, suggesting the model is a good fit to the data. The model correctly predicted 256 of 270, or 94.8%, of the adopters and non-adopters of ECDIs (with a total variance of 70.6% in adoption attributed to predictor variables combined). Farmerôs perceptions of chilli pepper were the only statistically significant predictor of the decision to take up the innovation (p = 0.000).

An odds ratio associated with perceptions of chilli pepper indicated that farmers with favourable perceptions toward the innovation are 2.31 times (or 31%) more likely to adopt chilli pepper than those displaying unfavourable perceptions. This is not unconnected with the generally high level of adoption of the innovation in the trial communities (69%, n = 268). Although the logit model was successful in predicting adoption 70.6% of the time, and indeed can explain 10% of the variance in adoption index (Nagelkerke R^2 = 0.097), risk-aversion (p = 0.523) and fatalism (p = 0.279) did not significantly influence individual farmerôs adoption decision (Table 4.4). But the statistical significance of perceptions about chilli pepper identified by the model meant that the hypothesis that farmersô psychosocial variables would not significantly predict adoption of ECDIs was not fully supported.

Table 4.4: Logistic regression of farmersô psychosocial variables on the likelihood to adopt ECDIs

Predictor	β	Wald	*df*	P-value	Odds Ratio (95% CI)
Perceptions ï chilli pepper	0.84	22.66	1	0.00	2.31 (1.64, 3.27)
Risk-aversion	ï 0.10	0.41	1	0.52	0.90 (0.66, 1.23)
Fatalism	0.18	1.17	1	0.28	1.20 (0.87, 1.65)
Constant	ï 2.55	9.90	1	0.01	0.08

Source: Field survey, 2015

Note: Cox & Snell $R^2 = 0.069$, Nagelkerke $R^2 = 0.097$

4.4. Institutional factors influencing farmers' adoption of ECDIs

Institutional factors comprised of extension delivery strategies, language(s) in which messages were delivered to farmers, extension agentsô credibility, and extension capacity and government support of extension services. Of the 388 sample farmers from the five trial communities, about 37.1% were contacted through *kgotla* meetings, while 28% stated to have obtained information only from VPCs (Figure 4.7). A few farmers (5.2%) indicated to have learnt about ECDIs mostly from workshops sponsored by DWNP and from VPCs. In general, it seems clear that VPCs were extensively used by extension agents in disseminating ECDIs to farmers.

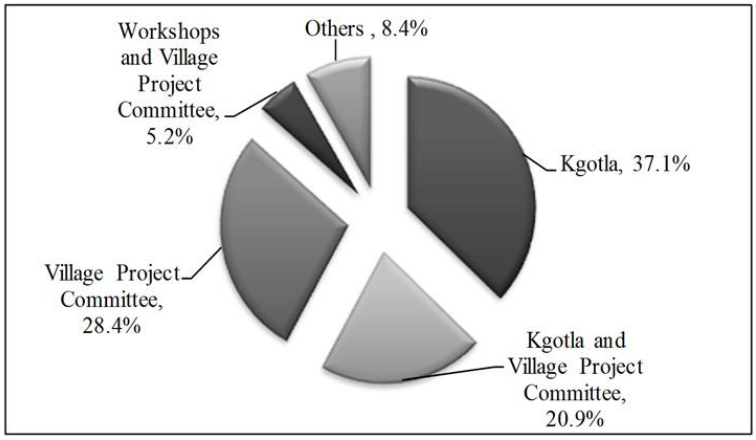

Figure 4.7: Proportions of farmers and the extension delivery strategies used to contact them

Communications between most participating members (either between extension agents and farmers, VPC members and farmers or between farmers themselves) were mostly done in Setswana. About 91% (n = 354) of the survey farmers stated to have received messages about ECDIs in Setswana while a minority gained the information in SeMbukushu (3.9%, n = 15), SeYei (2.6%, n = 10), SeSarwa (1.5%, n = 6) or in English (0.8%, n = 3). Apart from the fact that there are many languages and cultures within the studied communities that needed the use of one common language to communicate with, and possibly understand each other, it is logical that Setswana was the most used language of communication because it is one of the official languages of Botswana.

Regarding the credibility of extension agents to fulfil their promises, not so polarised opinions were expressed; 48.2% (n = 187) of the farmers believed that the extension agentsô were a credible body, but 46.4% (n = 180) thought otherwise. Only 5.4% (n = 21) of the farmers said extension agents were equally credible as not. Interviews with farmers indicated that majority (64.2%, n = 249) perceived extension agents to be adequate in the study area, while 31.7% (n = 123) believed they were limited, and the 4.1% (n = 16) were unsure if extension agents were enough or not.

During interviews with farmers regarding government support for public institutions, they were asked to indicate how they understood the role of government in extension services. The results are shown in Table 4.5. About 70% of the farmers specified that the government provides funding and logistic support to public institutions like DWNP to carry out extension activities. However, some farmers (20.9%, n = 81) stated that the government has not done enough in supporting extension work in the study area (Table 4.5). It thus seems that the surveyed farmers were well-versed on the subject matter.

Table 4.5: How farmers understood the role of government in extension services

Statement		Frequency	%
i.	Government provides logistic support for extension personnel to carry out their jobs	137	35.3
ii.	Government provides financial support to drive extension activities	135	34.8
iii.	Government provides enough training for extension personnel	16	4.1
iv.	Government is not doing enough to promote extension activities	81	20.9
v.	Don't know	19	4.9
Total		**388**	**100**

Source: Field survey, 2015

4.4.1. Test of hypothesis 3

The study hypothesised that there was no significant relationship between institutional factors and the adoption of ECDIs. Because the outcome (adoption versus non-adoption) and explanatory variables (which were a set of questions/statements addressing institutional factors) were both nominal, chi-square test of independence was used to discover if there is a relationship between two variables. Explanatory variables were extension delivery strategies, extension capacity, and credibility of extension agents as perceived by farmers.

First, credibility characteristics of extension agents as perceived by the farmers in the trial communities were assessed through a perception agreement scale during interviews with the farmers. They were asked to indicate their response to ñDo you think the extension agents fulfil their promises?ò using yes-sometimes-no scale to analyse whether adoption index (yes = 1 and no = 0) and perceived extension agentsô credibility (yes = credible, sometimes = neutral, and no = not credible) are independent to one another. A chi-square test of independence was calculated comparing the frequency of adoption in all the response categories. The results are as shown in Table 4.6.

Of the 69.6% (n = 270) of surveyed farmers who adopted at least one ECDI, 75.9% of them opined extension agents were credible, 61.7% said they were not credible at all, while 81% stated that extension agents were not entirely credible. These differences were statistically significant (χ^2 = 10.18, *df* = 2, *p* = 0.006), suggesting that there was a significant relationship between perceived credibility of extension agents and adoption of ECDIs. However, as shown by a small effect size of 0.16 (Cohen, 1992; McHugh, 2013), level of credibility of extension agents did not hugely impact on farmersô probability to adopt ECDIs.

Table 4.6: Influence of credibility of extension agents on farmersô adoption of ECDIs

Credibility response	**Adoption outcome**	
	Yes (%)	**No (%)**
Credible	142 (75.9)	45 (24.1)
Sometimes	17 (81.0)	4 (19.0)
Not credible	111 (61.7)	69 (38.3)

Source: Field survey, 2015

Note: (%) = Percentage within extension agentsô credibility

Secondly, extension capacity as perceived by surveyed farmers was examined using a three-point rating scale. The question ñWould you say there are enough extension agents at your disposal?ò was posed to farmers with response choices of yes, no or not sure. Chi-square test of independence was used to determine whether farmersô choice of adoption is related to perceived extension capacity. There was no statistically significant interaction found, χ^2 (2, N = 388) = 0.62, *p* = 0.734. Farmersô perceptions of extension agentsô capacity were not associated with their adoption index. The cross tabulation results are presented in Table 4.7.

Table 4.7: Farmersô evaluation of extension capacity and its influence on adoption likelihood

Response to extension agents' capacity	Adoption outcome	
	Yes (%)	No (%)
Yes	176 (70.7)	73 (29.3)
No	84 (68.3	39 (31.7)
Not sure	10 (62.5)	6 (37.5)

Source: Field survey, 2015

Note: (%) = Percentage within extension capacity

Thirdly, relationship between farmersô adoption outcome and extension delivery strategies (or methods) often used by extension agents to reach farmers was examined. Farmers were requested to indicate how were often contacted by extension agents, and the data were put into meaningful and useful themes. For statistical purposes, the data were collapsed into five groups of ó*Kgotla*,ô ôVPCs,ô ó*kgotla* and VPCs,ô ôWorkshops and VPCs,ô and óOthersô to compare the occurrences of adoption across the groups. About 86% (n = 94) of farmers who adopted ECDIs were contacted mainly through VPC, 81.5% by *kgotla*, while 80% were reached through *kgotla* and VPC and so on (see Table 4.8). These differences were statistically significant, χ^2 (4, N = 388) = 42.29, p = 0.000, indicating that farmers who learnt about or obtained ECDIs through VPCs were more likely to take up the innovations than those contacted using other dissemination pathways. VPCs had a fairly strong effect of 0.33 on ECDI adoption (Cohen, 1992).

Table 4.8: Extension delivery strategies used by extension agents to reach at farmers in the study area

Extension delivery strategies	Adoption outcome		Total
	Yes (%)	No (%)	
Kgotla	77 (53.5)	67 (46.5)	**144**
Kgotla and VPC	66 (81.5)	15 (18.5)	**81**
VPC	94 (85.5)	16 (14.5)	**110**
Workshops and VPC	16 (80.0)	4 (20.0)	**20**
Other delivery strategies	17 (51.5)	16 (48.5)	**33**

Source: Field survey 2015; *Note*: VPC = Village Project Committee. (%) = Percentage within extension delivery strategies

4.5. Characteristics of ECDIs

The distribution of farmers by perceptions toward characteristics of ECDIs is presented in Table 4.9. Analyses of the characteristics of beehive fence revealed no meaningful results due to the fact that majority of the farmers have not adopted the innovation, and provided one bit of data about the innovationôs characteristics. On the contrary, about 62% of the farmers indicated that chilli pepper can be completely tried out on a small scale, with 48.2% of farmers finding it easy to use. Although 60.9% of the farmers indicated no cultural barriers to using chilli pepper, only 30.4% asserted the innovationôs effectiveness in deterring crop-raiding elephants. However, some farmers (35.1%, n = 136) said chilli pepper was not costly to implement (Table 4.9).

Table 4.9: Distribution of farmers by their perceptions about ECDIs characteristics

	Chilli pepper		Beehive fence	
Innovation characteristic	**Frequency**	**%**	**Frequency**	**%**
Compatibility				
Not compatible with the culture of community	9	2.3	0	0.0
Less compatible with the culture of community	26	6.7	0	0.0
Compatible with the culture of community	235	60.6	3	0.8
Total	**270**	**69.6**	**3**	**0.8**
Cost				
Not expensive to implement	136	35.1	0	0.0
Less expensive to implement	47	12.1	0	0.0
Expensive to implement	87	22.4	3	0.8
Total	**270**	**69.6**	**3**	**0.8**
Complexity				
Not complex to implement	187	48.2	0	0.0
Less complex to implement	73	18.8	0	0.0
Complex to implement	10	2.6	3	0.8
Total	**270**	**69.6**	**3**	**0.8**
Trial-ability				
Not trial-able: Cannot not be tried out in small bit	5	1.3	0	0.0
Less trial-able: to some extent, can be tried out in small bits	25	6.4	3	0.8
Trial-able: Can be tried out in small bit	240	61.9	0	0.0
Total	**270**	**69.6**	**3**	**0.8**
Effectiveness				
Not effective (1)	42	10.8	2	0.5
Less effective (2)	108	27.8	1	0.3
Effective (3)	120	30.4	0	0.0
Total	**270**	**69.6**	**3**	**0.8**

Source: Field survey 2015

Note: Only adopters were considered for this analysis

4.5.1. Test of hypothesis 4

Hypothesis 4 states that ñThere is no significant relationship between characteristics of ECDIs and adoption of the innovations.ò Innovation characteristics were measured on a 3 items Likert scale which addressed compatibility, cost of implementation, complexity, trial-ability, and effectiveness. The logit model was used to determine which factors affected adoption of ECDIs.

The model predicted at least 67% of the cases correctly. The data for beehive fence characteristics were not included in the analyses because the variables had linear combinations of each other (or have perfect multicollinearity). There was no statistically significant predictor of ECDIs adoption ($p > 0.05$) (Table 4.10).

Table 4.10: Logistic regression for innovation characteristics predicting adoption of ECDI

Predictor	**β**	**Wald**	***df***	**P-value**	**Odds Ratio (95% CI)**
Compatibility	ï 0.64	0.09	1	0.76	0.53 (0.01, 30.81)
Cost	ï 1.12	0.23	1	0.63	0.33 (0.00, 32.17)
Complexity	0.40	0.02	1	0.88	1.49 0.01, 228.65)
Trial-ability	2.11	2.91	1	0.09	8.26 (0.73, 93.35)
Effectiveness	ï 0.87	0.20	1	0.65	0.42 (0.01, 18.91)
Constant	6.24	15.04	1	0.00	514.16

Source: Field survey, 2015

Note: Cox and Snell $R^2 = .69$. Nagelkerke $R^2 = .98$.

4.6. Adoption and intensity of use of ECDIs

The adoption indexes were generated by dividing the total number of ECDIs adopted by the farmer with the total number of ECDIs introduced to the farmer by extension agency (that is, DWNP) as depicted below:

$$Y = \frac{\sum \text{of ECDIs adopted by the farmer}}{\sum \text{of ECDIs introduced to the farmer by extension agency}}$$

Where Y = adoption index

Table 4.11 shows the adopted ECDIs as further reflected in Figure 4.8. There were varying but significantly low levels of innovation uptake, particularly beehive fence among subsistence farmers within the five rural communities of the eastern Okavango Delta Panhandle, Botswana.

Majority of the farmers (69%; n = 268) adopted chilli pepper, but 30.2% (n = 117) had not adopted any ECDI at all. While only one farmer (0.3%) used the beehive fence innovation, two farmers (0.5%) have incorporated both chilli-based and beehive fence innovations (Table 4.11).

Table 4.11: Proportions of famers by ECDIs adopted

Adoption behaviour	Frequency	%
Chilli pepper	268	69.0
Beehive fence	1	0.3
Chilli pepper and beehive fence	2	0.5
None	117	30.2
Total	**388**	**100.0**

Source: Field survey, 2015

Note: N = 388

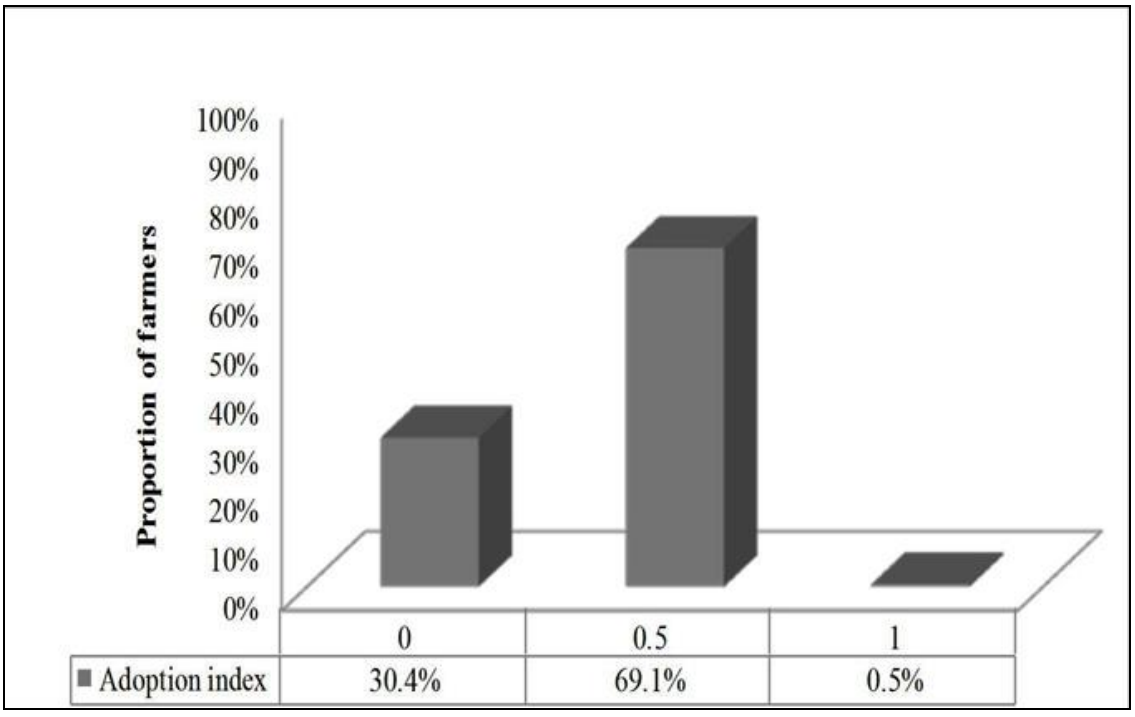

Figure 4.8: Distribution of famers by their adoption index

Note: Adoption index: None of the ECDIs adopted = 0/2 (i.e., 0); any ECDI adopted = ½ (i.e., 0.5); both ECDIs adopted = 2/2 (i.e., 1)

CHAPTER 5

DISCUSSION

5.1. Overview

Prevention of elephant crop-raiding is a social process involving wide-ranging actors and institutions in society. It involves interactions between state (often the wildlife managers ï from DWNP) and non-state actors (farmers themselves and local leaders together with NGOs) who are mutually concerned about protecting biodiversity and improving rural livelihoods. Because of the diversity in actors involved, and the heterogeneity that exists among them, uptake of initiatives directed towards mitigating elephant crop-raiding becomes complex, with several multi-interactive factors influencing it. Some studies (Graham & Ochieng, 2008) have highlighted farmersô demographics, their socio-economic characteristics, and perceptions of innovation effectiveness to be crucial in influencing adoption behaviour. However, a greater understanding of these dynamic factors is required in devising effective crop-raiding mitigation processes.

The current study, therefore, analysed the determinants of farmer adoption of two ECDIs within five rural communities of the Okavango Delta, Botswana. The study utilized most of the conceptual and theoretical underpinnings of the Diffusion of Innovations (DOI) theory to analyse farmersô uptake of ECDIs in the Okavango Delta, Botswana. The study invoked the theory and situated farmers within the framework of ECDIs adoption and implementation. To understand the adoption process of ECDIs and the factors influencing it, four (4) hypotheses were formulated based on the variables identified, namely: (1) There is no significant relationship between farmersô demographic and socio-economic attributes and the adoption of ECDIs; (2)

There is no significant relationship between farmersô psychosocial dispositions toward ECDIs and the adoption of these innovations; (3) There is no significant relationship between institutional factors and the adoption of deterrent innovations; and (4) There is no significant relationship between ECDIs characteristics and their adoption by farmers.

Data from the study were statistically analysed using logistic regression model and chi-square test of independence, and the results are shown in chapter 4. This chapter (chapter 5), therefore, focuses on the discussions of the results, from which conclusions and recommendations for both research and practice are offered.

5.2. Socio-economic and demographic characteristics of farmers

This thesis found that ECDIs were predominantly operated by females (59%, n = 228), with about 33% (n =127) aged 60 years and above. About 49% (n = 188) of the farmers had no formal education. On average, the mean family size was approximately 7 persons, with about 50% (n = 192) drawing a monthly income of between BWP0 ï 100. In respect to cosmopoliteness of farmers, the majority (89.9%, n = 349) had never gone outside their immediate communities to seek agricultural information, but 72.9% (n = 283) had contact with extension agents once per quarter. Seventy-five percent (n = 291) of the farmers had arable field. The farmers identified with four ethnic groups, mainly BaHambukushu (44.3%, n = 172).

Part of the first hypothesis, which assumed that farmersô demographics would not significantly contribute to adoption of ECDIs, was not fully supported. The logit model revealed a statistically significant relationship between ethnicity and adoption of ECDIs, implying that farmerôs ethnicity would significantly predict adoption of ECDIs. A farmer of the BaHambukushu descent was more likely to adopt ECDIs than of any other ethnic group. Consistent with this finding,

Sommer and Napierôs (1993) diffusion study found that farmers in Amish communities adopted sustainable agricultural practices more frequently than those of non-Amish due to their differences in cultural attitudes toward land and soil protection.

Based on the researchersô experience with the communities in the study area, BaHambukushu subsist predominately on arable crop farming. It thus seems logical to assume a HaMbukushu farmer would easily adopt any innovation meant to reduce the risk of crop loss, such as ECDIs. Besides, because they were in majority (n = 172), it was more probable that people from the BaHambukushu ethnic group served in VPCs, and perhaps favoured their ethnic members over others during distribution of necessary inputs. Accordingly, some farmers stated in interviews that there was ethnic bias in the delivery materials. In their words, óminority groups are side-lined and yet the resources were meant for the entire communityô. A 57 year old farmer in the village of Eretsha explained that óresources were given mostly to their relatives and tribesmenô. This viewpoint did not only bring to the fore ethnic divisions that exist between people in those communities, but has also shown incoherence in combating elephant crop-raiding. As recognised by diffusion theory, innovation diffusion rate and level of adoption can be modulated by cultural difference between participants (Rogers, 2003; Haider & Kreps, 2004).

Although family size and age were statistically not significant predictors of adoption, interviews with famers showed that many of them were elderly and were faced with labour constraints when they decided to implement the ECDIs. To them, ECDIs were highly labour intensive, especially the beehive fence innovation and certain forms of chilli pepper (e.g., chilli grease fence and chilli dung briquette). The drudgery may have compacted negatively on the adoption decisions of ECDIs. This observation, however, was made against the backdrop of large family sizes (Mean = 6.55, SD = 3.09) of the farmers. It seems that some family members, particularly the young ones,

may probably have contributed less to farming activities in the area. Similarly, Graham and Ochiengôs (2008) study on uptake and performance of ECDIs (referred to in their study as farm-based elephant deterrent systems) found that watchtower was discontinued by some farmers due to old age. As the authors say, farmers found watchtower too difficult to climb and that it required young labour. The general viewpoint is that, older people may not have the robustness needed in physically demanding activities of the innovations. In discussions with the extension agents, they noted that most farmers preferred chilli heap over chilli grease fence and chilli dung briquette. They explained that the practice require less investment in terms of labour and time. Since labour is a serious constraint, ECDIs that require less labour may help increase adoption of these innovations.

On the other hand, study hypothesis 1 postulated that farmersô socioeconomic status was not significantly related to adoption of ECDIs. Nonetheless, farmersô income, education level and land holding were significantly associated with the adoption of ECDIs. Farmersô income had a significant negative effect on the adoption of ECDIs. This may imply that farmers were poor and therefore, were constrained by inputs or hired labour to adopt ECDIs. But access to DWNP inputs by some farmers increased the probability of ECDI adoption. Alternatively, ówealthierô farmers (with diversified livelihood strategies) may have been less willing to invest in crop protection, possibly due to the highly uncertain rewards of preventive innovations such as ECDIs (Rogers, 2002) so as to reduce risks of losing their already limited resources. Interviews with these farmers showed that many of them discounted the use of ECDIs that currently are being promoted. This perspective is consistent with diffusion theory on innovation acceptance which explains that innovations which are not believed to adequately advance farmersô goals are more likely to be rejected (Rogers, 2003). It is, therefore, crucial for researchers, policy makers and

development practitioners to develop technologies requiring fewer inputs. Also, producing and applying traditional methods which uses locally available materials should be encouraged in addressing some of the socio-economic challenges faced by farmers (Kolawole, 2012; Korzun *et al.*, 2015).

Just like farmersô income, land holding had significant negative impact on the likelihood to adopt ECDIs. This implies that lack of arable field or borrowed land reduced the probability of ECDI adoption. Muzari *et al.* (2012) suggested that subsistence farmers who have greater access to land are more likely to adopt a new practice. Accordingly, some farmers stated in interviews that farmers who possessed arable land found it easier to implement ECDIs, while for many with borrowed land, the decision to adopt these innovations was dependent upon the approval of the owner of the field. Analysis of this response points to the fact that land ownership affects the scope and type of decision-making. On the other hand, farmerôs education levels had positive effect on decisions to adopt ECDIs. Studies have consistently found that farmers with higher education were more likely to understand and adopt agricultural innovations (Welch, 1970; Chianu & Tsujii, 2004; Chirwa, 2005). However, the significantly positive effect of education did not necessarily translate into any significant adoptions. This can be attributed to the high level of illiteracy across the trial communities, combined with farmersô inadequate contacts with the extension agents. The lack of sufficient contacts with extension agents may have greatly affected farmersô understanding of the intricacies involved in the adoption procedures of the innovations, and thus engendering considerable resentment and failure to implement or maintain ECDIs (OôConnell-Rodwell *et al.*, 2000; Sitati & Walpole, 2006; Songhurst, 2010). The people promoting adoption of these types of innovations need to robustly educate and train farmers

about them, and continuously engage with the farmers with a view to supporting them in their implementation efforts.

5.3. Farmers' perceptions about the use of ECDIs

Hypothesis 2 which assumed that psychosocial variables (i.e., perceptions, risk-aversion, and fatalism) would not significantly predict farmersô adoption probability of ECDIs was not supported altogether. Farmersô perceptions of chilli pepper had significant positive effect on farmersô decisions of the innovation, suggesting their preference for and acceptance of the innovation to ward off raiding elephants. This finding is consistent with a recent study, which found that farmers who had favourable perceptions about elephant deterrent innovations rapidly adopted them, and were also willing to invest their capital towards the cost of inputs (Graham & Ochieng, 2008). This perception came through in interviews with farmers who can best be described as champions of ECDIs based on successful adoption and continued use of these innovations. However, in a series of focus groups, some farmers indicated that the innovation is not necessarily helpful in protecting their crops. Instead, farmers use it simply because itôs given for free. It would seem that by accepting chilli pepper innovation, farmers were merely responding to their vulnerability of elephant raiding (Meinzen-Dick *et al.*, 2004). It also reinforces the point that innovation subscription (or acceptance) alone is not sufficient for innovation adoption (Robertson, 1971 in Nabih *et al.*, 1997). Therefore, it is important that any attempt to mitigating elephant crop-raiding has to critically take into consideration strategies on how favourable perceptions of ECDIs would be encouraged.

Contrary to chilli pepper innovation, interviews and FGDs with farmers indicated that they perceived beehive fence as not effective in preventing elephants from raiding crops. They opined that bees are too small to worry a dangerous and sizable animal like elephant. This viewpoint

manifested in the low adoption of beehive fence as a single technical solution (0.3%, n = 1). At focus group discussions, one discussant vehemently said, óAn elephant skin is thick and there is no way that a bee's sting can penetrate it. Therefore, it is only misleading to think that bees can scare elephantsô. Another participant in the group noted that crop-raiding happens at night when bees are asleep and inactive. These perspectives expressed by participants are an indication that certain considerations and situations are made when evaluating ECDIs. Some people may base their perceptions toward an innovation on the extent and frequency of crop-raiding (whether actual or perceived), and on the animal involved (Gillingham & Lee, 1999). As such, there will usually be some alternatives to a recommended innovation that people think are better ways to addressing crop-raiding. Therefore, actively engaging with farmers to understand the context of crop-raiding could help in devising innovations that address their concerns. This becomes crucial when convincing farmers to take up ECDIs as they are more likely to develop favourable perceptions toward these innovations. This viewpoint is consistent with the diffusion theory which posits that farmers with more favourable perceptions toward an innovation are more likely to adopt it than those who are not (Rogers, 2003).

5.4. Institutional factors influencing farmers' adoption behaviour

The third hypothesis, which evaluated the association of the different institutional variables using a series of chi-square test of independence, was supported. Two variables, credibility of extension agents and extension delivery strategies, were significantly associated with the adoption of ECDIs. The results demonstrated that an individual who develop more trust in extension agents and was contacted through VPC is more likely to adopt ECDIs. Consistent with this view, studies investigating adoption and use of ECDIs found farmersô trust in innovation promotors (Osborn & Parker, 2003; Zimmermann *et al.*, 2009), and extension delivery strategies

by which innovation was delivered to farmers (Longo, 1990) contribute significantly to whether or not the innovation gets adopted.

Key informant interviews (with wildlife managers and VPC chairpersons) and FGDs established a consensus on the involvement of local communities in combating elephant crop-raiding that it was a prerequisite, though VPC chairpersons had issues regarding power relations within the project which calls for urgent solution. VPCs described themselves as nothing more than input distribution channel. One VPC chairperson complained of exclusion of their voices by extension agents in key decision making processes. ôWe have suggested many reforms,ô he continued, óand all for nothingô. Consistently, participants at FGDs easily came to a consensus that extension agents had no respect for rural communities, and as such had no empathy for their situations. FGD discussants were more concerned that the government is doing little to assist them. A Gudigwa farmer said:

> é most government officials do not take us [people living in rural areas] or what we say seriously. Wildlife managers take a long time to respond to reports of crop-raiding incidences, and at times they never show up. Elephants destroy our crops and leave us with nothing to feed our children. We have complained several times about the issue, but no one seems to be listening to us. But when you kill an elephant, DWNP officials will immediately be all over the place. Clearly, wild animals are being valued and prioritised over the people.

Here, analysis point to the fact that some individuals perceive mutual respect as key to any development practice. So it is when people feel respected and appreciated that they will fully participate in any elephant crop-raiding mitigation program. As Juma (2011, 15) pointed out, ó[t]he process of technological innovation involves interactions among a wide range of actors in society, who form a system of mutually reinforcing learning activitiesé ô. Thus effective institutional relationships influence stakeholdersô attitudes, decisions, and actions for mutual

benefit. This will motivate them and makes it more likely for them to support any development program, as in the case of implementing ECDIs and upholding them (DeCaro & Stokes, 2008; Zimmermann *et al.*, 2009; Madden & McQuinn, 2014). Failure to do so may cause local people to ŏrevolt againstô the development practice and (deliberately) fail to implement or sustain any introduced innovations (Sitati & Walpole, 2006; Songhurst, 2010), even if they were helpful.

However, according to extension agents, VPCs were formed as one way of involving local communities in the project, and to encourage ownership of the ECDI initiative. They explained VPC members were equipped with the necessary knowledge to perform their duties with efficacy, including training of and diffusion of innovations to other farmers, and to administer the project. Nonetheless, issues such as limited resources for training of, reaching at, and even inclusion of, all farmers in the project kept recurring in interviews held with extension agents, suggesting that the project was not without challenges, which somehow validate VPC chairpersonsô discontents as mentioned earlier.

But for rural projects to be successful, communities and other key stakeholders should be engaged at all levels of decision-making, to facilitate partnership, collaboration and equitable distribution of power (Osborne & Murray, 2000; Walters *et al.*, 2000; Vigoda, 2002). This would mean that extension agents and local stakeholders need to come together to discuss pertinent social issues affecting the project, identify problems, and solve the problems together. It is therefore crucial for innovation promotors to have an understanding of local cultural and power relationships guiding how people interact and learn to ensure that appropriate dissemination pathways are put in place that facilitate effective information sharing and adoption of innovations (Rogers, 2003; Meinzen-Dick *et al.*, 2004).

5.5. Characteristics of ECDIs

The fourth hypothesis that ECDI-specific characteristics and adoption of these innovations are not significantly related was supported. Logit model analyses resulted in no significant associations involving ECDIs characteristics and adoption decisions, indicating that the characteristics were not significant predictors of farmersô adoption decisions. Although there are no studies on adoption of ECDIs that statistically tested the predictive power of individual innovation characteristic, the findings of this research contradict with agricultural innovations adoption literature and innovation-diffusion theory (Adesina & Zinnah, 1993; Rogers, 2003). Using a Tobit model to predict the effect of characteristics of improved mangrove swamp rice varieties on the adoption decisions of farmers in Sierra Leone, Adesina and Zinnah (1993) found yield, ease of cooking, tillering capacity and the ease of threshing the harvested rice as major factors determining their adoption and intensities of use. However, for the same study, the researchers found that farmersô contacts with extension agents were significant in explaining adoption decisions.

Innovation-diffusion theory assumes that access to information about an innovation is a key driver of adoption choices (Agarwal, 1983; Rogers, 2003). Most of the farmers in the current study had insufficient contacts with extension agents (72.9%, n = 283), which typically may have impacted negatively on their level of awareness about ECDIs. Another key point to remember is that the effect of cost of implementing ECDIs, especially regarding chilli pepper innovation may have been modulated by the fact that necessary inputs were freely given to farmers by the extension agency with a view to encouraging adopt of ECDIs (Rogers, 2003).

Although chilli pepper trial-ability was not statistically significant, its positive relationship with adoption index may provide the basis of rationale for its adoption by farmers, but without

subverting the impact that free inputs may have had on farmersô decisions to adopt or not to adopt it. While innovation effectiveness (relative advantage) and complexity represent the functional dimension (Tolba & Mourad, 2011), and arguably the most important aspects of innovation implementation, farmersô equivocal remarks about the effectiveness of chilli pepper suggest that most adoptions may have been due to its high degree of trial-ability, and of course its easy-to-use nature. Although they could not completely deny the effectiveness of chilli pepper, farmers at focus group sessions however said elephants are no longer troubled by the innovation as it was initially the case during the years of its inception. They were of the view that very large elephant populations in the study area undermine the innovation. Comparatively, interviews with local leaders and farmers pointed out chilli dung briquette to be a bit effective but did not solve the problem (Graham & Ochieng, 2008), while also complaining about the smoke produced by the approach saying it posed health hazards, both to people and their livestock.

On the other hand, key informant interviews with village *dikgosi* and FGDs indicated that local communities discounted the beehive fence innovation as ECDI. The local communities are of the opinion that bees would naturally ósleepô or become inactive at night when most of the raiding occurs. Although there are many facts to bee wakefulness and sleep, there is some evidence in entomology literature that honey bees sleep during the night (Kaiser, 1988; Sauer *et al.*, 2004), and during cold days (Hooper, 1991). An analysis of local communitiesô viewpoint in line with what literature says about bee sleep suggests that farmers made adoption decisions of beehive fence from an informed position. However, King et al.ôs (2011) study on the effectiveness of beehive fence found that the innovation was effective in deterring elephants from entering crop

fields in Kenya. But the study did not analyse uptake levels of the ECDI among the Kenyan farmers.

According to some farmers who were interviewed, the beehive fence innovation was expensive to implement. These sentiments were also echoed by one bee farmer, who was described by extension agents as champion of the beehive fence innovation. The farmer said he is faced with the challenges of ensuring that water is always available, while providing enough floral diversity for bee pollination in-between crop seasons. If not done, he continued, bees would normally relocate to other places. From what the champion said, beehive innovation is complex and costly, thereby having a significant negative impact on farmersô adoption behaviour. Put differently, intricacy and high costs of beehive fence implementation seem to have played a significant role in determining farmersô adoption decisions of the innovation. Thus, the high unfavourable local perceptions toward the innovation were significantly related to its low adoption intensity among farmers.

5.6. Adoption of ECDIs

This study has shown varying levels of ECDIs uptake among subsistence arable farmers in the Okavango Delta, Botswana. By contrast, 268 farmers have adopted chilli pepper while only one farmer reported to using the beehive fence innovation. The different components (i.e., chilli dung briquette, chilli ógreaseô fence and chilli heap) of the chilli pepper innovation were not equally practiced by farmers. Key informant interviews with extension agents showed that farmers tended to use chilli heap most often than the other two. They asserted that chili heap required less labour and time to implement compared to chilli dung briquette and chilli ógreaseô fence. In addition to labour constraints, some farmers stated in interviews that limited technical support

and skills on how to properly implement the chilli grease innovation have put them at a disadvantage, leading to non-adoption or marginal use of the innovation.

On the other hand, farmers who specified to be using chilli grease fence have only implemented the innovation on one side of their fields. Interviews with these farmers and VPC chairpersons showed that there was acute shortage of inputs, which negatively impacted on use and effectiveness of the innovation. They observed that chilli pepper was only provided in a container measuring less than five litters and, according to them, did not last the whole of the cropping season. Labour and resource constraints together with limited skills or technical support thus can engender low uptake levels or rejection of ECDIs. To demonstrate this, farmers disassembled chilli pepper components and adopted and used chilli heap most frequently, which somehow was formfitting their socioeconomic backgrounds and farm-associated labour, as asserted by Byerlee and Hesse de Polanco (1986).

On the contrary, beehive fence was broadly rejected by farmers across the trial communities. This study has shown that the innovation is riddle with several challenges including but not limited to labour and resource constraints, incompatibility with peopleôs belief systems, and negative local perceptions of effectiveness. More often during interviews, farmers asserted that bees were a good business venture, and not as ECDIs. Even when farmers believed bees were profitable when used as a business enterprise, they still could not adopt the innovation. This could be due to limited resources as explained by farmers or lack of markets where bee products can be sold at. On the latter part, King *et al.* (2011) documented 106 kg of honey sold by farmers who took part their research. It thus seems that participation of Kenyan farmers may have been motivated by an additional incentive of profit.

Some HEC researchers have suggested that an integrated approach or rotated interventions are more sustainable solutions to crop-raiding (Osborn & Parker, 2003; Sitati & Walpole, 2006; Hedges & Gunaryadi, 2010). Yet only two farmers in this study indicated they were using both chilli pepper and beehive fence to protect their crops. But the farmers said they their adoption of the beehive fence was not for purposes of deterring elephants, but for business. Indeed, this is the foundation for the basis underlying adoption of beehive fence, as implied by King *et al.* (2011).

Even with the negative perceptions of effectiveness, most farmers reported to still using the deterrent innovations, while some indicated to have discontinued their use. In interviews with farmers who are still using ECDIs, they indicated that appropriateness for monetary compensation for damaged crops through DWNP was based in part by whether or not a farmer has adopted ECDIs. If not, they explained, a farmer is personally had responsible for their crop damages by elephants, and as such they would not be compensation for such raid. This may be largely the reason why farmers still use the deterrent innovations. Key informant interviews with extension agents corroborated farmersô viewpoints. As Hill and Wallace (2012) argued in their study on the effectiveness of elephant deterrent techniques, frequent or widely used techniques do not necessarily reflect their effectiveness in deterring elephants. It may just mean that farmers do not have or have limited access to better alternatives (Hill & Wallace, 2012). Again, there was evidence that some farmers adopted ECDIs out of concern over the manner in which compensation for crop damages is awarded (which is based in part on whether or not a farmer is using ECDIs), suggesting conformity might have played a positive role in adoption, and innovation effectiveness. If these findings are something to go by, it would seem, therefore, that deterrent innovations were imposed on people by the extension agency or by the government.

5.7. Study limitations

The study findings should be interpreted in the light of the following limitations:

a) The study did not examine the diffusion process of ECDIs. Some complications of the adoption process may have been inherited from the diffusion process. Thus understanding how ECDIs were distributed could have helped understand the extent of the diffusion process and its effects on adoption of ECDIs. However, an item addressing communication pathways was included to understand how information about ECDIs was communicated.

b) The study used self-reported scales instead of more objective scales, thereby having several sources of social desirability bias among the respondents. As a means of correcting or reducing the limitations, negatively worded items were reversed and the purpose of the study was underlined during interviews (both individual and group interviews) as one way to encouraging objective responses.

c) The use of mostly nominal and ordinal data rather than data at highest levels of measurement possible (i.e., interval and ratio) restricted usage of more powerful statistical procedures, and in so doing limiting the amount of information that can be elicited from the data.

5.8. Summary

This study assessed uptake levels of ECDIs among subsistence arable farmers across the five trial communities in the Okavango Delta, Botswana, and the factors influencing adoption or non-adoption of these innovations. The study was informed by the DOI theory. Adoption (or uptake) has been defined in this study as an individual farmerôs decision to incorporate either chilli

pepper or beehive fence (or both) into his or her on-going arable farming practice as the best ECDI(s) available to wade off elephantsô destructive tendencies (Rogers, 2003). Focus was on an individual farmerôs adoption and use of ECDIs, and the influences shaping his or her adoption behaviour. As noted in this study, the ECDI initiative has in some instances shown potential in alleviating HEC particularly crop-raiding but requires reforms to address constraints modulating its effectiveness.

The study has shown a large proportion of farmers (30.4%, n = 188) across the trial communities who have not adopted any ECDI at all. The study identified a number of factors which attempt to explain farmersô non-adoption decisions; farmersô perceptions, ethnicity, and their socioeconomic backgrounds, farm-associated labour constraints, insufficient contacts with extension agents, and variables of institutional context. Although majority of the surveyed farmers (69.6%, n = 270) reported adoption of at least one ECDI, the reason has been that farmers sought to conform to the expectations of extension agents in order to satisfy the compensation criteria, but not that they believed the innovations were effective in protecting their crops (Hill & Wallace, 2012). Whether there is truth in this or not, it seems more likely that such viewpoint, if not immediately addressed, will prove to be more detrimental to the sustainability of the project in the long-term.

This study demonstrated a more favourable perception towards chilli pepper, but adverse towards beehive fence. Farmersô limited contacts with extension agents were shown to may have engendered the generally unfavourable perceptions towards ECDIs in the Okavango Delta. Although extension agents used VPCs to reach at farmers, VPC members had limited capacity to train and diffuse innovations to farmers. The problem was compounded by farmersô high illiteracy level across the trial communities.

The study has demonstrated that lack or limited institutional support is a major factor behind farmersô non-adoption of ECDIs in the Okavango Delta as evidenced by the fact that DWNP work station is available in the area but farmers were inadequately contacted by the extension agents. While individual farmers cited lack of expertise on proper application of ECDIs, VPCs stated that they were not supported in the administration of the project, especially during training and farm visits. It is therefore crucial for extension agents to discuss pertinent social issues with local stakeholders, identify problems together and support them with problem solving.

Farm labour and resources are significantly associated with farmersô adoption decisions of ECDIs. The majority of farmers in the trial communities are females and elderly people, and somehow contributed to the shortage of farm labour, especially when ECDIs are physically demanding and require youthful labour. Moreover, poor farmers are constrained to either hire labour or procure supplementary inputs (i.e., grease, oil and cloth). DWNP procure inputs, especially chilli pepper from abroad and provide them to farmers in the communities free of charge. Although supply of inputs to farmers increases their likelihood of adoption, the arrangement is expensive and has negative long-term impact on the success and sustainability of the project. As a matter of policy, government or DWNP has to spell out the need for ensuring sustainable and stable means of input production locally. Better still, the government need to incentivise the private sector to conduct research on how to strengthen indigenous knowledge of deterring crop-raiding elephants.

5.9. Recommendations for Research and Practice

Recommendations for Research

Future research on adoption of ECDIs needs to focus on the following:

1. The current study assumed that the farmers using the recommended deterrent innovations should make the choice out of volition. However, findings indicated that some adoptions may have been somewhat informed by certain conditions within institutional framework and directives. Therefore, future studies need to define adoption in a way that it will capture adoptersô actual adoption behaviour.
2. The current study focused on novel approaches of deterring crop-raiding elephants. But then, farmers still use them concurrently with traditional methods. Therefore, there is need for future research to explore utilization of traditional methods to find ways on how to improve and integrate them with the óforeignô ones to address not only issues of socioeconomic context, but to achieve sustainability of the mitigation program.
3. The study found institutional issues to play a vital role in the adoption of ECDIs. It is, therefore, recommended that future studies need to focus on the diffusion process per se and establish how it affects adoption of ECDIs.

Recommendations for practice

1. In order to address factors which adversely affect farmersô likelihood to adopt ECDIs, extension agents need to thoroughly engage with, robustly train, and support VPCs and farmers in their adoption efforts. Policies have to prioritise factors that affect ECDI adoption decisions related to socioeconomic and institutional structure of the communities.
2. Those advocating for change, including wildlife managers, need to identify appropriate dissemination and training pathways which are context-specific and essential for imparting knowledge to people with low literacy level. While the local farmers studied were involved in administering and monitoring of the project (which to some extent

increased the prospect of ECDI adoption), extension agents need to sustain their institutional support to aggressively address some of the challenges confronting subsistence farmers. There is need for creating a genuine farmer-scientist-extension linkage, which would facilitate exchange of useful information and bring about better understanding of the introduced innovations.

3. Also, it is crucial to integrate a compensation program (for damaged crops) into the broader elephant crop-raiding mitigation program. This is with a view to increasing farmersô tolerance for elephants by alleviating the farming communitiesô socioeconomic hardships associated with elephant crop-raiding. The recommendation is made in the light of farmersô frequent digression during discussions and interviews by harping on the hardships they experienced in their livelihood activities. So policymakers would need to reflect on the current compensation scheme as whether or not it has effectively achieved its goals.

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APPENDIX A

4.7. INFORMED CONSENT

INFORMED CONSENT

ADOPTION OF ELEPHANT CROP-RAIDING DETERRENT INNOVATIONS BY SMALLHOLDER ARABLE FARMERS IN THE OKAVANGO DELTA, BOTSWANA

Please read this consent letter carefully before you decided to participate in this stud,

I am SEKONDEKO RONNIE NOGA, an MPhil graduate student at the Okavango Research Institute (Maun), University of Botswana. You are kindly requested to take part in this study. However, your decision of participation is voluntary and as such you are free to withdraw from it anytime you feel so without necessarily having to give explanation. You are also advised that your consent to participate in the study would not result in a form of benefits specifically for you, whether direct or indirect. Further, you are assured that there are no any perceived risks or harm that you will be exposed to by taking part in this research study. The study is intended to assess the levels of elephant crop-raiding deterrent innovations (i.e., chilli pepper and beehive fence) uptake among arable farmers in the Okavango Delta, Botswana, and the factors influencing their adoption. In the event that you agree to participant in this study, you will be requested to provide answers to a set of research questions aimed at addressing the study objectives. The interviews are expected to last for about 15 minutes or even less, and your cooperation is highly appreciated. Moreover, your participation in this study would be kept confidential between me and you, and my other project team members. This is meant to protect you from any form of prejudices that may arise as a result of your participation in the study. Thank you once again for taking your time to participate in this research study.

Please do not hesitate to contact me at 72859862 or 6861 7286, ORI, Private Bag 285, Maun, Botswana should any need arise or if you require any further explanation about the study or your participation in it. Alternatively, you can contact my supervisors Prof O.D. Kolawole, Drs O.T. Thakadu and G.S. Masunga at 6861 7230, Private Bag 285, Maun.

Participant's consent

I have read and understood the contents of this agreement form, and consent that I will take part in the study. I declare that my decision to participate in the study is out of my own volition. [Name of researcher] has answered all my questions.

_____ _____

Signature of participant Date

_____ _____

Signature of Researcher Date

APPENDIX B

4.8. DATA COLLECTION INSTRUMENTS

FARMERS' ECDI ADOPTION SURVEY

Date of Interview: | | | | | | | |

Start time

Enumeratorôs name: _____

DEMOGRAPHIC/SOCIO-ECONOMIC CHARACTERISTICS			
Q1	**Gender**: Please indicate whether you a male or female by ticking one of the options	Male Female	0 1
Q2	**Age**: How old are you?	20 ï 29 years 30 - 39 years 40 - 49 years 50 - 59 years 60 years and above	1 2 3 4 5
Q3	**Level of education**: What is your level of education?	None Primary Secondary Tertiary Adult literacy	1 2 3 4 5
Q4	**Family size**: How many people live and eat together under your roof?		
Q5	**Ethnicity**: To which ethnic group do you belong?	HamBukushu BaSarwa BaYei BaXhereku BaKgalagadi	1 2 3 4 5
Q6	**Income level**: What is your total monthly income?	BWPÒ100 BWP101 ï 500 BWP501 ï 1 000 BWP1 001 ï 5 000 BWP5 001 ï 10 000 BWP10 001 ï 20 000 Above BWP20 0001	1 2 3 4 5 6 7
Q7	**Sources of income**: What is your current source of income?	Farming Fishing Hunting Remittances Government fund	1 2 3 4 5

		Cash employment Sale of craft products Others (specify):	6 7 8
Q8	**Land ownership**: Do you own land for arable farming?	Yes No	1 2→ **Q10**
Q9	**Size of land owned**: How many hectares is the land?		
Q10	**Nature of farming**: Do you engage in part-time arable farming or full-time?	Part-time Full-time	1 2
Q11	**Contact with extension agency**: How many times do you have contact with extension per quarter?	Once/quarter Twice/quarter Thrice/quarter Always	1 2 3 4
Q12	**Cosmopoliteness**: How often did you travel outside of your immediate community to other surrounding communities to seek agricultural information regarding your farming in the past 5 years?	Never 1 ï 2 times 3 ï 4 times More than 5 times	1 2 3 4
Q13	**Sources of information**: Do you have access to the following modes of communication?	Radio Television Tel/Cell phone Newspapers Friends Neighbors	1 2 1 2 1 2 1 2 1 2 1 2

Note: SA ï Strongly Agree. A ï Agree. U ï Undecided. D ï Disagree. SD ï Strongly Disagree.

ESTABLISHING RISK-AVERSION AND FATALISM CONCERNS						
Risk-aversion: An individualôs tendency to take or avoid risks in their decision making OR the extent to which an individual is not willing to venture into something new for fear of failure						
	Statements	**SD**	**D**	**U**	**A**	**SA**
Q14	I like to double my enterprise					
Q15	If I believe an investment will carry a profit, I am willing to borrow money for it.					
Q16	I donôt like to invest in something that I have little knowledge about					
Q17	I find it more important to invest safely and to get a guaranteed return than to take risks in order to possibly get a higher return.					
Q18	Investing in new enterprises is something I donôt do, since it is too risky.					
Q19	I want to be sure my investments are safe					
Q20	I am increasingly convinced that I need to take more financial risks if I want to improve my annual agricultural harvests.					
Q21	I am willing to run the risk of losing money if there is also a chance that I will get better return from it.					
Fatalism: The tendency for an individual to resign to fate; the belief in the notion of ówhat will be will beô						

	Statements	SD	D	U	A	SA
Q22	What will be will be					
Q23	Each person is primarily responsible for his/her success or failure in life					
Q24	Oneôs success or failure in life is a matter of his/her destiny					
Q25	To be successful, above all one needs to work very hard					
Q26	If I just pray to God about my crop protection, he will work it out					
Q27	If God want me to survive, he will protect my crops against raiding elephants					
Q28	I trust God, not elephant deterrents, to protect my crops					
Q29	I donôt need to try to improve my crop protection measures because I know it is up to God					

PERCEPTIONS TOWARDS CHILLI PEPPER INNOVATION						
	Statements	SD	D	U	A	SA
Q30	The procedure for adopting chilli pepper innovation is clear and understandable to me					
Q31	I find the innovation very effective in deterring elephants					
Q32	The innovation is a waste of time					
Q33	The input supply base for the innovation is satisfying					
Q34	The adoption process of the innovation is full of drudgery and boring					
Q35	I find traditional methods much more effective than the innovation					
Q36	I think that using chilli pepper to deter elephants would fit well with the way I like to work					
Q37	I find the innovation very expensive to implement					

PERCEPTIONS TOWARDS BEEHIVE FENCE INNOVATION						
	Statements	SA	A	U	D	SD
Q38	The procedure for adopting beehive fence innovation is clear and understandable to me					
Q39	I find the innovation very effective in deterring elephants					
Q40	The innovation is a waste of time					
Q41	The input supply base for the innovation is satisfying					
Q42	The adoption process of the innovation is full of drudgery and boring					
Q43	I find traditional methods much more effective than the innovation					
Q44	I think that using beehive fence to deter elephants would fit well with the way I like to work					
Q45	I find the innovation very expensive to implement					

ESTABLISHING INNOVATION CHARACTERISTIC CONCERNS				
Q46	**Compatibility**: The degree to which the procedures and outcomes of the innovation is in agreement with peopleôs belief systems			
	Innovation	Not compatible with culture of the community (1)	Less compatible with culture of the community (2)	Compatible with culture of the community (3)
	1. Chilli pepper			
	2. Beehive fence			
Q47	**Cost**: The degree to which the financial or capital outlay required for adopting the innovation is bearable to the resource-poor farmer			
	Innovation	Not expensive (3)	Less expensive(2)	Expensive (1)
	1. Chilli pepper			
	2. Beehive fence			
Q48	**Complexity**: The degree to which an innovation adoption process is easy to understand by the end users			

	Innovation	Not complex to implement (3)	Less complex to implement (2)	Complex to implement (1)
	1. Chilli pepper			
	2. Beehive fence			
Q49	**Trial-ability**: The degree to which innovations could be tried out in small bits			
	Innovation	Not triable: Cannot be tried out in small bit (1)	Less triable: To some extent, it can be tried out in small bit (2)	Triable: Can be completely tried out in small bit (3)
	1. Chilli pepper			
	2. Beehive fence			
Q50	**Effectiveness**: The degree to which a farmer perceives that the objectives of the innovation has been achieved (Kolawole, 2002; 2006)			
	Innovation	Not effective (1)	Less effective (2)	Effective (3)
	1. Chilli pepper			
	2. Beehive fence			

INSTITUTIONAL FACTORS AFFECTING ADOPTION			
Q51	**Extension methods**: Which methods did extension agents use to spread innovation messages?		
	Communication channels: Which communication channels were most used to deliver messages to you?		
Q52	**Language of innovation dissemination**: In which language were you informed about the innovation?	Setswana Sekgoa Xhireku Mbukushu Sesarwa Sekgalagadi Seyei Others (specify):	1 2 3 4 5 6 7 8
Q53	Did you understand the messages you were told?	Yes No	1 2
Q54	**Credibility**: Do you think extension agents fulfil their promise?	Yes Not	1 2

		Sometimes	3
Q55	**Extension manpower**: Would you say there are enough extension agents at your disposal?	Yes No	1 2
Q56	What do you understand about the role of the government in extension services to be as?	Government provides logistics support for extension personnel to carry out their jobs Government provides financial support to drive extension activities Government provides enough trainings for extension personnel Government is not doing enough to promote extension activities	1 2 3 4
Q57	What should the government be doing to assist extension services to carry out their work efficiently?		

ADOPTION OF ELEPHANT CROP-RAIDING DETERRENT INNOVATIONS			
Q65	Which of the introduced deterrents did you adopt?	Chilli pepper Beehive fence Chilli pepper & beehive fence None	1 2 3 4
Q64	When did you adopt the innovation?	In the first year In the last 2 years In the last 3 years In last 4 yeas In the last 5 years	1 2 3 4 5
Q65	Why did you adopt the innovation?	Because it is effective Because others are using it Had no other option Others (specify):	1 2 3 4é é é é é
Q66	Was a cash investment involved?	Yes No	1 2

Q67	If you made cash investment, how much did you invest?	<P100 P101 ï P500 P501 ï P1000 P1001 ï P5 000 P5 101 ï P10 000 P10 001 ï P20 000 >P20 000	1 2 3 4 5 6 7
Q68	Do you feel you have received a positive return on your investment?	Yes No	1 2
Q69	Do you still use the innovation?	Yes No	1 2
Q70	Do you currently have plans to implement additional changes in your operation in the future?	Yes No	1 2

Note: Adoption index; none = 0/2 (i.e. 0); 1 adopted = ½ (i.e. 0.5); 2 adopted = 2/2 (i.e. 1)

APPENDIX B ï 1

FOCUS GROUP DISCUSSION GUIDE—[farmers]

1. Which animal 'pests' are common raiders of your fields?
2. At what time of the year are these raiders more active and destructive?
3. Rank raiders in order of impact on your food supply and income.
4. What in your opinion has engendered the rise in crop raiding by elephants?
5. How do you normally protect your crops from raiding elephants?
6. Do elephants still raid your fields even though you have put in place some deterrent measures?
7. Does the community assist each other in the battle against raiding elephants?
8. How committed are the individual farmers in the implementation of recommended elephant deterrent measures?
9. Do you think that the institutions or people advocating for the recommended innovations do understand the realities of farming, or at least of your farm?
10. Are there any beliefs about the use of chilli pepper and bees in mitigating crop damage by elephants?

APPENDIX B ï 2

Key Informant Interview Guide

Introduction and purpose of the survey

This survey has been authorized by the Okavango Research Institute, University of Botswana. The study is intended to understand the dynamics in the diffusion and adoption of elephant mitigation strategies in the Okavango Delta and it's environ. You are being contacted for your expertise in either/all of agricultural innovations, wildlife management and community people. Your responses will be used to identify priority intervention areas of communication of and education in agricultural innovations.

Thank you very much for your responses

1. What criteria guide the choice of innovations that are to be diffused?
2. What influence does society's social structure have over individual innovation adoption decisions?
3. Do you think the technological innovations being introduced and diffused are appropriate, well-proven and adequate for the area under current study?
4. To what extent is the role of government in agricultural extension services in the study area?
5. In your own views as extension personnel, what would you say are the pressing issues in your day to day work that need government support but have not yet been addressed?
6. Does your organization engage in impact evaluation of the introduced elephant deterrent innovations, in particular through interventions not directly supported by your agency, e.g. through your research budget?
7. Do you think scientific findings are helpful in solving the problems of innovation diffusion and adoption?