Stated preference and cost-based approaches to estimate the benefits of controlling invasive alien plant species in the Hhohho region of Swaziland

by

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Declaration of originality

I hereby declare that this dissertation which I submit for the degree of MSc Agricultural Economics at the University of Pretoria is my own work and it has not been previously submitted by me for a degree at this or any other institution of higher learning.

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Date .....

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Signature .....

Dr E.D. Mungatana

Date .....

Signature .....

Dr B.O. Abidoye

Date .....

Dedication

I humble dedicate this paper to the Almighty God for allowing me to have all the strength and potential for pushing it till the last word. I would not have done it was it not for his grace on me.

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Abstract

This study uses stated preference and cost-based approaches to estimate the benefits to cattle farmers of controlling invasive alien plant species (IAPS) on communal grazing lands in the Hhohho region of Swaziland, where about 80% of the grazing land is invaded. This invasion has lead to some government ranches having to close down and the death of over 7,000 heads of cattle due to starvation-related ailments, thus causing huge welfare losses. In response, the study assessed cattle farmersô levels of knowledge of IAPS and their associated impacts, used a probit model to identify factors affecting cattle farmersô willingness to pay (WTP) for their control, estimated cattle farmersô mean WTP for reducing IAPS infestation from current levels by 50% and 100% respectively, and elicited cattle farmersô preferences for institutional arrangements to control and manage IAPS. Using a sample size of 192 farmers, the study established that over 85% of the cattle farmers had a high level of knowledge of the dominant IAPS affecting their grazing lands. Over 90% of the farmers were familiar with the negative effects of IAPS (e.g. reducing agriculture land, contributing to economic loss and great threat to biodiversity). Over 60% of the farmers were at least familiar with the positive effects of IAPS (e.g. providing food, firewood and preventing soil erosion). Levels of knowledge of IAPS were significantly influenced by age (χ^2 = 3.43, p=0.000). The mean WTP for complete removal of IAPS was found to be significantly influenced by level of bid offered (Z= -3.371, p=0.000), number of dependents (Z= -2.23, p=0.026), levels of income (Z= 2.19, p=0.029), and number of cattle owned (Z= -.3.12, p=0.020). A mean WTP of E60.50 per head of cattle (95, 54.51 ï 72.64) was established for 100% removal of IAPS and a mean WTP of E35.89 per head of cattle (95, 31.53 ï 49.95) for 50% removal. Mean WTP for 100% removal was significantly higher than that of 50% removal (t= -10.23, p=0.000) satisfying the scope test for stated preference responses. An estimated mean WTP of E52.23 per animal was obtained using the mitigation cost approach, which is consistent with theoretical expectations considering that the later gives a lower bound to the true Hicksian welfare measure. Finally, the study revealed a preference for community members to control and manage the spread of IAPS over private contractors or NGOs. In conclusion, this study demonstrates that making investments in the control of IAPS today would potentially save society huge future welfare losses.

Key words: invasive alien plant species (IAPS), willingness to pay (WTP), welfare estimates, institutional arrangement.

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List of Acronyms

CDF	Cumulative Distribution Function
CVM	Contingent Valuation Method
DBDC	Double Bounded Dichotomous Choice
DC	Dichotomous Choice
EU	European Union
GDP	Gross Domestic Product
GISP	Gonococcal Isolate Surveillance Project
IAPS	Invasive Alien Plant Species
IAS	Invasive Alien Species
IPS	Invasive Plant Species
IRIN	Integrated Regional Information Network
LB	Lower Bound
LHS	Left hand side
LR	Likelihood Ratio
NGO	Non-governmental Organization
RDA	Rural Development Area
RHS	Right hand side
SBDC	Single Bounded Dichotomous Choice
SZL	Swaziland Lilangeni
UB	Upper Bound
UK	United Kingdom
UNDP	United Nations Development Program
US	United States
USA	United States of America
WTP	Willingness To Pay
ZAR	South African Rand

1. Introduction

1.1 Background

Invasive alien plant species (IAPS) are defined as plants that are non-native to an ecosystem and which may cause economic or environmental harm or adversely affect human health (The Convention on Biological Diversity, 2009). IAPS may also be termed as weeds, that is, plants that are objectionable or interfere with the activities and welfare of people (Ossom, Lupupa, Mhlongo & Khumalo, 2007:704). IAPS have indicated their prominence by invading and occupying about 80% of Swazilandôs land area at varying densities (Kotzé, Sibandze, Beukes, Van den Berg, Weepener & Newby, 2010:38). Unmanaged land areas like grazing lands had been greatly hit by IAPS. This had adversely affected the livestock industry and consequently the welfare of livestock farmers countrywide.

Generally, IAPS may contribute negatively or positively to society. Many authors (e.g. Garcĕa-Llorente *et al.,*2008; Marais *et al.,* 2004; Pimentel *et al.,* 2000*)* have studied the positive and negative effects of IAPS and several findings have been obtained. Some species have been found to be of economic benefit yet others are just a menace. Some of the economic benefits highlighted by Garcĕa-Llorente *et al.* (2011:418) include provision of food (e.g. fruits from *Psidium guajava*), firewood, horticultural use and commercial forestry. Even though some IAPS have some positive benefits, in Swaziland these benefits are not observed as the dominant IAPS have no use as they encroach on grazing lands, deplete biodiversity and some being poisonous when consumed by livestock.

Garcĕa-Llorente *et al.* (2011:418) further mentioned that IAS are one of the greatest threats to biodiversity and consequently have effects on a range of ecosystem services essential for human well-being. Pimentel *et al.* (2000:61) emphasized that IAS are now ranked as the second most serious threat to global biodiversity loss after direct habitat destruction. Marais *et al.* (2004) added that these species also affect catchment stability and the agricultural potential of land. IAPS in Swaziland pose a greater threat as the invasion has reached over 80% of the total land size. Even though IAPS gradually invaded the country with no much notice since the 90s, their impact was felt in 2004/5 when most government ranches were affected.

The beef industry had already been badly hit by IAPS in Swaziland. In 2006 a government owned ranch (Nkalashane Ranch) in the Lubombo region was forced to cease operation as the weed invaded its entire territory. In the same year, the infestation of IAPS also compelled Magoga Sisa Ranch in the Hhohho region to reduce the number of cattle from 2000 to 800 (60% reduction). Bhalekane Fattening Ranch has also been badly infested and Khumalo (2010) reported that cattle numbers were dwindling. Communal grazing lands have diminished significantly as a result of IAPS invasion. These plant species have replaced fodder and taken full control over pastures as they grow fast and overcrowd the grass (Integrated Regional Information Network (IRIN), 2007). The future of livestock farmers is at stake. In July/August 2012, about 10 000 cattle died due to malnutrition related deaths as a result of overstocking as more pastures are covered by IAPS (IRIN, 2012).

The direct and indirect impacts of IAPS invasion in Swaziland are not yet quantified. Estimating such impacts cannot be easily done. However, with the reported densities that about 10.68% of the land area is said to be invaded at 100% density, one can tell that so great is the impact already. About 80% of the land area is also invaded at varying densities (Kotzé *et al.*, 2010:38). IAPS were declared a national crisis by the Swaziland government in 2005. This was after some government officials (including the Prime Mister at that time, Dr. Sibusiso B. Dlamini) had some field visits to some parts of the country which included the Hhohho and Lubombo regions. They discovered that the countryøs biodiversity, human health and socio-economic development were faced with serious threat from IAPS (Zwane, 2010).

There are about 340 IAPS that are listed in Swazilandøs alien plants data base (Ossom *et al.,* 2007:705). Among these, four major species dominate in most parts of the country and are highly prolific. These are *Chromolaena odorata* (Triffid weed), *Lantana camara, Solanum mauritanum* and *Psidium guajava.* These species occupy a significant portion of the 80% of infested land on both Title Deed Land[1] and Swazi Nation Land[2], which are the two land ownership systems in the country. Kotzé *et al.* (2010:57) estimated the cost to clear these four

[1]Privately owned land
[2]Land held in trust for the nation by the King with the assistance of chiefs

species to be SZL213 596 360.00[3], SZL144 575 175.00, SZL20 687 177.00 and SZL8 317 981.00 for *Chromolaena odorata, Lantana camara, Solanum mauritanum* and *Psidium guajava* respectively in condensed areas. These figures alone indicate how great an impact this will likely have on government coffers if IAPS remain uncontrolled.

About 70% of Swazilandôs population depend on agriculture for their livelihood (African Outlook, 2010) of whom 63% live below the US$1.25 per day poverty line (UNDP, 2011:2). The over E387 million estimated cost of clearing condensed areas of these four species could significantly improve the lives of a number of Swazis. This is one indicator that IAPS invasion is negatively affecting the economy. The proliferation of IAPS also negatively affects farmers by reducing the size of arable land and grazing pastures. IAPS also limit the availability of water for irrigation through itôs over utilization of underground water. Thus said, the impact of IAPS in Swaziland is already felt on the economy, biodiversity and most importantly the beef industry as fodder has been replaced significantly on communal grazing lands.

The IAPS control programme which was initiated in 2005 was suspended in 2010 when politicians felt the programme should be undertaken by community members. At that time, the control programme was conducted by private contractors who took over from community members in 2006/7 after their failure to carry out the control due to very poor incentives. Parliamentarians felt the contractors charged government exorbitant funds. Worth noting, however, is that the control process was first given to community members. Government would provide working tools and food to the participants but there was later a poor turn up from the community members because the incentives were not attractive enough. It was then that the programme was given to private contractors. Of note is that the species are growing at an alarming rate and continually replacing fodder and sweeping out biodiversity with the prevailing control suspension. This means more and more unmanaged ecosystems will be invaded leaving pastures completely engulfed and cattle owners badly hit. Greatest infestation densities are observed in the Hhohho and Lubombo regions. This has led the study to be

[3]SZL represents Lilangeni, the Swaziland currency. 1SZL = 1ZAR, the South African Rand ($1=9.16ZAR)

conducted in one of these regions, Hhohho. The study was limited to this region due to the fact that this region has the largest number of livestock and cattle owners compared to the other region. Also, financial constraints confined the study to the Hhohho region as resources were not enough to incorporate sampling units from the other region. However, results obtained from the analysis of data from one of the regions can be generalized to other regions as the respondents are a bit homogenous.

1.2 Study area

The study was conducted in the Hhohho region (Ntfonjeni RDA) of Swaziland which is in the northern-most part of the country. It was conducted in communities under the Ntfonjeni Rural Development Area (RDA) with coordinates 25^0.82ô62.69òS and 31^0.32ô11.50ôôE. This location has an estimated total area of about 3,500ha. The areas (under Ntfonjeni RDA) which according to Kotzé *et al* (2010) who conducted a mapping programme on the density and spread of IAPS, are reported to be the highly infested in the region and with the highest density in the country. Even the other three administrative regions (Manzini, Lubombo and Shiselweni) are infested but the greatest density is reported to be in this region (Northern part of the Hhohho region), particularly in the communities where the study was conducted.

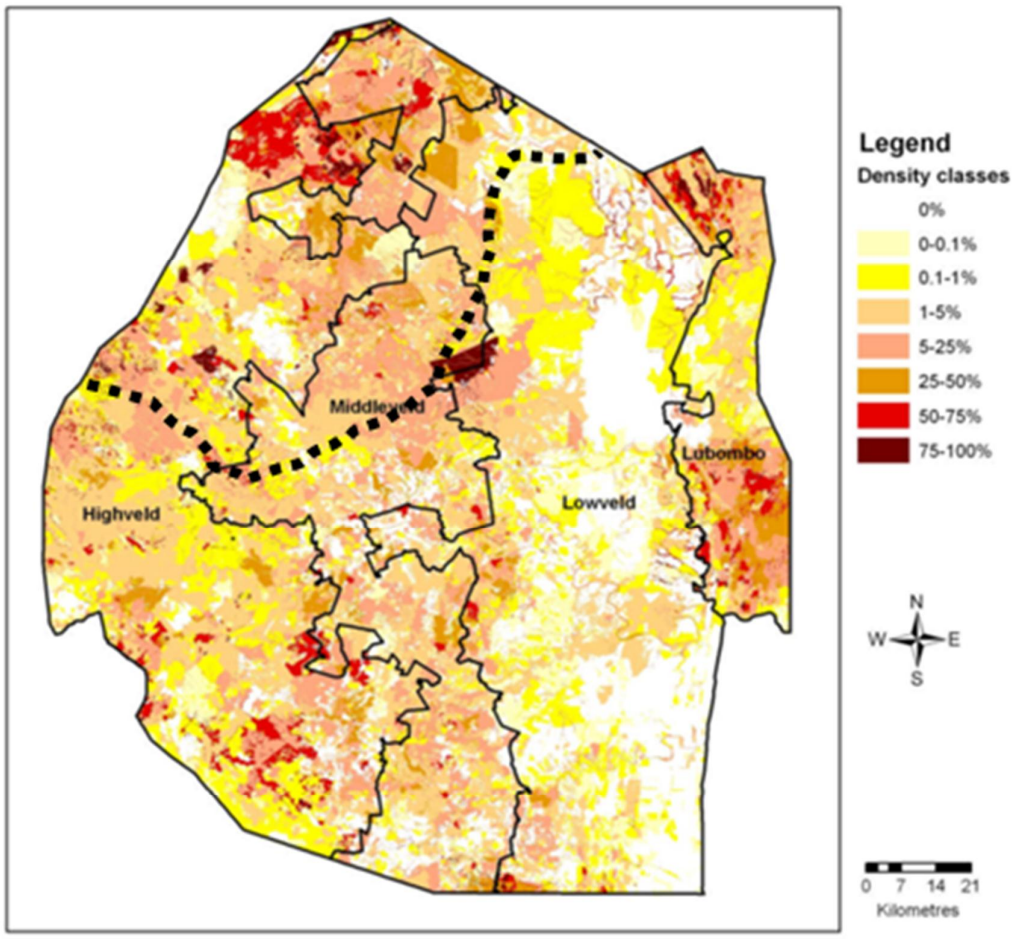
About 160 hectares of land had been cleared of IAPS in the Hhohho region since the control programme was initiated in 2005. However, still large areas remain infested to date and re-growths have established on the areas which were cleared. This region is the smallest in size yet it has the greatest proportion of cattle owners after Manzini in relation to the other regions. Hhohho has an estimated cattle population of about 125,436 which is about 20.6% of the total cattle population in Swaziland. The estimated population of household heads owning cattle was 11,829 in Hhohho alone (Government Statistics, 2012). In Ntfonjeni RDA, there were about 1,518 cattle owners owning a total of about 13,820 cattle and grazing them on communal lands (Ntfonjeni RDA, 2013).

Even though there were other livestock types which utilize grazing lands like goats and sheep, the focus was only on cattle owners because most households own cattle relative to the other

types of livestock. Cattle are also the main users of communal grazing lands in the country at large. This was done because the researcher aimed at obtaining results from a homogeneous group of respondents.

Figure 1 below shows the map of Swaziland with the Hhohho region being the top most part demarcated by the dotted line. The map shows the infestation and density of IAPS invasion in the country with a key alongside indicating percentage density classes. The study was conducted in the northern-most part of the country where high densities are observed.

Figure 1: The Hhohho region and the map of Swaziland showing IAPS infestation densities.



Source: Kotzé *et al* (2010:40).

1.3 Problem statement

The dominant IAPS in Swaziland prove to be a menace as they have affected pastures. One would acknowledge the benefit that is offered by *Psidium guajava* which include provisioning of fruits and firewood but these benefits cannot be compared to the effect they cause on grazing lands as they replace fodder and biodiversity. When IAPS grow into unmanaged ecosystems, they dominate the land as they grow fast and are easily disseminated. IAPS invasion on grazing lands have greatly reduced the grazing landsô carrying capacities. As a result the Swaziland government projected a 90% loss in grazing lands in the next few years (IRIN, 2007). Stocking rates are going to be so high. This is going to drastically affect cattle owners who have been enjoying large revenues from beef exports to the European Union (EU) and Norway. The Swaziland government must protect the beef industry by controlling IAPS on grazing lands. However, since the control process is a very costly undertaking, it is of paramount importance to estimate the welfare benefits on cattle owners of controlling IAPS. This study aims at obtaining this. The welfare changes which are obtained using monetary measures of welfare will help influence policy decisions on the control of IAPS. By conducting this study, the welfare benefits of controlling IAPS on communal grazing land were estimated through willingness to pay (WTP) elicitation and cost-based approaches. Also established are the factors that affect livestock ownersô WTP for the control of IAPS which helped in making the relevant conclusions and recommendations on the magnitude of the farmersô WTP.

For the control process to be economically and efficiently carried out, a clear strategy and coordination process should be devised. The suspension of the control programme by policy makers came to effect because, among other reasons, there was no clear strategy. Even though policy makers felt the control process should be removed from private contractors to community members due to observed cost effects, their move should be based on realistic facts. A clear and precise view of a better institutional arrangement on the choice of who should effectively control IAPS between the community members and private contractors lies with the main stakeholders (the community members). Therefore, because of the strong public good element in the eradication of IAPS, it was imperative to study the knowledge of community members on IAPS effects and the proposed design of the eradication process. It is

therefore as a result of the aforementioned background that this study is designed to address the following objectives.

1.4 Objectives of the study

1.4.1 General objective

The general objective of this study is to estimate the welfare benefits of controlling IAPS to cattle farmers in the Hhohho region of Swaziland through willingness to pay (WTP) elicitation.

1.4.2 Specific objectives

The specific objectives are:

i. To determine the knowledge of livestock farmers on IAPS and their associated impacts.
ii. To identify the factors affecting livestock farmersô willingness to pay for the control of IAPS on grazing land in the Hhohho region of Swaziland.
iii. To estimate the welfare benefits to cattle famers of the Hhohho region of Swaziland when there is a control of IAPS on grazing land.
iv. To assess the institutional arrangement of controlling IAPS as suggested by livestock farmers, that is, if it can be better off to employ the service of private contractors or that of community members in the control process.
v. To compare the WTP 50% and WTP 100% by a way of conducting internal validity of the WTP instrument.

1.5 Hypotheses of the study

The hypotheses were in line with the objectives of the study. These hypotheses correspond to the general objective of the study together with the five specific objectives thereof and written in a chronological manner.

General hypothesis:

The control of IAPS will help to improve the welfare of the livestock farmers in the Hhohho region of Swaziland by enabling fodder growth. For that reason, it is hypothesized that livestock farmersô willingness to pay will be different from zero.

Specific hypotheses:

1. The government of Swaziland had since 2005 been raising awareness of the dominant IAPS and their effects to the environment, socio-economy and biodiversity.
    a. It is therefore hypothesized that livestock farmers have a high level of awareness of IAPS
    b. Livestock farmers have a high level of knowledge of the associated impacts of IAPS

2. Many authors (e.g. Farolfi *et al* 2007; Garci`a-Llorente *et al.*2008; Du Preez *et al.* 2009) indicated that WTP is a function of different variables depending on the good in question. The WTP function for the control of IAPS is hypothesized to be influenced by; household income, household size, age of the household head, gender of household head, number of livestock owned, bid offered, marital status and education level.

3. The welfare benefit of controlling IAPS to livestock farmers is different from zero.

4. Socio-economic characteristics of respondents (e.g. income, education level, quantity of cattle owned, gender and age of respondent) do not influence respondentsô view on who should be employed in the control of IAPS.

5. According to Hanley and Barbier (2009), the last step in conducting a CVM study involves conducting validity checks. Among the validity checks explained is the scope test which examines whether WTP varies significantly with quantity on offer. Therefore a simple scope test that was conducted is a null hypothesis that $WTP(q_2) > WTP(q_1)$ where q_2 is assumed to be greater than q_1.

1.6 Importance of the study

The control of IAPS has already significantly drained Swazi governmentôs coffers whereby over E40million was spent to clear IAPS from about 18000ha. This large sum of money had been spent to clear rangelands of IAPS in an attempt to prevent loss of fodder and biodiversity. By conducting this study, livestock farmersô welfare benefits to the control of IAPS will be estimated and this will help in making informed decisions on the justification of these expenditures. By eliciting the WTP of the livestock farmers, a comparison of their estimated contributions with the marginal cost of the control programme which can enable policy makers to say the control programme is necessary or not, can be done (i.e. when sum of total contributions is greater than marginal cost then the control programme is necessary and justified).

Having mentioned that WTP was a tool that was employed in the study, it was noted that there were many approaches that could have been used to value the environmental goods. These approaches may include cost-based approaches. However, cost-based approaches do not measure preferences yet the control of IAPS on rangelands needs the farmers to state their preferences to better measure the benefit of the control. It is therefore with that reason that WTP was found to be an appropriate measure of welfare to livestock farmers relative to other approaches at it measures preferences.

On another note, since parliamentarians have felt that the control of IAPS should be done by community members and be paid a certain amount as compensation other than hiring the services of private contractors, it had remained a question of interest as to whether community members are willing to participate in the control programme or not. By conducting this study, substantial evidence was obtained on the institutional arrangement that community members felt should be employed between the use of private contractors and community members for the control process. This will help policy makers to make informed decisions on the design of the overall control programme.

1.7 Organization of the study

The study is organized into five chapters. Chapter one discusses the background/introduction of the study. Chapter two gives the theoretical and empirical literature of the study. This is where a discussion of the measures of welfare are discussed in detail together with other findings from studies conducted in the same area of interest as this study. Chapter three discusses the methodologies used in conducting the study. The results are given and discussed in Chapter four. Lastly Chapter five gives the conclusion and recommendations of the study.

2. LITERATURE REVIEW

2.1 Empirical Literature

2.1.1 Factors affecting WTP

Farolfi, Mabungu and Ntshingila (2007:159-160) whose main objective was to determine the amount Swazi households were willing to pay for an improvement in quality and quantity of water and also determine the factors which influence the WTP for both quality and quantity, observed that several factors influence this. In their study, a Tobit model was employed to explain respondentsô preferences for improved water quantity and quality. And since the Tobit model simple gives the probability of occurrence of an event and not the actual WTP value, descriptive statistics were used to obtain the actual estimated WTP for improvement in quality and quantity of water.

The WTP function was expressed as a function of eleven explanatory variables and among these, only six were statistical significant in explaining WTP. Among the significant variables, four were positive and these are; household income, collection time (i.e. time taken to reach to the source of water and collect it), age and gender of respondent. Water consumption and water source were negative and significantly affecting the WTP of households.

Du Preez *et al.* (2009:142-146) on a different study identified a WTP function and fitted the Tobit model to the data. This was done because the Tobit model only predicts non-negative values compared to the ordinary least squares. The parameters of the Tobit model were then estimated using the maximum likelihood model. Two variables were significantly influencing the WTP in the reduced Tobit model and these were the knowledge variable and the income of the respondent. The results were obtained after respondents were asked how much they were WTP for a project that eradicate invasive species and restores indigenous vegetation based solely on their preferences for indigenous vegetation rather than invasive species.

Garci`a-Llorente *et al.*(2008) who conducted a study to identify stakeholdersô WTP for the eradication of selected species, showed pictures of the species which were under investigation. This was to make sure the respondents were clear about the species under investigation. In their study, they employed an open-ended type of questions aiming at obtaining a more realistic and direct measure of respondentsô WTP value. To rectify the problem of the high zero responses which is associated with open ended questions, they employed a Heckman model where a WTP or unwillingness to pay is estimated first and then the positive WTP is estimated. In their study, when trying to obtain the factors that influenced respondentsô WTP for the eradication of invasive species, they found that among the several factors, only five were significant. These variables were: the household size, age of respondent, economy (which were all negative). Distance and respondentsô attitude towards invasive species were positive variables. These were obtained from using a probabilistic (Probit) regression function.

In a probit regression analysis by Garcé a-Llorente, *et al.* (2011:425-426), four variables explained the likelihood of participation in the eradication of IAS. These variables were active interest in nature and IAS knowledge, sense of place, impacts of IAS and household size. Education level also influenced the probability to pay. A larger household size negatively influenced an individualsô probability to pay. Higher WTP was associated with higher levels of income, active interest in nature and knowledge of IAS, and sense of place.

From the above reviewed studies it is observed that the variables affecting WTP differ depending on the environmental resource under question. The sign (+/-) (or direction) of each variable can not be predicted easily as it varies also with the resource under investigation. However, it is noted that variables like respondents, income level (or economy) positively influenced oneôs probability to pay. Household size and number of dependents on the other hand negatively influenced the likelihood to pay. This observation can be easily explained. An individual with high income level is most likely to pay because if one has more resources he/she is mostly likely to spare some for an extra project compared to one with low income level. The more dependents one has will most likely have to spare resources for the dependents compared with someone who has fewer dependents and having to spare just

enough for a few heads. The behaviour of variables like age, education level and marital status may vary depending on the environmental resource or service under discussion.

2.2 Welfare measurement in theory and in practices

2.2.1 Theory of welfare measurement

The starting point for the measurement of welfare changes from a utilitarian point of view is to measure the change in utility. The control of IAPS can either increase or decrease the utility an individual obtains from their existence. The difference in utility levels can be said to be equivalent to the welfare change of a particular individual. Utility maximization subject to an income constraint gives a framework upon which a market based consumption function can be analyzed. From this function, one can derive an indirect utility upon which other functions like the expenditure function can be derived.

According to Eom and Larson (2003:503), the expenditure function is used to measure welfare. Other welfare measures include; consumerôs surplus, compensating variation and equivalent variation. However, these are good welfare measures that are highly suitable for market goods. For environmental goods and services they cannot fit well unless there is a possibility for creating a market for that particular good or service under investigation. According to Chipman and Moore (1980:935), a good welfare indicator is said to be an acceptable measure of welfare change if it is a numerical indicator of change in the consumer's indirect preferences.

Gafni (1991:1247) highlighted that ñthe methods that are recommended in welfare economic theory to measure changes in a person's welfare as a result of a resource allocation change are 1) the person's maximum WTP for the good or service gained as the measure of benefits; and 2) the minimum level of compensation (willingness to accept) required for the person to give up a good or service as the measure of costs.ò Gafniôs statement is in line with the thought of the Millennium Ecosystems Assessment (2005:134). Adams, Bwenge, Lee, Larkin and Alavalapati (2011) highlighted that researchers have of recent decided to use hedonic analysis and stated preference approaches to determine the non-market value of efforts to control

invasive species. To obtain an appropriate measure of welfare, the value of environmental goods should be known. For proper allocation of scarce resources and for a good cost-benefit analysis, one has to be able to value the goods in question. Therefore the theory on valuation of environmental goods is essential in this study.

2.2.1.1 The concept of economic valuation

Ecosystems provide a number of services which include; provisioning, supporting, regulating and cultural services. These ecosystem services provide human beings with a certain degree of utility. This can either be enjoyed directly or indirectly (MEA, 2003). An individual derives some utility in the provision of a public good/service. This utility can be obtained by obtaining the individualôs reservation price. The reservation price is, however, unobservable. To obtain it, the individual should be given a good hypothetical scenario and be asked to state it, that is how much will he/she be willing to pay for the provisioning of the ecosystemôs good or service in question. This reservation price is equivalent to his/her willingness to pay (WTP) for the good.

The starting point for the valuation of environmental goods and services is the theory of public goods. There are two main characteristics of public goods. Public goods are non-rival and non-excludable. A good is said to be non-rivalry when a unit of the good can be consumed by one individual without detracting, in the slightest sense, the consumption opportunities still available to another individual for an equal unit. Goods are said to be non-excludable if their benefit is available for all individuals at once. The demand curve for the environmental good/service is unobservable. The consumption pattern of an environmental good/service cannot be easily determined but it can only be observed through observing the consumersô behaviour towards the goods/services that are linked to that good/service of interest (Bockstael & McConnel, 1998). An understanding of a good framework for the valuation of public/environmental goods is essential.

According to the Millennium Ecosystem Services (2003), the Total Economic Value (TEV) is the most widely used framework for looking at the utilitarian value of an ecosystem. The TEV

framework is disaggregated into two categories: use values and non-use values. Use value is the value of those ecosystems that are used by human beings for both consumption and production purposes. Under use values we have direct use values (consumptive and non-consumptive), indirect use values and option values (bequest value, quasi-option value). There are several methods that are used in the valuation of these values. For direct use values; change in productivity, cost-based approaches, hedonic prices, travel costs and contingent valuation can be used. Also, change in productivity, cost-based approaches and contingent valuation can be used to estimate indirect use values and similarly option values.

Non-used values on the other hand include existence values which can be estimated using contingent valuation methods. The TEV framework is shown in Figure 2. It indicates the TEV categories and most commonly used methods of valuation for the different TEV categories.

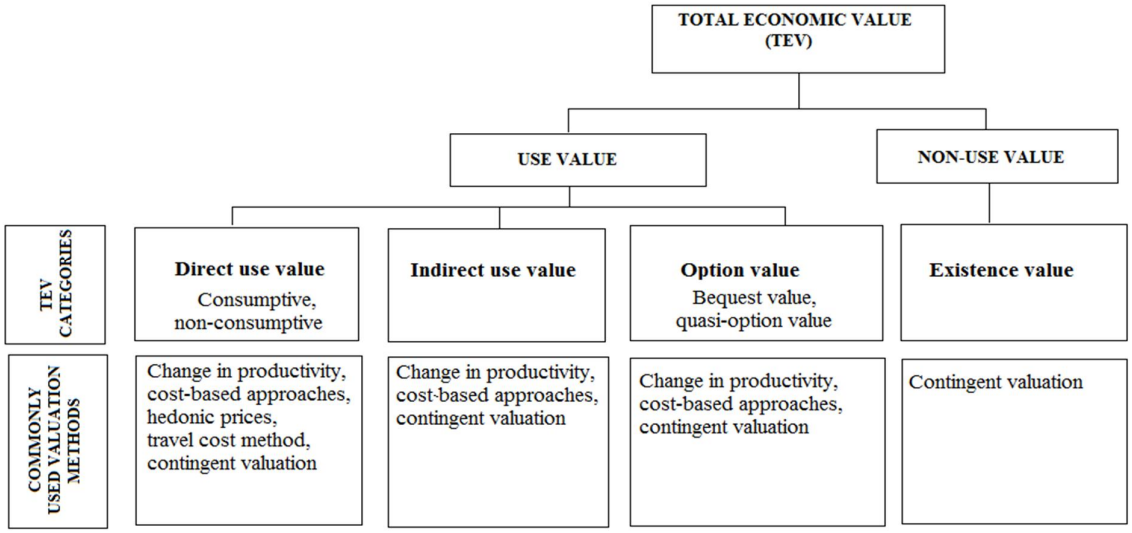


Figure 2: The Total Economic Value Framework
Adapted from: MEA 2003.

Since this study seeks to obtain the welfare changes of livestock farmers as a result of controlling IAPS, different welfare measures are discussed in the next sub-section.

2.3 Tools of welfare measurement

2.3.1 The indirect utility and the expenditure functions

According to Haab and McConnell (2002:5), for welfare benefit estimation, one has to first estimate the individual preference function. The individual utility function, u(**x**, **q**) can be assumed where **x** is assumed to be a vector of private goods and **q** is a vector of public goods. The **x** are assumed to be available at parametric prices (p_1, p_2, é , p_m = **p**), which may or may not be market-determined. Every rational individual aims at maximizing utility which is subject to income, y, constraint. However, since the direct utility cannot be observed and since we cannot get a monetary measure for it, the indirect utility function is a best money metric for welfare changes. The indirect utility is a function of commodity prices and income. It can be presented algebraically, V(**p**, **q**, y), as:

$$V(\mathbf{p}, \mathbf{q}, y) = \max_{x} [u(x, q) | x.p \leq y]$$

The utility maximization problem is a primal and has its dual which is the expenditure minimization problem. In the utility maximization problem, the income is a constraint yet in the expenditure minimization problem the utility is a constraint. This makes the two functions to be inverses of each other. Since these functions are inverses of each other, calculation of one facilitates the calculation of the other. Snyder and Nicholson (2012:123) mentioned that the utility maximization approach yields the same results as its dual which is the expenditure minimization approach. Since the expenditure of an individual is often observable, then the expenditure minimization approach is often more useful compared to the utility approach. The expenditure function helps to investigate how an individual can be compensated for a price change (or precisely increase). The minimum expenditure function, E(**p**, **q**, u) can be presented algebraically as:

$$E(\mathbf{p}, \mathbf{q}, u) = \min_{x} [x.p | u(x, q) \geq u]$$

From Shepherdôs lemma, the derivative of the expenditure function with respect to prices of goods, gives the Hicksian demand for the good in question.

$$\frac{\partial E(p, q, u)}{\partial p} = h_p(p, q, u)$$

It is also worth noting that from the Royôs Identity, the negative ratio of the derivative of the indirect utility function with respect to price and income gives the Marshallian (ordinary) demand functions:

$$x^{M}(p, y) = -\frac{v_p(p, y)}{v_y(p, y)}$$

The indirect utility and the expenditure functions provide a theoretical structure for welfare estimation. For stated preference approaches, one needs the changes in these functions. Contingent valuation can be viewed as a way of estimating the change in the expenditure or utility function. For pure public goods, only the expenditure and indirect utility functions are relevant. Behavioral methods lead to areas under the demand or marginal value curves. They also lead to indirect utility and expenditure functions from which welfare can be measured directly.

2.3.2 The compensating variation and the equivalent variation measures

Hanley and Barbier (2009:16) defined compensating variation (CV) as the minimum compensation an individual is offered to make him/her as ówell offô without the price change, compared to a situation where prices were lower and no compensation was offered. CV is the amount of income that has to be given to an individual to restore his/her initial utility (u^0) level after a price increase. It assumes that the individual has a right to the initial or status quo thus maintaining the initial level of utility (u^0). This is the individualôs minimum WTA.

CV may also be defined as the difference between the expenditure, $e(p^1, u^0)$, needed to achieve the initial utility level (u^0) at the old price (p^0), that is lower price, and the expenditure ($e(p^0, u^0)$) needed to achieve initial utility level (u^0) at the new higher price (p^1). CV is often used in the cases when there is a reduction in the good or service and it is usually associated with WTA. CV may be given in notation form as:

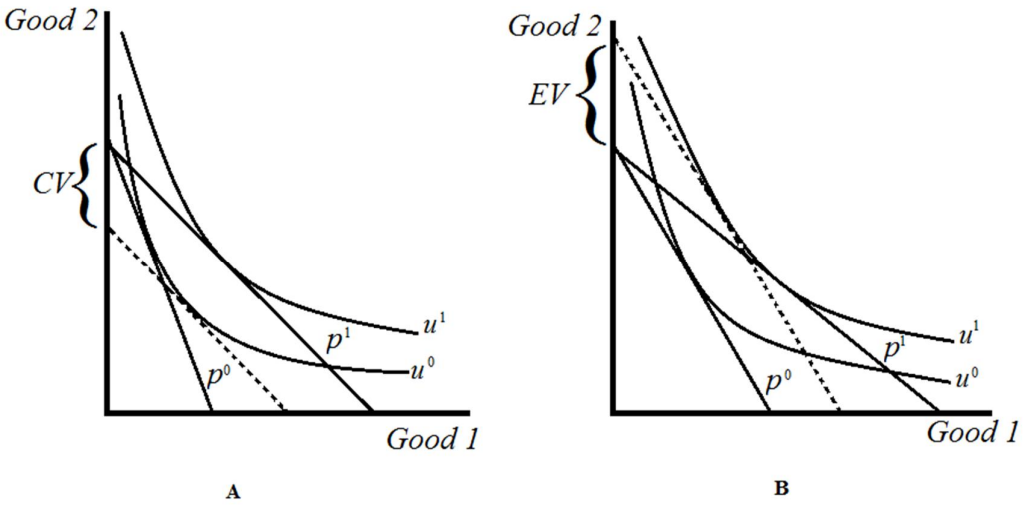
$$CV = e(p^1, u^0) - e(p^0, u^0)$$

Equivalent variation (EV) on the other hand is defined as the amount of income that has to be taken away from an individual to bring him/her back to the same level of utility as would be

the case after the price of the good has increased. It assumes that an individual has a right to the new situation. It measures losses and gains derived from not implementing the proposed change in relative price. It is said to be the amount of income that has to be taken away from an individual to leave him/her at the new utility level under the initial set of prices. EV holds utility constant after the price or policy change not before the change. This is the individualôs maximum WTP to avoid a price increase (or change) and can be presented in notation form as:

$$\text{[illegible]} = \text{[illegible]}(p^1, p^2, u^0) - \text{[illegible]}(p^1, p^2, u^1)$$

Both CV and EV can also be illustrated graphically as shown in figure 2 below.



Adapted from: Mungatane, 2011, Class Notes, with modifications.

2.4 Practice of welfare measurement

2.4.1 Theoretical methods for estimating the benefits of environmental goods and services

2.4.1.1 Revealed Preference methods

Revealed preference methods deduce individualsô WTP for a good by examining the actual behaviour of the individual in a real market (hedonic pricing) or in the consumption of the

good itself (travel cost). In hedonic pricing method, the valuation of the non-market good relies on the price of a market good. The price of a non-market good affects the price of a market good in a well-functioning market. For example, the prices of a hotel located next to the beach may be high simply because people visit the beach now and again to enjoy its view, swimming and hiking.

Travel cost method has been used most often to value recreational sites like beaches, parks and rivers. The number of visits an individual has to a national park for example together with the cost incurred whiles going to the park is likely equivalent to the value that individual places on the national park. Unlike CVM though, revealed preference methods cannot value existence value of a good. The hedonic pricing and the travel cost methods usually estimate and report changes on the Marshallian surplus.

2.4.1.2 Stated preference based methods

CVM and choice experiments (also known as choice modeling or conjoint analysis) are the only two methods that rely on stated preference for the valuation of environmental goods and services. In stated preferences, a researcher asks the respondents directly to state their WTP or WTA compensation for changes in environmental quality. If there is a proposed policy that is aimed at improving peoplesô wellbeing, the right question the researcher may ask the respondents is ôhow much will they be willing to pay for the environmental improvement.ô Sometimes respondents may be asked to state how much they are willing to accept for an environmental degradation or to go without the change (improvement).

Choice modeling is also used to value both use and non-use values. Respondents are asked to compare and select alternative combinations of goods or policy characteristics. Choices are given to the respondents from the different combinations and each respondent sees one or more choice sets. The respondent has to select the preferred alternative, rank the alternatives and then rate them. In this study, CVM was used and a full discussion of how it is conducted is given below.

2.4.2 The contingent valuation method (CVM)

CVM is an approach that is used to estimate economic values of all types of ecosystem and environmental goods and services. It is a preferred valuation method when measurement of values is the focus of the study and when revealed preference data is not available to the researcher (Haung, Haab & Whitehead, 1997:240; Korsgaard & Schou 2010:22). It estimates both use and non-use values and it is most often used for estimating non-use values. It involves mainly asking people directly what is the maximum amount of money they will be willing to pay for a given environmental good or service. People are asked to state their WTP if the policy intends to improve their livelihoods. Sometimes people, mainly in a survey, may be asked how much minimum compensation they will be willing to accept to give up an environmental good or service (or for an environmental degradation or pollution they are exposed to). People are asked to state their willingness to pay for a hypothetical scenario given a well described environmental good or service is clearly understood by the respondent. This is the reason this approach is called contingent valuation.

2.4.2.1 Steps for conducting a CVM

Hanley and Barbier (2009) stated that there are five stages for executing most CVM exercises. These stages are: 1) setting up a hypothetical market; 2) obtaining the bids; 3) estimating mean/median WTP (or WTA); 4) aggregating the data; and 5) carrying out validity checks.

CVM is used for valuing environmental goods and ecosystem services by creating a hypothetical but realistic market (Du Preez, Tessendorf & Hosking, 2009) and this is the first step of a CVM. A full description of the environmental change or good/service should be given when setting up the hypothetical market. One must state clearly the environmental change or good/service that the respondents should be expecting and over what time period. It should also be stated clearly as to who should pay for the change, how long will payments be made, why should that actor pay, together with stating the payment mechanism. The respondents should also be told what will happen if the status quo is maintained and the policy/change is not implemented. This should be found in the survey instrument. Good questionnaire design is very important to a good CVM exercise. The questionnaire can be

developed using focused groups from the relevant population and should be pre-tested before the main survey occurs, (Hanley and Barbier, 2009).

The second step in executing a CVM is obtaining the bids. This can be done by conducting a survey. The survey should be executed when the questionnaire has been well designed. This can be done through one of a variety of ways which may include: face-to-face interviewing, via internet, via mails, or by telephone interviewing. All these methods have got different setbacks. Mail interviews suffer from a greater percentage of non-response bias and low response rates. Telephone interview on the other hand are least preferred since it may be difficult to convey information about a good/service over the phone and they may be costly. Personal face-to-face interviews are generally very costly. However, these (face-to-face interviews) provide the most scope for detailed questions and answers. A CVM survey may be characterized by questions on: environmental attitudes; test for knowledge of the good or service in question; provide information of the hypothetical scenario; collect information on WTP/WTA; ask for respondentsô socio-economic data; and also ask some de-briefing questions.

Willingness to pay can be obtained from respondents by using a number of ways which may be: payment cards, an open-ended question, a single-bounded dichotomous choice, or as a double-bounded dichotomous choice. In a payment card method, a range of values are presented on a card and the respondent is requested to choose those values which most closely matches their WTP. In open-ended questions, the respondents are just asked to state their maximum WTP and no value is suggested to them. A single value is suggested on which the respondent will be asked to either accept or reject in the single-bounded dichotomous choice. Yet in the double-bounded dichotomous choice, a bid is given and if the respondent answers ónoô to the first bid, a smaller value to that bid is then offered. If they, however, answer óyesô to the first bid, a higher value is offered and they are asked if they would be willing to pay that amount.

The third stage in a CVM survey is estimating the mean or median WTP. Estimating the mean and median WTP for open-ended responses is generally simple. Researchers must, however, take care to separate out protest responses first. The mean WTP is a relevant value for use in cost-benefit analysis. Hanley and Barbier (2009) mentioned that authors often focus on median WTP because it is less impacted by extreme values, and because it is more meaningful from a political point of view. The confidence interval for WTP should also be stated.

Aggregating the data is the forth step in a CVM exercise and it is a process whereby the mean bids are converted into a population total value figure. The last step is conducting validity and reliability checks. How these are conducted is discussed in a later sub-section in this chapter. Even though we can correctly conduct a CVM survey, but the estimate may be affected by a number of biases. These biases may affect the reliability of the obtained mean or median WTP values. An understanding of the biases associated with CVM is essential in executing it.

2.4.2.2 The biases of the CVM

CVM is an appropriate measure of welfare change for a majority of given situations (Harris & Brown, 1992:76; Korsgaard & Schou 2010:22). According to the Secretariat of the Convention on Biological Diversity (2007:18), WTP can provide useful and reliable information when used carefully. This is despite the fact that CVM estimates/values have been criticized for several biases. According to literature, three types of biases are associated with CVM. These are indicated as: strategic bias, starting point bias, and hypothetical bias and they are discussed below.

2.4.2.2.1 Strategic bias

This bias arises when an individual decides he may influence an investment or policy decision by not answering the CV question truthfully. According to Whittington *et al*. (1990:299), strategic bias may influence oneôs response in either of the two ways. An individual may decide to overstate his willingness to pay if he thinks an agent will ultimately pay for the provision of a good or service if the societal responses are positive. Knowing that someone else will eventually pay for the provisioning of the good or service without the individual

paying, the individual finds an incentive in overstating his WTP. Also an individual may understate his willingness to pay if he thinks the agent that will provide the good or service has already decided on providing it but just want to obtain the price that users should pay for it. In this case the individual has a good reason for understating his WTP.

2.4.2.2.2 Starting point bias

Starting-point bias is more common in the bidding-game question format. The enumerator starts the questioning at the initial price and if the respondent is not sure of a good response and wishes to please the enumerator, he may interpret this initial price as a clue to the correct bid. In this paper, the researcher implemented a single-bounded kind of questions and this bias was automatically eliminated.

2.4.2.2.3 Hypothetical bias

This bias may arise from one of two reasons. First, the respondent may not correctly understand the attributes of the good or service described by the enumerator. This problem is most prevalent when CVM is used to elicit respondentsô willingness to pay for changes in environmental quality. Respondents may not understand, for instance, what an improvement in air quality means. For the purpose of this research paper, the researcher made sure respondents were clear of the environmental service in question and most respondents seemed to be having good understanding of it. Secondly, respondents from developing countries may not take CV questions seriously and may respond by offering any answer that comes to mind without carefully thinking it over. Hypothetical bias may also arise as a result of over-bidding when respondents do not expect any actual payments to be made for the provision of the good.

2.4.2.3 Validity and reliability of the CVM

The reliability of a good CVM estimate can be examined by using either of the following validity checks. The first method is the scope test. Scope test examines if WTP varies significantly with quantity on offer. The WTP value on a smaller quantity should, from

expectations, be smaller than that placed on a larger quantity. For example, this is to say a value placed by people on clearing IAPS from a hectare of land should be smaller than the value placed on clearing the one entire region in Swaziland. A simple scope test would be to test a null hypothesis that $WTP_{q2}>WTP_{q1}$ given that q2 is greater than q1.

Protest rates may give another indicator for the reliability of a CVM instrument. A protest rate is the percentage of the responses which are protest bids. For a good CVM survey, the protest rate should be below 40% (Hanley & Barbier, 2009). A high protest rate indicates that there is something wrong with the design of the instrument of hypothetical market.

Convergent validity on the other hand compares the WTP estimates obtained from using two different methods. It tests whether there is a significant difference between the estimates obtained from a CVM and that which is obtained from another method. An example may be testing the significant difference between WTP value obtained from a CVM and WTP value obtained from Travel Cost Method (TCM). If there is a significant difference between the WTP values from the two methods, then the reliability of the CVM estimate is questionable.

Sometimes some researchers compare WTP values from CVM with real commitments that may have been obtained from experimental economics. If CVM WTP is greater or equal to real WTP, then the CVMM estimate is accepted with doubt. This method is called calibration factors. Construct validity on the other hand aims to identify if WTP value varies in accordance with theoretical expectations. This is usually addressed by estimating a bid function and seeing whether parameter signs are in line with expectations, and also examining what percentage of the variation in WTP is explained statistically. It is not easy though to decide what relationship a variable has with WTP. Construct validity is therefore not as useful as it seems (Hanley & Barbier, 2009).

2.4.3 The cost based approaches

Korsgaard and Schou (2010:22) stated that cost based approaches together with revealed preference methods are most widely used approaches for valuing non-market ecosystem

services. Several methods can be used to obtain money values for ecosystem services. These money values include three methods and these are: 1) ñthe price paid in market transaction relating directly to ecosystem services, 2) price information from parallel market transactions that are associated indirectly with the valued ecosystem service and, 3) hypothetical markets which may be created in order to obtain values of ecosystem services.ò However, if both the direct and indirect price information is not obtainable then (3) is used. Direct market valuation consists of three main methods and these are: a) market price-based approach, b) production function-based approach and c) cost-based approach (Mngatana & Muchapondwa, 2012:2224).

The cost-based approach which is also the focus of this study, together with contingent valuation, uses three approaches to obtain. These approaches include: avoided cost, replacement costs and mitigation costs. These are discussed below.

2.4.3.1 Mitigation costs

Mitigation costs are the costs that are incurred to control that particular damage for the ecosystem service or good. In the case of this study, the mitigation costs are the costs that had been incurred in the control of IAPS. These costs are available from government reports of capital projects in the Ministry of Agriculture (Swaziland), Forestry department which is now found in the Ministry of Tourism and Environmental Affairs. In this study, the mitigation cost approach was employed. The figures from this approach was expected to give the lower bound of the money value of eradicating the IAPS in the Hhohho region and the mean value that was obtained from WTP elicitation gave the upper bound.

2.4.3.2 Replacement costs

Replacement costs on the other hand refer to the costs that are incurred to provide artificial technologies which can do similar services as that particular ecosystem service which might have been degraded. Replacement costs provide the minimum estimate of money saved. According to Garrod and Willis 1999 (in En Chee, 2004:554), this technique (replacement

cost) assess the estimated value it would cost to replace or restore an ecosystem service or good after it had been damaged. En Chee stated that the total expenditure incurred in replacing an ecosystem service is equivalent to the measure of the minimum WTP to recover or continue to receive that particular service/good. This gives a minimum estimate because more money may have been spent had it been deemed to be necessary and justified to do so. These estimates (replacement cost values) are only said to be valid when individuals in aggregate would be willing to incur these costs if the natural ecosystem services were no longer at all available.

2.4.3.3 Avoided costs

The avoided costs are the costs that are avoided when the ecosystem is for instance protected. If for example in the case of the invasion of IAPS on grazing land, the farmers have to purchase fodder for their cattle. Without the invasion which decreases the availability of grazing land, farmers do not have to purchase any fodder. The cost of purchasing fodder which feedlots incur is the avoided costs by farmers raising their livestock on communal grazing land. These costs are not avoided when all grazing land had been invaded and the farmers are compelled to purchase fodder.

2.5 Chapter summary

This chapter gave a theoretical background for welfare measurement. The tools used in the valuation of environmental goods are discussed in this chapter together with those which were used in this study. The indirect utility, expenditure function, compensating variation and equivalent variation were discussed. Detailed discussion on conducting a CVM together with its associated biases and validity checks are also given in this chapter. The cost-based approaches to environmental valuation are also discussed since they make another important element of the study. The next chapter gives the research methodology for the study.

3. Research methodology and data

3.1 Application of the CVM

3.1.1 Steps in conducting the CVM survey

The first step in executing a CVM survey is setting up a hypothetical market. In this study a hypothetical market for the control of IAPS was created. First, the respondents were asked to give their level of knowledge with the dominant IAPS and also indicate their factual knowledge with the benefits and negative impacts associated with IAPS invasion. After ascertaining their knowledge and understanding, they were requested to rate the level of severity of IAPS in the communal lands where their cattle graze. The cattle farmers (respondents) were then given a detailed list of the benefits of 100% removal of IAPS from grazing lands. They were then asked if they felt it would be proper if the community would come together to a scheme that would pool resources that would be used in the control of IAPS. If the respondent answered óYESô, then he/she would be asked if he would be willing to pay bid X (there were three bids for 100% removal and they were E70, E50 and E40 and half these for 50% removal necessary for scope testing). A respondent would either be willing to pay the randomly assigned bid or would not be willing.

The next step in a CVM survey is obtaining the bids. In this study the bids were obtained by calculating the cost per hectare per cow. This was calculated from the total costs (which was E40 million) that were already incurred in clearing about 18 000 hectares of land. Calculation of the costs needed to clear a hectare of land from these figures was done (using the E40 million that was used to clear 18000ha) to obtain E2222.22 per hectare. Then an estimate of the land size where the pre-survey was to be conducted was done and it was about 120 hectares of which 96 hectares is estimated grazing land. In this land size there were an estimated 3727 cattle. From using these figures, an estimated cost of E57.24 per cow ((96□□ × □2222.22)/3727□□□□□96ha) was obtained to be the cost per animal to clear a hectare of land. From the E57.24, an upper, middle and lower percentile values were obtained for the bids that were used in the pre-survey.

The obtained bids were E42, E28 and E14 and were rounded up to E40, E30 and E15. These bids were used in a pre-survey which was conducted at Lomahasha with a sample size of 30 respondents. Results obtained from the analysis of the pre-survey data indicated that about 80% of the respondents were willing to pay for the higher bid offered. This was contrary to economic theory in that as the price of the good increases the quantity demanded will fall. This, therefore, necessitated another pre-survey with adjusted and higher bids to align the results with economic theory.

Another pre-survey of 30 respondents was again conducted with new bids raised to E70, E50 and E40 for 100% eradication. This second pre-survey was conducted in the same area using different respondents. The results that were obtained in this second pre-survey were in line with theory after analysis. They were then used in the implementation of the final survey.

3.1.2 Instrument design and implementation

After pretesting and designing the questionnaire, it was then implemented at Ntfonjeni in the Hhohho region. The questionnaire was administered through face-to-face interviews by one enumerator. During questionnaire administering, the enumerator used the home language (SiSwati) to ensure there was clear understanding of every aspect of the survey. The questionnaires were designed in such a way that they enabled the study to capture all the data required to answer all key aspects of the research question. The data that were captured included; socio-demographic characteristics (age, sex, number of dependents, number of livestock [cattle], income status, source of income, education level, number of school going kids, etc), knowledge of IAPS and their associated impacts, choice of institutional arrangement to be employed in the control of IAPS and maximum willingness to pay (WTP) of household head for the control of IAPS for both 50% and 100% eradication (see Appendix B)

There were about 1518 cattle owners at Ntfonjeni owning a total number of 13820 cattle when the study was conducted. These cattle owners were randomly selected to form part of the 192

respondents who were part of the study's sample. This is because the researcher aimed at using a purposive type of sampling where a simple random sampling criteria was used.

An estimate of about 30 respondents per bid was targeted. This was after a sample size of 180 was targeted. The sample size was obtained after a calculation where an estimated margin of error was 5.7% at a confidence level of 90% and a population size of 1518 respondents (cattle owners under this RDA). However, having estimated the sample size to be 184 by calculation, the actual sample size that was used in the study was 192.

The sample size of 184 was obtained through the use of a sample size calculator available online at http://www.raosoft.com/samplesize.html. This calculator is designed such that any variable of interest can be varied to obtain the desired figures. Among the components of the calculator are these features; margin of error, confidence level used, population size, response distribution and lastly the desired sample size. The calculator uses the following formulae:

$$x = Z\left(\frac{c}{100}\right)^2 r(100 - r) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ldots (3.1)$$

$$n = \frac{N x}{(N - 1)E^2 + x} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.2)$$

$$E = \mathrm{Sqrt}\left[\frac{(N - n)x}{n(N - 1)}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3.3]$$

where: N is the population size, E is the margin of error, r is the fraction of respondents the researcher intends to cover, and $Z\left(\frac{c}{100}\right)$ is the critical value for confidence level *c*.

3.2 Application of cost-based approaches

3.2.1 Costs acquisition

Another data that was collected for the study was secondary data on the costs of controlling IAPS. This data was the costs of mitigating/restoring the pasture through controlling IAPS.

These costs were readily available in government reports and they were obtained from the Ministry of Tourism and Environmental Affairs. In total, a sum of about E40 million was used to clear land in an attempt to restore pastures. These costs were said to be incurred in clearing about 18000 hectares of land.

3.2.2 Calculation of mitigation costs

In order to get the mitigation costs and to enable convergent validity to be carried out without a problem, the cost per cow was calculated. Given that there were about 765 829 cattle in Swaziland as of December 2012 and the reported costs that were incurred in clearing IAPS standing at E40 000 000.00, the cost per animal was calculated as:

$$\text{Mitigation cost per animal} = \frac{\text{Total mitigation costs incurred in clearing IAPS}}{\text{Total number of cattle in Swaziland}} = \frac{E40\,000\,000}{765\,829}$$

$$\text{Mitigation cost per animal} = E52.23$$

This value is equivalent to the mitigation cost per animal. That is, how much it has cost government to clear a piece of land for one cow.

3.3 Approaches to data analysis

After the data was collected, it was captured in Microsoft Excel spread sheet and then exported to STATA for analysis. The analysis, as done in the next sub-section, was conducted in accordance with the studyôs specific objectives.

3.3.1 Cattle farmers' knowledge of IAPS and their associated impacts

Descriptive statistics were used to assess cattle ownersô level of knowledge of the dominant IAPS together with the negative and positive impacts attributed to IAPS using STATA version 12. After obtaining the descriptive statistics, a test of association (Chi-square test) was done to test the degree of association of the respondentsô socio-economic characteristics and the level of knowledge with the IAPS and the associated impacts. This was done to check if socio-economic factors had an influence on the responses the farmers gave on the knowledge of IAPS and their impacts.

3.3.2 Factors affecting cattle farmers' willingness to pay

There are several factors that may affect householdsô maximum WTP. These factors have been identified by many researchers (e.g. Garcé a-Llorente, *et al.* 2008 & 2011; Farolfi, *et al.* 2007) as either influencing WTP positively or negatively. However, these variables may behave differently depending on the type of service or good in question. Therefore, a number of variables prior assumed to be influencing respondentsô WTP were tested. The variables that were perceived to influence WTP were as follows: age of the household (AGE), sex of the household (SEX), number of dependents (DEPENDENTS), level of education (EDULEVEL), estimated monthly income (INCOME), number of cattle owned (LIVSIZE), bid amount offered (BID) and marital status of the respondent (MSTATUS).

A combination of both the probability (Probit model) regression and OLS were estimated to identify the factors that affected respondentsô WTP. The Probit model was used to estimate the parameters for the case whereby the respondent answered ñYes [1] or No [0]ò to the willingness to pay question. And since there was a part where the respondent had to offer his/her maximum willingness to pay when the given bid was not accepted, that allowed the researcher to have some kind of continuous data which enabled OLS to be estimated. The Probit model estimated was as shown in equation [3.4] below:

$$Pr(\square\square = 1|\square) = \Phi(\acute{a} + \square\hat{a}) \quad \text{..[3.4]}$$

where Pr denotes probability, Φ denotes the Cumulative Distribution Function (CDF) of the standard normal distribution, $\square'$ is a vector of explanatory variables which influence the outcome of WTP, and â denotes a vector of parameter estimates. Assuming there exists an auxiliary random variable ($\grave{\imath}_\square$) then equation [3.4] can take the following form:

$$\square\square^* = \acute{a} + \square'\hat{a} + \grave{\imath}_\square \quad \text{..[3.5]}$$

Assuming that $\grave{\imath}_\square \sim \square(0,1)$, then $\square\square^*$ can be seen as an indicator for whether this latent variable is positive or not. Equation [3.5] after some manipulations will attain the status of equation [3.4] and if we lay this equation to indicate all the regressors it takes the following form:

$$Pr(\square\square = 1|\square) = Pr(\hat{a}_\square + \hat{a}_\square X_\square + \hat{a}_\square X_\square + \hat{a}_\square X_\square + \hat{a}_\square X_\square + \hat{a}_\square X_\square + \hat{a}_\square X_\square + \hat{a}_\square X_\square + \hat{a}_\square X_\square) \quad \text{..[3.6]}$$

where: Pr(= 1|) is the probability that one is willing to pay given a vector of regressors.

X_1 is the bid offered to respondent (BID)

X_2 is the respondentôs gender (SEX)

X_3 is the respondentôs age (AGE)

X_4 is the number of dependents in the household (DEPENDENTS)

X_5 is the respondentôs marital status (MSTATUS)

X_6 is the respondentôs education level (EDULEVEL)

X_7 is the respondentôs estimated monthly income (INCOME)

X_8 is the number of cattle a respondent raise (LIVSIZE)

$\hat{a}_{\square}$ are the coefficients or parameters being estimated

When estimating the OLS, the following multiple regression function was estimated and the variables and parameters are as defined in equation [3.6]:

$$ = \hat{a}_{\square} + \hat{a}_{\square}X_{\square} + \hat{a}_{\square}X_{\square} + \hat{a}_{\square}X_{\square} + \hat{a}_{\square}X_{\square} + \hat{a}_{\square}X_{\square} + \hat{a}_{\square}X_{\square} + \hat{a}_{\square}X_{\square} + \hat{a}_{\square}X_{\square} + \grave{\imath}_{\square} \ldots \ldots . \quad [3.7]$$

3.3.3 Estimating the mean/median willingness to pay of controlling IAPS

After estimating the probit model, the mean WTP was estimated in STATA using the **wtpcikr** command that was developed by Jeanty (2007). Jeantyôs command obtains both the mean and median WTP values. It uses the formulae provided in Table 3.1 to obtain:

Table 3.1: Formulae used to obtain mean and median WTP values

Distribution	WTP or Welfare Measure	Functional form	
		Linear	**Exponential**
Normal	Mean	$-\frac{\hat{a}_1}{\hat{a}_2}$	$\exp\left(-\frac{\hat{a}_1}{\hat{a}_2}+0.5\sigma^2\right)$
	Median	$-\frac{\hat{a}_1}{\hat{a}_2}$	$\exp\left(-\frac{\hat{a}_1}{\hat{a}_2}\right)$
Logistic	Mean	$-\frac{\hat{a}_1}{\hat{a}_2}$	$\frac{\sigma\pi}{\sin(\sigma\pi)}\exp\left(-\frac{\hat{a}_1}{\hat{a}_0}+0.5\sigma^2\right)$
	Median	$-\frac{\hat{a}_1}{\hat{a}_2}$	$\exp\left(-\frac{\hat{a}_1}{\hat{a}_2}\right)$

Where: $\bar{x}$ is row vector of sample mean including 1 for the constant term
$\hat{a}'$ is column vector of estimated coefficients
$\hat{a}_0$ is coefficient on the bid variable

The command is shown in equation 3.8 below. The mean WTP gave the average with which respondents were WTP for clearing IAPS for both 100% and 50% eradication. This represents the value livestock farmers placed on grazing land per cow.

wtpcikr BID GENDER AGE DEPENDENTS MSTATUS EDULEVEL INCOME LIVSIZE.....[3.8]

3.3.4 Institutional arrangement for controlling IAPS

After a thorough inquiry from respondents as to which institutional arrangement they felt would be best and effectively employed in the control of IAPS, descriptive statistics were used to analyze the data obtained from their responses. A chi-square test was then used to test for any degree of association between the socio-economic characteristics of respondents and their choice of the institutional arrangement. The hypothesis test was that there is no degree of association between socio-economic characteristics of respondents and their response towards the choice of institutional arrangement to be used in the control of IAPS on grazing land.

3.4 Socioeconomic characteristics of respondents

In this sub-section a discussion of the respondentsô socioeconomic characteristics is given. There were 192 respondents who participated in the survey. The socio-economic characteristics are summarized in Table 3.2. Table 3.2 indicates that an average respondent was 44 years old from a household that raises an average of 18 cattle and with 8 dependents. A majority of the respondents (58%) were married males (69%). About 7.3% of the respondents had no formal education and the remaining portion had at least been to a formal academic institution and the results indicate that about 19.8%, 47.4% and 25.5% attended up to primary school level, high school level and tertiary level respectively. About 46.4% of the respondents (which is the majority) identified gainful employment as their primary source of income and a majority of whom (42.2%) had an estimated monthly income falling within the range of E3000.00 and E7000.00. About 4.7% of the respondents reported that their monthly income was above E12000.00.

Table 3.2: Respondents' socio-economic characteristics

	Frequency	Percent	Cumulative percentage
Total households	192		
Gender:			
Female	59	30.7	
Male	133	69.3	
Marital status:			
Single	58	30.2	30.2
Married	111	57.8	88
Divorced	1	0.5	88.5
Widowed	22	11.5	100
Education level:			
No formal education	14	7.3	7.3
Primary level	38	19.8	27.1
High school level	91	47.4	74.5
Tertiary level	49	25.5	100
Occupation:			
Builder	4	2.1	2.1
Hawker	7	3.6	5.7
Farmer	50	26.0	31.7
Gainful employment	89	46.4	78.1
Other	42	21.9	100
Estimated monthly income			

Below E3000	60	31.3	31.3
E3000 - E7000	81	42.2	73.4
E7000 - E12000	42	21.9	95.3
Above E12000	9	4.7	100

	Mean
Average age:	44
Average number of dependents:	8
Average number of cattle owned:	18
Average number of school going kids:	3

Source: Authorôs own elaboration.
Note: Average exchange rate at the time of conducting the study was $1 = E9.16 (World Currency Exchange Rates History, n.d.)

3.5 Chapter summary

The purpose of this chapter was to present the methodologies that were used in the study. Discussed in the chapter is how the CVM survey was conducted in this study including all the methodologies that were applied in achieving the studyôs specific objectives. Also the acquisition of costs that were used in the mitigation cost approach together with how the cost per animal was calculated is illustrated in this chapter. Finally, respondentsô socioeconomic characteristics were also discussed. In total the sample size was 192 respondents who were interviewed using face-to-face interviews administered in local language.

4 Results and discussions

4.1 Introduction

This chapter presents the empirical results and discussions in accordance with the studyôs specific objectives. The results were obtained from the data and were analyzed in STATA. The presentation and discussions start with the respondentsô factual knowledge of the positive and negative effects of IAPS. This gives descriptive statistics of what the respondents know about IAPS and their associated impacts. After that there is a discussion of the analysis of WTP, summary statistics, results from costs-based approach and lastly validity and reliability checks.

4.2 Respondents factual knowledge of IAPS and their positive and negative effects

Objective 1 of the study was intended to assess respondentsô level of knowledge of IAPS and their associated impacts. Among six dominant IAPS (*Chromoleana odorata, Lantana camara, Solanum mauritanum, Psidium guajava, Caesalpinia decapetala and Rubus species*), 100% of the respondents indicated that they were very familiar with *Chromoleana odorata* and *Lantana camara*. This may be due to the fact that these two species are the most prevalent of all the IAPS in this region and they were observed almost everywhere in grazing land and uncultivated areas. Although *Psidium guajava* was not observed in a majority of the areas and 22% of the respondents mentioned that it is not available in their communities, 100% of them had a clear knowledge of this species. About 79% and 70% of the respondents claimed to know *Solanum mauritanum* and *Rubus species* respectively. The unfamiliarity of respondents with these two species might be associated with the fact that they are not prominent in the region as 64% and 33% claimed *Rubus species* and *Solanum mauritanum* respectively were not available in their communities.

Table 4.1 indicates the respondentsô level of familiarity, that is, knowledge, with the six IAPS and table 4.2 indicates the frequency of the available IAPS in respondentsô communities. The top number in each table indicates the frequency of familiarity level whereas the percentage in parenthesis indicates the percentage of observing the said level of familiarity.

Table 4.1: Respondents' level of familiarity with the dominant IAPS

IAPS		Very Unfamiliar	Unfamiliar	Neutral	Familiar	Very Familiar	TOTAL
Chromoleana odorata	#	0	0	0	0	192	192
	%	(0%)	(0%)	(0%)	(0%)	(100%)	100%
Lantana camara	#	0	0	0	0	192	192
	%	(0%)	(0%)	(0%)	(0%)	(100%)	100%
Solanum mauritanum	#	32	7	2	27	124	192
	%	(17%)	(4%)	(1%)	(14%)	(65%)	100%
Psidium guajava	#	0	0	0	6	186	192
	%	(0%)	(0%)	(0%)	(3%)	(97%)	100%
Ceasalpinia decapetala	#	3	6	0	19	164	192
	%	(2%)	(3%)	(0%)	(10%)	(85%)	100%
Rubus species	#	44	15	0	32	101	192
	%	(23%)	(8%)	(0%)	(17%)	(53%)	100%

Source: Authorôs own data.

Table 4.2: IAPS availability as indicated by respondents

		AVAILABILITY		
IAPS		**YES**	**NO**	**TOTAL**
Chromolaena odorata	#	192	0	192
	%	(100%)	(0%)	(100%)
Lantana camara	#	191	1	192
	%	(99%)	(1%)	(100%)
Solanum mauritanum	#	93	99	192
	%	(48%)	(52%)	(100%)
Psidium guajava	#	149	43	192
	%	(78%)	(22%)	(100%)
Caesalpinia decapetala	#	128	64	192
	%	(67%)	(33%)	(100%)
Rubus species	#	69	123	192
	%	(36%)	(64%)	(100%)

Source: Authorôs own data.

The descriptive statistics on the knowledge of the IAPS offers a basement upon which further statistics can be tasted to deduce how the respondents gave the above claims. This was done by testing if there is any dependence between the given responses and the respondentsô characteristics. Therefore, a chi-square test was employed to determine the influence of the socio-economic characteristics (age, gender, education level, income level and quantity of cattle owned) on the knowledge of these IAPS. It was hypothesized that the socio-economic

characteristics of the respondents do not influence the level of knowledge of IAPS. The results are summarized in Table 4.3.

Table 4.3: The influence of sex, age, education, income and quantity of cattle owned on the knowledge of the four different dominant IAPS

Variable	Sex	Age	Education	Income	Quantity of cattle owned
Solanum mauritanum	3.567	277.884	6.351	4.733	120.618
	(0.468)	(0.000)***	(0.897)	(0.966)	(0.999)
Psidium guajava	3.7578	31.1381	0.9762	2.4315	24.675
	(0.053)*	(0.983)	(0.807)	(0.488)	(0.989)
Caesalpinia decapetala	1.235	205.332	6.138	8.312	137.310
	(0.745)	(0.002)**	(0.807)	(0.760)	(0.292)
Rubus species	3.278	147.840	4.772	15.713	119.525
	(0.351)	(0.535)	(0.854)	(0.205)	(0.713)

Source: Authorôs own data.
Note: * Significant at 10% ** Significant at 5% *** Significant at 1%
Top figure is chi-square statistic and bracketed figure is the p-value.

As can be noticed in table 4.3, most of the variables that were used in the test of association appear not to reject the null hypothesis. This suggests that there is no association between respondentsô socio-economic characteristic and the knowledge of the dominant IAPS under investigation. This is to say, respondents characteristics did not influence the knowledge of the IAPS. However, it can be noted that there are some cases where significance in the chi-square values are observed. Age seems to have influenced respondentsô knowledge of *Solanum mauritanum* and *Caesalpinia decapetala* indicating p-values significant at 1%. This may be attributed to the fact that a majority of respondents (52% and 33%) mentioned that *Solanum mauritanum* and *Caesalpinia decapetala* respectively are not available in their communities whereas older people may have travelled and observed these species elsewhere. Also older people may be familiar with these species because they might have known most of the native species that had been replaced by the invasives giving them a better chance to notice exotic species.

After having assessed respondentsô level of knowledge with the six invasive species, their level of knowledge with the impacts (negative and positive) was then determined. The results of respondentsô knowledge on these are shown in tables 4.4 and 4.5 in the next pages.

Table 4.4: Respondents' factual knowledge of the negative effects of IAPS

Negative effects of IAPS		Very Unfamiliar	Unfamiliar	Neutral	Familiar	Very Familiar	TOTAL
Decrease water quantity	#	19	10	1	23	139	192
	%	(10%)	(5%)	(1%)	(12%)	(72%)	(100%)
Reduce agriculture land	#	1	1	0	11	179	192
	%	(1%)	(1%)	(0%)	(6%)	(93%)	(100%)
Harbour thieves	#	0	0	0	9	183	192
	%	(0%)	(0%)	(0%)	(5%)	(95%)	(100%)
Poisonous to livestock	#	75	28	16	11	62	192
	%	(39%)	(15%)	(8%)	(6%)	(32%)	(100%)
Causes soil erosion	#	66	24	9	16	77	192
	%	(34%)	(13%)	(5%)	(8%)	(40%)	(100%)
Increase fire intensities	#	1	0	2	9	180	192
	%	(1%)	(0%)	(1%)	(5%)	(94%)	(100%)
Decrease land values	#	13	3	0	19	157	192
	%	(7%)	(2%)	(0%)	(10%)	(82%)	(100%)
Reduce peoplesô welfare	#	17	6	1	23	145	192
	%	(9%)	(3%)	(1%)	(12%)	(76%)	(100%)
Harbouring dangerous animals	#	1	1	0	5	185	192
	%	(1%)	(1%)	(0%)	(3%)	(96%)	(100%)
Great threat to biodiversity	#	0	0	0	4	188	192
	%	(0%)	(0%)	(0%)	(2%)	(98%)	(100%)
Contribute to economic loss	#	8	6	2	31	145	192
	%	(4%)	(3%)	(1%)	(16%)	(76%)	(100%)

Source: Authors own data.

Table 4.5: Respondents' factual knowledge of the positive benefits of IAPS

Positive effects of IAPS		Very Unfamiliar	Unfamiliar	Neutral	Familiar	Very Familiar	TOTAL
Provide building material	#	38	10	2	35	107	192
	%	20%	5%	1%	18%	56%	100%
Provide food	#	0	0	0	2	190	192
	%	0%	0%	0%	1%	99%	100%
Helps in carbon sequestration	#	30	10	0	24	128	192
	%	16%	5%	0%	13%	67%	100%
Prevent soil erosion	#	13	6	0	33	140	192
	%	7%	3%	0%	17%	73%	100%
Provide aesthetic benefit	#	53	15	10	27	87	192
	%	28%	8%	5%	14%	45%	100%

Source: Authors own data.
Note: The top figure is the frequency and the number in brackets is the percentage of observed frequency.

To assess if there is any association between the impacts (negative and positive) and the socio-economic characteristics of respondents this included: sex, age, education, income and quantity of cattle raised, it was not possible to test one generalized hypothesis for all the variables since their nature varied very significantly. Due to this fact, it can be hypothesized first that education level influence respondentsô level of knowledge with the impacts of IAPS. From table 4.5 it is observed that most of the chi-square p-values against education do indeed influence the respondentsô knowledge of the positive impacts of IAPS which makes one fail to reject the null hypothesis. However, education could not influence the fact that respondents knew that IAPS provide building materials and this may be attributed to the fact that most of the respondents in these rural communities have their houses and cattle kraals constructed from some of these species.

However, other than education, it was hypothesized that the other respondentsô characteristics do not influence their level of knowledge with the positive benefits of IAPS. As hypothesized, we cannot reject the null hypothesis as the chi-square p-values for almost all the variables came out to be insignificant. Age however, appeared to be significantly influencing respondentsô knowledge of the fact that some IAPS provide food and this may be attributed to the fact that with age one may have experienced a number of species and their benefits. So older people may have observed and tested fruits from IAPS while younger respondents may not have done so due civilization and modernization where people tend not to go out to fetch fruits from forests and mountains which the olden folks used to do. Quantity of cattle raised seemed to have influenced respondentsô level of knowledge with the fact that some IAPS provide building materials. This may be due to the fact that the larger livestock one has the greater the need for that individual to construct a large cattle kraal to house them and for that to happen, there must be enough building material to build the kraals. These kraals are then made from materials obtained from IAPS because of lack of wood which can substantially house large cattle numbers.

Table 4.6: The influence of sex, age, education, income and quantity of livestock owned on the knowledge of positive effects of IAPS

Variables	Sex	Age	Education	Income	Quantity of cattle
Provide building material	5.326	154.679	12.543	7.955	224.423
	(0.255)	(0.992)	(0.403)	(0.789)	(0.004)**
Provide food	0.353	111.158	8.191	4.446	20.615
	(0.553)	(0.000)***	(0.042)*	(0.217)	(0.998)
Helps in carbon sequestration	5.454	165.759	40.193	14.433	93.068
	(0.141)	(0.179)	(0.000)***	(0.108)	(0.993)
Prevent soil erosion	3.062	143.968	19.511	15.284	105.182
	(0.382)	(0.644)	(0.021)**	(0.083)*	(0.939)
Provide aesthetic benefit	6.043	202.893	28.929	10.726	182.873
	(0.196)	(0.433)	(0.004)**	(0.553)	(0.271)

Note: Top figure is chi-square statistic and bracketed figure is the p-value.
* Significant at 10% ** Significant at 5% *** Significant at 1%

Table 4.7: The influence of sex, age, education, income and quantity of livestock owned on the knowledge of negative effects of IAPS

Variables	Sex	Age	Education	Income	Cattle quantity
Decrease water quantity	1.314	200.267	12.783	11.313	140.176
	(0.859)	(0.481)	(0.385)	(0.502)	(0.964)
Reduce agriculture land	3.924	150.336	6.169	8.867	161.610
	(0.270)	(0.477)	(0.723)	(0.450)	(0.027)
Harbor thieves	0.835	49.525	4.147	10.968	16.864
	(0.361)	(0.492)	(0.246)	(0.012)	(1.000)
Poisonous to livestock	3.105	190.204	9.704	9.256	176.633
	(0.540)	(0.679)	(0.642)	(0.681)	(0.388)
Causes soil erosion	3.246	201.355	13.064	16.188	138.562
	(0.518)	(0.460)	(0.364)	(0.183)	(0.971)
Increase fire intensities	3.147	192.267	9.712	7.066	49.578
	(0.370)	(0.011)	(0.374)	(0.630)	(1.000)
Decrease land values	3.290	152.399	6.773	11.036	110.889
	(0.349)	(0.430)	(0.661)	(0.273)	(0.873)
Reduce peoplesô welfare	0.640	211.904	6.187	8.455	218.537
	(0.958)	(0.269)	(0.906)	(0.749)	(0.009)
Harboring dangerous animals	1.090	90.517	6.669	3.991	78.345
	(0.780)	(1.000)	(0.672)	(0.912)	(1.000)
Great threat to biodiversity	0.063	77.617	0.360	5.235	56.432
	(0.802)	(0.007)	(0.948)	(0.155)	(0.082)
Contribute to economic loss	4.913	202.805	30.139	13.859	137.915
	(0.296)	(0.431)	(0.003)**	(0.310)	(0.974)

Note: Top figure is chi-square statistic and bracketed figure is the p-value.

Among the number of negative impacts which were under investigation, it was generally hypothesized that respondentsô level of knowledge was not influenced by their socio-economic attributes. A chi-square test was used to test the level of dependence within the said variables. For most of the variables which were operationally designed to capture this objective, they could not reject the null hypothesis of dependency in the variables. The results are shown in table 4.7 and as it can be noted there, some (just a minority) could reject the null hypothesis. Cattle quantity for instance is observed to be influencing respondentsô knowledge of the fact that IAPS reduce agriculture land. This may not be very surprising because the more cattle one raises, the greater the need for rearing the animals and those with more cattle may have noted that IAPS significantly reduce agriculture land compared with those raising small numbers of cattle. Income status of respondent is one other variable that seems to significantly influence respondentsô knowledge of the fact that IAPS may also harbour thieves. This may be due to the fact that those individuals of high income status are susceptible to thieves because they may be having a lot of assets which may lure thieves.

Age had also appeared to be rejecting the null hypothesis and significantly influenced two variables and those are respondentsô knowledge of the fact that IAPS increases fire intensities and are also a great threat to biodiversity. This may be due to the fact that older people have witnessed the fire intensity patterns before IAPS invasion and now when there are IAPS. Young respondents on the other hand may not be in a position to compare a before and after situation of the IAPS when it comes to the fire intensity patterns. Also older people have a great knowledge of native species compared to the younger folks. They may have observed native species vanishing due to IAPS invasion and therefore it may not be that surprising that age significantly influenced respondentsô level of knowledge with the fact that IAPS are a great threat to biodiversity.

The significance of the chi-square value of education towards IAPS as being contributing to economic loss may be attributed to the abstract nature of the variable. Most people may not be clear of what economy is and it is only a majority of those who attended school who can better define what an economy is and therefore it may not be surprising why education significantly influenced the knowledge that IAPS contributes to economic loss.

4.3 Analysis of WTP

The main objective of the study was to measure the welfare benefits of controlling invasive alien plant species in the Hhohho region of Swaziland through willingness to pay (WTP) elicitation. To obtain the mean WTP, the WTP was first regressed against the bid amounts and socio-economic variables using a Probit model in STATA and then using the **wtpcikr** command which usually follows after estimation of the probability model, the mean was obtained. Since the WTP questions were given to two groups of respondents (one offered for 100% clearing and the other offered for 50% clearing), mean WTP was obtained for both groups. The results under this sub-section will be presented starting with the output from the Probit function. This will be followed by the mean WTP that was estimated after this function for 100% IAPS clearing and lastly those for 50% IAPS clearing.

4.3.1 Summary statistics for WTP 100% IAPS removal

After running a Probit model for the 100% IAPS removal, the results indicated in table 4.8 were obtained. The equation that was regressed for this output is equation 3.6. The STATA command that was ran is:

probit WTP BID GENDER AGE DEPENDENTS MSTATUS EDULEVEL INCOME LIVSIZE

Probit regression	Number of obs	=	105
	LR chi2(8)	=	55.81
	Prob> chi^2	=	0.000
Log likelihood = -41.366386	Pseudo R^2	=	0.4028

Table 4.8: Probit regression output of WTP for 100% IAPS removal

WTP	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
BID	-0.053	0.014	-3.710	0.000***	-0.081	-0.025
GENDER	0.240	0.340	0.710	0.480	-0.426	0.906
AGE	-0.011	0.016	-0.680	0.497	-0.043	0.021
DEPENDENTS	-0.113	0.051	-2.230	0.026**	-0.213	-0.014
MSTATUS	0.039	0.376	0.100	0.917	-0.698	0.777
EDULEVEL	0.136	0.228	0.600	0.550	-0.310	0.582
INCOME	0.553	0.253	2.190	0.029**	0.057	1.049
LIVSIZE	-0.045	0.014	-3.120	0.002**	-0.074	-0.017
_cons	3.650	1.375	2.650	0.008	0.954	6.346

Source: Authorôs own data
Note: * Significant at 10% ** Significant at 5% *** Significant at 1%

From the output indicated in table 4.8 above, it is observed that at least four variables (bid, dependents, income level and livestock quantity) significantly influenced the probability of an individualôs willingness to pay. From the priori expectations, an increase in bid amount (BID), dependents (DEPENDENTS) and cattle quantity (LIVSIZE) should decrease an individualsô likelihood of paying. However, an increase in income level (INCOME) was expected to be positively related to the individualôs willingness to pay. The obtained results are inline with the priori expectations. Assuming all factors are held constant, a unit increase in bid amount will decrease the probability of an individualôs willingness to pay by 0.053. The direction of the variables; dependents and income are inline with sentiments shared by Du Preez *et al.* (2009:142-146), Farolfi, *et al.* (2007:159-160) and Garcé a-Llorente, *et al.* (2011:425-426).

Again, *ceteris paribus*, a unit increase in the respondentôs number of dependents will decrease the probability of willingness to pay by 0.113. A unit increase in the number of cattle an individual owns will decrease the probability of his/her willingness to pay by 0.045. On another note, a unit increase in respondentôs income level increases his/her chances of willingness to pay by 0.553. Other variables like respondentsô age, gender, marital status and education level were not significantly influencing individualôs willingness to pay for range land improvement by completely removing IAPS. The likelihood ratio (LR) chi-square of 55.81 with a p-value of 0.000 tells us that our model as a whole is statistically significant, that is, it fits significantly better than a model with no predictors.

After the probit model was estimated, a multiple regression model was also estimated. Results obtained from the OLS for the 100% removal of IAPS indicate three variables which significantly influenced respondentsô maximum willingness to pay. These variables are: bid offered, income level and number of cattle raised by the farmer. These are the very same variables which significantly influenced WTP in the probit model. The output for the OLS function is given below and analysis is given after the output.

Table 4.9: OLS results for 100% IAPS removal

maxWTP100	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
BID	-0.255	0.122	-2.090	0.039	0.013	0.498
GENDER	2.596	2.804	0.930	0.357	-2.970	8.162
AGE	-0.077	0.136	-0.560	0.574	-0.347	0.193
DEPENDENTS	-0.435	0.429	-1.010	0.313	-1.286	0.417
MSTATUS	-2.641	3.027	-0.870	0.385	-8.649	3.367
EDULEVEL	1.119	1.967	0.570	0.571	-2.786	5.023
INCOME	3.899	2.066	1.890	0.062	-0.202	7.999
LIVSIZE	-0.287	0.116	-2.480	0.015	-0.517	-0.058
_cons	30.719	11.965	2.570	0.012	6.969	54.469

The given bid (BID) is significant at 5% ($p<0.05$), income of the respondent (INCOME) is significant at 10% ($p<0.1$) and quantity of livestock raised by a household (LIVSIZE) is significant at 5% ($p<0.05$). *Cetaris paribus*, a unit increase in the offered bid decreased the respondentsô WTP by 0.255. Increasing the income level of respondent by one unit increased respondentsô WTP by 3.899 and increasing the quantity of livestock a respondent raised by a unit reduced respondentõs WTP by 0.287. All these coefficients are consistent with our priori expectations. The priori was that when the price amount (BID) increases the respondents will be less willing to accept the offered bid. Also, with an increase in income level of respondent, the respondent will be more likely to be willing to pay. However, with an increase in number of cattle raised, that is the more cattle a respondent raised, the less likely will that respondent be WTP the offered bid per cattle. The results from the two models (OLS and Probit) are consistent.

4.3.2 Estimating mean WTP 100% removal

The estimated mean WTP for 100% removal of IAPS was E60.50 per cow. This means that on average the respondents were willing to pay E60.50 per cow for complete removal of IAPS from the range lands to allow for fodder growth and improved efficiency of range land. Table 4.10 shows the mean WTP for 100% removal of IAPS. Since the motivation behind getting the mean WTP is that it can be multiplied by the number of individuals to obtain the total value of the resource (Duffield & Patterson, 1991). In this study, if we multiply this mean by the total number of cattle in Ntfonjeni we then obtain the value of grazing land in this area. After calculations, the total value of grazing lands to Ntfonjeni cattle farmers was a value of E836 110.00 (E60.50x13 820). With the total number of cattle in Swaziland estimated around 765 829 (Cattle Census, 2012), the estimated value of grazing land is about E46 332 654.50 (about E46 million). With this figure, we cannot reject the null hypothesis that WTP is

different from zero. It is a clear indication that livestock farmers value their livestock together with the rangelands where the livestock are grazed. This indicates that livestock farmers prefer an initiative intended for removal of IAPS on rangeland compared to one that aims at not controlling IAPS.

The STATA command used to obtain mean WTP:

wtpcikr BID GENDER AGE DEPENDENTS MSTATUS EDULEVEL INCOME LIVSIZE

Table 4.10: Mean WTP for 100% IAPS removal

MEASURE	WTP	LB	UB	ASL*	CI/MEAN
MEAN/MEDIAN	60.50	54.51	72.64	0.000	0.30

Source: Authorôs own data.
* Achieved Significance Level for testing H0: WTP<=0 vs. H1: WTP>0
LB: Lower bound; UB: Upper bound

4.3.3 Summary statistics for WTP 50% removal

A similar probit model to the 100% removal of IAPS was applied to the 50% removal of IAPS and the results obtained are shown in table 4.11. From the eight variables that were part of the regressors in the probit function, only three were significantly influencing the probability of respondentsô WTP. Two of these variables were negatively influencing the probability of respondentsô WTP and these variables were offered bid (BID) and livestock size (LIVSIZE). Respondentsô income (INCOME) positively influenced WTP 50% removal.

Cetaris paribus, a one unit increase in the bid amount will decrease the respondentôs probability for willingness to pay by 0.139. Also a unit increase in the number of cattle raised by a household will decrease the respondentôs probability for willingness to pay by 0.092. However, a unit increase in respondentôs income will increase his/her probability of willing to pay by 1.110. Since the coefficient of income is greater than 1 we can say that a respondent will be more likely to be willing to pay for any given increase in income. From the model, the likelihood ratio chi-square of 40.05 with a p-value of 0.000 tells us that our model as a whole is statistically significant and it fits significantly better than a model with no predictors.

Table 4.11: Probit regression output of WTP for 50% IAPS removal

Probit regression				Number of obs	=68	
				LR chi2(8)	=40.05	
				Prob> chi2	=0.000	
Log likelihood = -22.011179				Pseudo R2	=0.4764	
WTP	**Coef.**	**Std. Err.**	**z**	**p>z**	**[95% Conf.**	**Interval]**
BID	-0.139	0.052	-2.680	0.007	-0.241	-0.038
GENDER	-0.310	0.586	-0.530	0.598	-1.459	0.840
AGE	-0.017	0.018	-0.950	0.344	-0.054	0.019
DEPENDENTS	0.098	0.074	1.330	0.184	-0.047	0.242
MSTATUS	0.310	0.556	0.560	0.578	-0.780	1.399
EDULEVEL	0.545	0.356	1.530	0.126	-0.153	1.243
INCOME	1.110	0.417	2.660	0.008	0.293	1.927
LIVSIZE	-0.092	0.028	-3.290	0.001	-0.147	-0.037
_cons	2.664	1.973	1.350	0.177	-1.203	6.531

Source: Authorôs own data

Considering the OLS results for 50% removal of IAPS in table 4.12, it is observed that similar conclusions to those for 100% removal of IAPS can be drawn since the same variables which are significant in the OLS regression for 100% removal are also significant in the 50% removal. The consistence in these results indicates respondents understood the experiment and that validates the data that was used in the analysis.

Table 4.12: OLS results for 50% removal of IAPS

				Number of obs	68	
				F(7, 60)	2.700	
				Prob> F	0.017	
				R-squared	0.239	
				Adj R-squared	0.151	
maxWTP50	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf.**	**Interval]**
BID	-0.387	0.148	-2.610	0.011	0.090	0.684
GENDER	-0.269	1.909	-0.140	0.888	-4.088	3.550
AGE	-0.027	0.070	-0.390	0.699	-0.167	0.113
DEPENDENTS	0.327	0.273	1.200	0.236	-0.219	0.872
MSTATUS	-0.086	1.834	-0.050	0.963	-3.753	3.582
EDULEVEL	3.084	1.100	2.800	0.007	0.883	5.285
INCOME	-0.230	0.083	-2.760	0.008	-0.396	-0.063
_cons	7.950	7.049	1.130	0.264	-6.150	22.050

4.3.4 Estimating mean WTP 50% removal

Estimated mean WTP was found to be 35.89 for the 50% removal of IAPS. This indicates that on average, respondents were willing to pay E35.89 to make sure that at least half of the

infested land was cleared for every cattle owned. This shows that livestock farmers prefer the removal of IAPS on rangelands to ensure their livestock have at least some fodder to graze on. There is value placed by livestock farmers on grazing land and that value is different from zero which emphasizes the point that IAPS should not remain uncontrolled to save the social, economic and environmental interests of livestock farmers. Tables 4.13 shows the results of the mean WTP for 50% removal.

Table 4.13: Mean WTP for 50% IAPS removal

MEASURE	WTP	LB	UB	ASL*	CI/MEAN
MEAN/MEDIAN	35.89	31.53	49.95	0.0018	0.51

*: Achieved Significance Level for testing H_0: WTP<=0 vs. H_1: WTP>0

4.3.5 Validity and reliability of WTP welfare estimates

According to Hanley and Barbier (2009), there are five validity and reliability checks that can be carried out to ensure the reliability of a CVM results. In this study, two of those methods were applied and these are the scope test and the convergent validity test. Since the results had both mean WTP for 100% removal and 50% removal, a t-test was conducted to test if there is any significant difference in the two mean WTP estimates. The results indicated that there is a significant difference between the mean WTP 100% and mean WTP 50%. From economic theory, individuals should place a lower value to a small piece of land cleared compared to the entire piece of land. This compels us not to reject the null hypothesis that there is a significant difference between WTP 100% and WTP 50%. Our WTP instrument as a whole was therefore valid and reliable. Table 4.14 shows the sample t-test.

Table 4.14: Two sample t-test

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
maxWTP50	68	21.471	0.920	7.583	19.635	23.306
maxW~100	105	40.857	1.402	14.369	38.076	43.638
combined	173	33.237	1.171	15.409	30.925	35.549
diff		-19.387	1.894		-23.126	-15.647

diff = mean(maxWTP50) - mean(maxWTP100) t = -10.2339
Ho: diff = 0 degrees of freedom = 171
Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0000 Pr(|T| > |t|) = 0.0000 Pr(T > t) = 1.0000

4.4 Results from the cost-based approaches

The mitigation cost in the control of IAPS after calculation was found to be E52.23. This was obtained after using data on the total number of cattle in the country and the amount of money that has already been spent mitigating the IAPS. Using the following equation and calculations, the costs were obtained. Given that there were about 765 829 cattle in Swaziland as of December 2012 and the reported costs that were incurred in clearing IAPS standing at E40 000 000.00, the cost per animal was calculated as:

$$\text{Mitigation cost per animal} = \frac{\text{Total amount spent mitigating IAPS}}{\text{Total number of cattle in the country}} = \frac{E40\,000\,000}{765\,829}$$

$$\text{Mitigation cost per animal} = E52.23$$

This value is equivalent to the mitigation cost per animal. That is, how much it cost government to clear a piece of land for one cow.

4.5Comparison of the welfare estimates from WTP and cost-based approaches

The mean WTP 100% eradication can thus be compared with the value obtained from the cost-based method. The mean WTP 100% removal is E60.50 and this gives an estimated total willingness to pay of E46 332 654.50. This is larger than the estimated value obtained from cost-based method which is about E40 000 000.00. This is in line with the expected conclusions that the cost-based approach will give a value that is smaller than that obtained using the stated preference method. The cost-based method gives a lower bound to the Hicksian welfare measure.

4.6 Institutional arrangement of controlling IAPS

Since the control the control of IAPS ceased in 2010 because it was not clear as to who should control it between community members and private contractors after there was a heated debate in parliament, it was found to be necessary to seek the views of cattle owners on the matter. The results in table 4.15 indicate the percentage of respondents who said community members should be employed and private contractors should be used instead. From the results, it is observed that a majority (94.79%) of the respondents felt the community members should be employed in the control of IAPS.

Table 4.15: Respondent's view on who they think should be employed in the control of IAPS for an effective removal to be observed

Variable	Frequency	Percentage
Community members	182	94.79
Private contractors/NGOôs	10	5.21

Source: Authorôs own data

Before the employment of private contractors in the control of IAPS, community members were used but they were offered food and it was therefore necessary to deduce what respondents felt should be the arrangement between the employer (government) and community members. About 77.1% of the respondents felt that government should pay the community members some monthly salaries while about 16.7% felt those controlling IAPS should be paid based on quantity removed, that is, there should be a value attached to a given mass of the roots of IAPS and anyone who brings roots of IAPS he/she should be paid based on the quantity the person has removed. These results are indicated in table 4.16.

Table 4.16: Arrangement between government and those controlling IAPS

Arrangement	Frequency	Percent
1. Paid monthly salaries	148	77.08
2. Offered food for work	2	1.04
3. Paid based on quantity removed	32	16.67
4. Other	10	5.21

Source: Authorôs own data

It was noted that even though a majority of the respondents felt government should employ community members and be paid monthly salaries, a majority (71.35% of the respondents) further felt government should provide the working tools and protective clothing to the combatants of IAPS. However, this cannot be a sustainable approach as people may see this as a job creation strategy and start planting the IAPS. Table 4.17 summarizes the obtained results.

Table 4.17: Support that should be provided to those controlling IAPS

Support that should be given	Frequency	Percent
1. Working tools/equipments	18	9.38
2. Protective clothing	2	1.04
3. Provide both 1 and 2	137	71.35
4. Provide nothing	35	18.23

Source: Authorôs own data

After obtaining the results on who should control IAPS, a chi-square test was ran to test the influence of socio-economic characteristics on their responses. It was hypothesized that the socio-economic characteristics of respondents do not influence their responses to these variables (who should control IAPS, what should be the arrangement and what support should be provided). Table 4.18 indicates the results. Age of respondent was observed to be the only socio-economic characteristic that significantly influenced respondentôs view on what support should those controlling IAPS be given. This may be due to the high unemployment rate observed in the country and as age increases people enter into the working class and they are out of school and so they are available to be consumed by the job market which is somehow saturated in Swaziland. Also there are those who are already retired but they were still willing to work to earn some income and that might be the reason this variable is significant.

Table 4.18: The influence of sex, age, education, income status, cattle size and marital status on who should be employed in the control of IAPS, what should be the arrangement and the support that should be given.

Variable	Sex	Age	Education	Income Status	Cattle size	Marital Status
Who should be employed to control IAPS	0.003	42.700	3.052	1.473	39.588	0.521
	(0.959)	(0.758)	(0.384)	(0.688)	(0.620)	(0.914)
What should be the arrangement	0.363	230.279	14.482	10.159	125.308	10.119
	(0.948)	(0.000)	(0.106)	(0.338)	(0.576)	(0.341)
Support that should be given	5.042	110.703	3.298	16.134	180.292	11.406
	(0.169)	(0.993)	(0.951)	(0.064)	(0.002)	(0.249)

Source: Authorôs own data
Note: Top figure is chi-square statistic and bracketed figure is the p-value.

4.5 Summary

This chapter presented the results that were obtained from the data after analysis in STATA. The results are presented to answer each of the specific research objectives of the study. All parameters obtained were discussed and descriptive statistics that came out of the analysis were discuss in depth in the chapter. Four variables (bid, dependents, income level and number of cattle raised) significantly influenced the respondentôs WTP for 100% removal of IAPS. The mean WTP for 100% removal of IAPS was E60.50. On average, the respondents were clear about the dominant IAPS in their communities and the respondentsô socio-economic characteristics did not influence their factual knowledge of the IAPS and their

availabilities in the communal grazing lands. A majority of the respondents felt that community members should be responsible for the control of IAPS and they should be paid monthly salaries other than employing private contractors.

5. Summary, conclusions and recommendations

5.1 Summary

This study was perpetuated by the fact that Swaziland, the smallest landlocked country, had been invaded by about 80% IAPS. And research and government reports had proved that millions of Emalangeni are lost each year in an attempt to control IAPS. Grazing land had considerably been reduced due to the infestation of IAPS and cattle farmers were the main stakeholders affected. Therefore, it was necessary to estimate the welfare benefits of controlling IAPS on grazing lands and this was the main objective of the study. The specific objectives were to: i) determine the knowledge of livestock farmers on IAPS and their associated impacts, ii) identify the factors affecting livestock farmersô willingness to pay for the control of IAPS on grazing land in the Hhohho region, iii) estimate the welfare benefits on cattle famers of the Hhohho region of Swaziland when there is a control of IAPS on grazing land, and iv) assess the institutional arrangement of controlling IAPS as suggested by livestock farmers, that is, if it can be better off to employ the service of private contractors or that of community members in the control process or other measures.

The study was conducted in the Hhohho region in one of the areas (Ntfonjeni RDA) that is densely infested with IAPS and a total of 192 questionnaires were administered through face to face interviews. The questionnaires were translated to SiSwati to ensure all respondents could understand the survey pretty well. A probit model was used to identify the factors that influenced respondentôs WTP after which the mean WTP was estimated.

5.2 Conclusion

From the results obtained from the study, it was observed that cattle farmers were willing to pay for the protection of communal grazing lands. The cattle farmers were willing to pay E60.50 per cow on average for the control of IAPS as an indicative for the value they placed on grazing land. This is a good foundation upon which the control of IAPS on grazing lands can be based. Government can save a lot of resources of she can control IAPS now.

If government controls IAPS now, the rate of spread to currently un-affected areas will be reduced. If IAPS are controlled, there will be more land available for grazing animals and

stocking rates will be low and thus cattle will have enough pasture to feed on. When cattle have enough to feed on, their growth rates become fast and they grow big which increases the meat quality and that attracts a good market price. This then will lead to cattle owners enjoying significant returns from the sale of their animals. This consequently improves the beef industry and the welfare of the farmers, their household members together with that of the country at large improves. This can ease the government burden on paying school fees for children who cannot afford school fees if cattle flourish.

The costs of clearing IAPS now are still low since the density of the invasion on a number of areas is still not yet very high. However, if government can clear IAPS now, she can save millions of Emalangeni because the IAPS are still growing and most of them are not very large enough. The time that can be spent on the clearing now can be short compared to time spent in future years where the invasion will be almost every where and big enough requiring large effort. Also future costs will be high due to inflation which keeps going up. According to data sourced from the Swaziland Ecological Zone Data Analysis (undated), about E213,596,360.00 is needed to clear condensed areas of *Chromolaena odorata* alone. This is a clear indication that government should urgently focus on clearing IAPS to avoid unnecessary losses due to continued invasion.

5.3 Recommendations

The following recommendations were made after the studyôs results:

1. There is a need to urgently continue with the control of IAPS to avoid future costs which may result if the control of IAPS remains suspended. The control and management of IAPS should be given priority. This is because livestock farmers are losing more of grazing land to the continued invasion by IAPS. The continued suspension of the control of IAPS encourages these species to encroach even more unmanaged ecosystems destroying biodiversity in the process and causing environmental harm.
2. There is a great need to invest into research to explore some economic means that can be employed to control IAPS. This may include exploring some economic ways of using the different IAPS so that even if the infestation spread further to even more areas but community members can apply a best use and start utilizing them and in the process reducing their effects.

3. There is also a need to increase awareness and educate the general populations on all media houses on the effects of IAPS so that communities can be in a position to take relevant initiatives to combat these IAPS. This can help in ensuring that even though the control of IAPS is a public good but the communities can control them in their communities provided they have extended knowledge of the benefits of such controls to them and the environment.
4. There is a need to invest into scientific research on the possible efficient ways of controlling IAPS in Swaziland. Studies on the biology and physiology of the different species should be conducted to determine which methods can be employed in the control methods of IAPS. This can allow for the use of cost effective methods which will be environmentally sound.

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APPENDIX A: LETTER OF CONSENT

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Natural and Agricultural Sciences

Informed consent for participation in an academic research study

Department of Agriculture Economics, Extension and Rural Development

WELFARE BENEFITS OF CONTROLLING INVASIVE ALIEN PLANT SPECIES FOR LIVESTOCK FARMERS IN THE HHOHHO REGION OF SWAZILAND

Research conducted by:
Mr. Z.N. Vilakati (11260344)
Cell: +27734821192 (RSA)
+268 7666 0292 (SWD)

Dear Respondent

You are invited to participate in an academic research study conducted by Zweli Ntokozo Vilakati, a Masters student from the Department of Agriculture Economics, Extension and Rural Development at the University of Pretoria.

The purpose of the study is to determine the welfare benefits of controlling IAPS for livestock farmers. The specific objectives are to: 1) estimate the welfare benefits on livestock famers of the Hhohho region of Swaziland when there is a control of IAPS on grazing land, 2) identify the factors affecting livestock farmersô willingness to pay for the control of IAPS on grazing land in the Hhohho region, 3) assess the institutional arrangement of controlling IAPS as suggested by livestock farmers, that is, if it can be better off to employ the service of private contractors or that of community members in the control process or other measures, and 4) determine the knowledge and perceptions of livestock farmers on the effects of IAPS.

Please note the following:

- This study involves an anonymous survey. Your name will not appear on the questionnaire and the answers you give will be treated as strictly confidential. You cannot be identified in person based your answers.
- Your participation in this study is very important to us. You may, however, choose not to participate and you may also stop participating at any time without any negative consequences.
- Please answer the questions in the attached questionnaire as completely and honestly as possible. This should not take more than 40minutes of your time.
- The results of the study will be used for academic purposes only and may be published in an academic journal. We will provide you with a summary of our findings on request.
- Please contact my supervisors, Dr E.D. Mungatana and Dr. B. Abidoye at (012) 420 3253 or email address: eric.mungatana@up.ac.za if you have any questions or comments regarding the study.

Please sign the form to indicate that:

- You have read and understood the information provided above.
- You give your consent to participate in the study on a voluntary basis.

_____ _____

Respondent's signature **Date**

APPENDIX B: QUESTIONNAIRE

Part 1: Knowledge of IAPS

This section seeks to identify the respondentôs knowledge and perceptions of the dominant IAPS found in Swaziland together with the associated negative impacts and benefits. The respondent is requested to indicate the level of familiarity with the reported dominant invasive species that are listed below.

1. Do you know what invasive alien plant species are? Yes [1] No [2]
2. Can you please indicate your level of knowledge/familiarity with regard to the list of IAPS indicated in the table by putting an ñXò or a tick to the corresponding level of familiarity together with availability in your community? The first one has been done as an example.*[See pictures of included IAPS]*

Example:	Very Unfamiliar (VU), Unfamiliar (U), Neutral (N), Familiar (F) & Very Familiar (VF), Available in your community (AIC)						
		VU	**U**	**N**	**F**	**VF**	**AIC**
	What is your level of familiarity with Sandanezwe?	-2	-1	0	1	X	X
	This means the respondents is very familiar with Sandanezwe and it is available in his/her community.						
	What is your level of familiarity with:						
	Chromolaenaodorata(Sandanezwe or wandile)	-2	-1	0	1	2	
	Lantana camara(Bukhwebeletana or Magazini)	-2	-1	0	1	2	
	Solanummauritanum(Gwayana)	-2	-1	0	1	2	
	Psidiumguajava(Umgwava)	-2	-1	0	1	2	
	Ceasalpiniadecapetala(Lugagane)	-2	-1	0	1	2	
	Rubus species (Inchacabutane)	-2	-1	0	1	2	

3. Can you please indicate your level of familiarity with the following negative impacts of IAPS. Did you know about the following effects?

Effects of IAPS:	VU	U	N	F	VF
Decreasing water quantity	-2	-1	0	1	2
Reducing agriculture land for growing crops	-2	-1	0	1	2
Harboring thieves	-2	-1	0	1	2
Some are poisonous to livestock	-2	-1	0	1	2
Causes soil erosion	-2	-1	0	1	2
Increases fire intensities	-2	-1	0	1	2
Decreasing land values	-2	-1	0	1	2
Reduces the welfare of people by being a sore to the eye.	-2	-1	0	1	2
Harboring dangerous animals like snakes	-2	-1	0	1	2
Great threat to biodiversity	-2	-1	0	1	2
Contribute to economic loss through increasing government expenditure	-2	-1	0	1	2

4. Even though there are so many reported effects of IAPS but there are also benefits which may be obtained from them. Kindly indicate your level of familiarity with the following benefits derived from IAPS. Did you know about the following benefits?

Benefits of IAPS:	VU	U	N	F	VF
Provide building material	-2	-1	0	1	2
Provide food, e.g. guavas	-2	-1	0	1	2
Helps in carbon sequestration	-2	-1	0	1	2
Prevent soil erosion	-2	-1	0	1	2
Provide aesthetic benefits	-2	-1	0	1	2

Part 2: Livestock farmers' preference for improved range quality

In this section of the interview, I would like to know your opinion about a potential project to improve the quality of the range in support of livestock farming in this region by removing IAPS.

5. In your opinion, how would you rate the effects of IAPS to you as a livestock farmer? Mark your rating with an X or a tick in the likert scale below.
NAAS = Not At All severe **NS** = Not severe **N** = Not sure
SS = Somehow severe **VS**= Very severe

NAAS	NS	N	SS	VS

6. Why do you rate it so?

_____

_____

_____

7. The removal of IAPS can bring about a number of benefits not only to the beef industry or livestock farmers but also other sectors which include agriculture and the national economy at large. Among the benefits that can be observed after the removal of IAPS are:
   - Increase in livestock unit since more land will be available for livestock to graze on.
   - Allowing a health stock to farmers since some IAPS are poisonous to livestock, e.g. *lantana camara,* therefore removal of such species can eliminate this potential effect.
   - Biodiversity will be observed and protected since IAPS eliminate biodiversity thus leading to extinction of some useful plants species and palatable grass species useful for cattle raring and other plants which may include some shrubs that are mainly enjoyed by other livestock such as the browsers (goats and sheep), these varieties of plant species regenerate when IAPS are removed.
   - It had also been noticed that IAPS increases fire intensities which leave range lands with nothing for livestock to graze upon after the fires, therefore their complete removal would help remove these fire intensity effects.
   - Moreover, IAPS also reduce stream flow and the amount of underground water which is so useful for both fodder support, other useful plants and for the animals and people, therefore their removal can allow streams to rejuvenate thus availing water for both livestock, domestic and industrial uses.
   - IAPS also harbour dangerous animals like snakes which are harmful to both man and animals; therefore their removal can eliminates such dangers.

In your opinion, do you think it would be a good idea if the community can come together and invest in a fund that will be used to improve livestock range land quality by removing IAPS?

Yes [ ] No [ ]

If Yes, go to question 9 otherwise answer question 8.

8. If No, why do you think it is a bad idea?

_____

_____

_____

9. Assuming there is no budget or manpower constraint, from your knowledge or experience with the management of IAPS, do you think it is possible to clear the range of all IAPS?

Yes [ ] No [ ]

If Yes, go to question 11 otherwise answer question 10.

10. If No, why donôt you think so?

_____

_____

_____

11. In question 7, you said that it would be a good idea if the community came together and invested in the removal of IAPS. Having highlighted the control benefits (above), it is worth noting that the removal or control of IAPS is a costly undertaking since there is a need to invest in chemicals, equipments (digging and cutting tools, e.g. peaks, slashers, saws and bush knives), protective clothing and compensation or food to those doing the control process or salaries if itôs a private contractor. Suppose that to fund this noble objective, the community decided to set up an IAPS fund that will only be used for the removal of IAPS with guaranteed results. Further suppose that the fund will be utilized to remove all (i.e. 100% removal) the IAPS that currently occupy the range. As you may know, if all the IAPS are completely removed, the range will provide maximum productivity for the cattle, that is, there will be increased land area to allow for fodder growth which can support livestock all year round. Would you be willing to pay a once off amount to contribute to this fund intended to completely remove IAPS from all range land?

Yes [ ] No [ ]

If Yes, go to question 13 otherwise answer question 12.

12. If No, why?

_____

_____

_____

13. Suppose the community fund was set up to manage the IAPS and that the amount paid would be as per unit animal. Thinking about the number of cattle you own and remembering that the number might increase and that every cow introduced in the range would require a unit payment. Would you be willing to pay **EX**[4]per cow as a once-off payment that each livestock farmer can be requested to contribute assuming that every livestock farmer will pay the same amount per animal owned as you?

Yes [ ] No [ ]

If No answer question 16, if No answer question 14.

14. If **No,** how much money would you suggest should be the payment made per farmer as a once-off payment per animal given that all livestock farmers will pay the same amount for a unit animal? E_____ (if zero answer question 15)

15. Why do you think you have to pay zero for the proposed project?
    - I donôt have money to pay for the project

[4] X being varied between E70, E50, E40

- To me, range land has no benefit/ I have no value for range land
- It is not my responsibility to pay for the proposed project
- Other reason (Specify)

_____

_____

16. Now that you would be willing to pay a once-off value of EX per animal introduced in the range, what would be your most preferred maximum number of cattle to raise? Remember that the range is limiting and for each animal owned you will have to pay EX for IAPS clearing in addition to the other regular costs of maintaining the cattle.
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17. Suppose that the community decides to only remove half (50%) of the IAPS infestation from the range, which may necessitate continuous control in future years since IAPS are highly prolific and their seeds are easily dispersed. Controlling IAPS in one piece of land and leaving it in another nearby had been observed to be equivalent to insignificant work done as the IAPS will regenerate within a short space of time as seeds will be dispersed from the uncontrolled land to the land that had earlier been cleared. Therefore with 50% removal we mean in a hectare (i.e. an equivalent of a football field) for instance, only half that field is cleared and the remaining half just remains untouched. Do you think that can be a good idea considering that at least 50% of the range will be free from infestation and a 50% improvement in quality of the range will be observed?
Yes [ ] No [ ]

If Yes go to question 19 otherwise answer question 18.

18. If **No,** why?

_____

_____

_____

19. In question 16 you said 50% removal of IAPS from the range can be a good idea. Suppose that the community see the 50% removal as a good idea as you see it and then decides on forming a fund where all livestock farmers will contribute an equivalent amount to ensure a perfect 50% removal of the IAPS. Would you be willing to pay a once off amount to contribute to this fund intended to remove 50% IAPS from all range land?
Yes [ ] No [ ]

If Yes, go to question 21 otherwise answer question 20.

20. If **No**, why?

_____

_____

21. Would you be willing to pay EX[5] as a once off contribution per farmer per cow for the 50% removal of IAPS on the range land?
    Yes [ ] No [ ] (If No, answer question 22)
22. How much money do you think it can be fair enough for the livestock farmers to contribute for the 50% removal of IAPS from the range land per farmer per cow?
    E_____ (if nothing answer question 23)
23. Why do you think there should be zero contributions?

_____Now that you would be willing to pay a once-off value of EX per animal introduced in the range, what would be your most preferred maximum number of cattle to raise? Remember that the range is limiting and for each animal owned you will have to pay EX for 50% IAPS clearing in addition to the other regular costs of maintaining the cattle.

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Part 3: Institutional Arrangement for Controlling IAPS

This part seeks to identify the respondentôs view on which institutional arrangement (IA) can best be employed in the control programme of IAPS in the country as perceived by livestock owners.

24. In your opinion, who do you think should be employed to remove IAPS on range lands?
    - Community members [ ]
    - Governmentemployees [ ]
    - Private contractors/NGOs [ ]
    - Other (Specify) _____
25. What should be the arrangement/agreement between those employed and the coordinating body?
    a. Paid monthly salaries [ ]
    b. Offered food for work [ ]
    c. Should be paid based onquantity removed [ ]
    d. Other (specify) _____
26. If government coordinates the control of IAPS and community members are employed, what support should be provided?
    a. Working tools/equipments [ ]
    b. Protective clothing [ ]
    c. Other (specify) _____

Part 4: Demographic information

27. Respondentôs name (Optional)? _____
28. Respondent's dip tank number? _____
29. Enter the details of the household head in the following table.

[5] X being varied between E35, E25, E20

Gender*		Age [Years]	Number of dependents	Number of school going kids if any	Marital Status*				Education level*				Primary source of income*				
M	F				S	M	W	D	N	P	H	T	GE	F	B	H	O
1	2				1	2	3	4	1	2	3	4					

* **M**= male **F**= female **S**= single **M**= married **W**= widowed **D**= divorced

***N**= No formal education **P**= Primary level **H**= High school level **T**= Tertiary level

***GE**=gainful employment (specify) _____ **F**= famer (specify) _____ **B**= builder
H= hawker **O**= other (specify) _____

30. What is your estimated monthly income (from all sources including non-wage/salary)?
    a. Below E3000
    b. Between E3000 and E7000
    c. Between E7000 and E12000
    d. Above E12000

Part 5: Socioeconomic information

31. Can you please provide the details requested in the following table.

Types of livestock owned		**Quantity**	**Land where livestock is grazed**		**Supplement feed provided**		**Active interest in nature/ biodiversity**	
Cattle	1		Communal	1	Y	N	Y	N
Goats	2		Private	2	1	2		
Sheep	3		Both	3				
Horses	4		Other	4	If Y, what is it?			
Donkeys	5				Silage	1		
Other					Hay	2		
					thrash	3		
					Other	4		

32. Any Comment on this interview?
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Part 6: Debriefing

33. How well do you think the interviewee understood the questions? Rank in terms of level of understanding using the following ratting scale.

1 = Very well understood (VWU) 2 = Well understood (WU) 3 = Understood (U)
6 = Not at all understood (NAU) 5 = Not well understood(NWU) 4 = Not understood (NU)

VWU	**WU**	**U**	**NU**	**NWU**	**NAU**
1	2	3	4	5	6

34. How do you rate the reliability of the responses given by this interviewee? Rank the reliability using the following ratting scale.

1 = Very reliable (VR) 2 = Quite reliable (QR) 3 = Reliable (R)
4 = Not quite reliable (NQR) 5 = Not reliable (NR) 6 = Not at all reliable (NAR)

VR	QR	R	NQR	NR	NAR
1	2	3	4	5	6

35. Give reasons for your answers to the above reliability data question (15 and 16).

_____
_____

Thank you very much for your time and participating in this survey!