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AN ECONOMIC ASSESSMENT OF INVASIVE ALIEN PLANT IMPACT ON SMALLHOLDER FARMERS AGRICULTURE PRODUCTION. CASE OF CHIMANIMANI DISTRICT WARD 21.

By

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DEDICATION

I dedicate my research work to my family and friends. A special feeling of gratitude to my loving parents Mr. Tivone Mutendera and Mrs. Itai Mutendera whose words of encouragement and push always rings in my ears. My brothers Talon, Ronald and Henry have never left my side and are very special. I also dedicate this research to my church family who have supported me throughout the process. I will always appreciate their assistance. I dedicate this work and give special thanks to my best friend valentine Moyo for being there for me throughout the entire program. You have been my source of motivation and you influenced me to stay strong.

DECLARATION

I, Armton Mutendera, solemnly declare that this thesis entitled an economic assessment of invasive alien plant impacts on smallholder farmer's agriculture production. Case of Chimanimani district ward 21submitted to Bindura University of Science Education, Department of Agricultural Economics, Education and Extension is a result of my research investigations and findings. All the work that was written by other authors and used in the thesis is fully acknowledged and a reference list is included. This work has not been previously submitted in part or entirety for degree purposes to any other university

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ABSTRACT

Agriculture biodiversity is the cornerstone of Zimbabwe economy and the realization that most poor rural African communities are directly dependent on agriculture warrants its conservation. Invasive alien plants threaten subsistence farming and compromise crops and livestock ability to provide goods and services for rural communities, thereby negatively affecting productivity and profits. Information on IAPs is lacking in most African countries, thus the economic effects of invasive alien plants (IAPs) are not clearly understood. In Zimbabwe, Vernonanthura Polyanthes has invaded Chimanimani district in Manicaland province compromising local smallholder farmers agricultural production that contribute to poverty alleviation and food security through altering the agriculture ecosystem. This study exposed the level of awareness, perceptions , vulnerable crops and impact of v.polyanthes to smallholder farmers in relation to contribution of local institutions .The impacts of IAPs on subsistence farmers in Zimbabwe were analyzed by looking at production stresses that arise because of v. polyanthes. The research used multi-stage sampling to select a representative sample of respondents. Primary data was collected using semi-structured questionnaires, group discussion and key informant guides. Furthermore, document analysis was conducted to collect secondary data. The data analysis process used Computer packages Microsoft Excel and SPSS .Results showed that that invasive alien plants provide nectar, live hedge, green manure, compost ,bananas proper's and mulch .However, costs of vernonathura polyanthes outweigh any benefits, which suggests that the species should be managed. Crop yield loss was the key negative with maize, banana, pineapple, tea and coffee as the most susceptible crops which constituted 68.5% of the total cultivated area. The long-term result of such a situation in the absence of control is increased poverty and the failure to realize sustainable development. However, results indicated that IAPs could also improve the poverty situation of a community before they have reached the threshold points. It is therefore imperative to know the threshold points of an invasive plant in order to ascertain the efficient point to intervene. Greater policy emphasis on funds for curtailing widespread ,create awareness through join efforts of institution to solve economic inefficiencies.

KEY WORDS: Vernonathura polyanthes, agriculture biodiversity, agriculture ecosystem and Institutions

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LIST OF ABBREVIATIONS

CEPF	Critical Ecosystem Partnership Fund
CBD	Convention on Biodiversity
CGE	Computable General Equilibrium
CABI	Centre for Agriculture and Bio-sciences International
CVM	Contingent Valuation Method
DTT	District Training team
EMA	Environmental Management Agency
FAO	Food and Agriculture Organization
GEF	Global Environmental Facility
GDP	Gross domestic Production
IAP	Invasive Alien Plant
IAS	Invasive Alien Species
ISSG	Invasive Species Specialist Group
NGO	Non-Governmental Organization
OXFAM	Oxford Committee for Famine Relief
PB	Partial Budgeting
PE	Partial Equilibrium
PFM	Production Function Approach
RDC	Rural District Council
TSURO	Towards sustainable use of resources organization
UNDP	United Nations Development programmed
UNEP	United Nations Environmental Programmed

WTP	Willingness To Pay
WTAC	Willingness To Accept Compansation
Zimasset	Zimbabwe Agenda for Sustainable Socie-Economic Transformation
ZANUPF	Zimbabwe African National Union Patriotic Front
ZRP	Zimbabwe Republic Police
ZimStats	Zimbabwe National Statistical Agency

CHAPTER 1

INTRODUCTION

1.1 Research Background

Controversial alien species has become threat to developing nations particularly on food security ,rural development and biodiversity. In Africa empirical evidence suggests that invasive alien plants causes an estimated yield loss of 80% annually (Zeddies and Schaab, 2000) .The total estimated economic cost of IAS to agriculture in Africa is believed to be US$ 65.58 billion per year, which represents on average 13.0% of the national agricultural GDP for Zimbabwe (Sileshi et al, 2019).Moreover, CABI (2022) highlighted that the problem of invasive species at global scale almost cost US$1.4 trillion each year. According to Claid et al (2021) globalization assisted with colonialism, tourism and continual expansion of trade blocks has assisted the movement of plants and animals beyond their places of origin.

The rise in human activities is alluded to be the major driver of invasive species into novel environments. Linders (2020) indicated that humans are both drivers and victims of invasive alien species impacts. Intentional introduction of IAS for economic purpose is believed to be the most common driver of invasive alien species (IAS) pathway (Elmer, 2001). That is during the colonial era native plants for agriculture and recreational activities were brought from Europe and America and thy were expanded into new lands to support the migration of the whites (Bebber, 2014).These plants were incorporated into botanical gardens to enhance perpetual propagation and further distribution to new lands.

The most available literature for invasive alien species and research organizations are mainly from developed economies (Nghiem, 2007). In African countries low data is available yet the agriculture sector is more vulnerable to invasive alien plants (IAPs) because the majority of people are poor rural smallholder farmers with land holding of two hectors or less. Apart from that, the spread of invasive plant species is exerting serious consequences for Africa due to weak environments and institutions to combat them. According to CABI (2017) toxic weeds and harmful shrubs are significantly shrinking grassing lands and lowering the productivity of major

horticultural foods such as bananas by 45%.In addition, alien plants has suppressed the growth of staple crops and take over fields with potential for agriculture therefore, this fundamentally threaten the economic growth supported by sustainable development programs. In the context of food security in Africa, the 2014–2017 AUC strategy emphasizes that declining agricultural productivity due to invasive plants is an area of focus for future research and development (FAO, 2017).

In Zimbabwe agriculture biodiversity is viewed as the cornerstone of Zimbabwe's economy and the livelihoods of the majority of population. Invasive alien plants (IAPs) are not yet prioritized into the agricultural policy framework yet they are seriously threating agriculture biodiversity, and smallholder farmer's production. A representative for Zimbabwe on his opening remarks at a workshop in Zambia stated that, it is important to have an IAS policy for the management of further invasions (Sithole, 2002). Moreover, there have been a number of international responses to support management of invasive species and requests for action from countries for example the Strategic Plan for Biodiversity (CBD) (CABI, 2017).Despite that, action against invasive alien plants in Zimbabwe have to date been low attention or non-existent (CABI, 2017).

In Zimbabwe the latest discovery of invasive alien plant (IAP) is *V. polyanthes* in the Eastern Highlands of Zimbabwe (EMA, 2010). The plant is a shrub from South America which is native to Brazil (Robinson, 1992) . It was deliberately introduced to Mozambique in 1990s for community apiculture at Sussendenga district by a non-governmental organization as a bee fodder (Timberlake J, 2011). The worst infestation have been documented in Chimanimani district and the plant have managed to expand its habitat range to Chipinge and Mutare. *V. polyanthes* is associated with heavily disturbed habitats particularly maize and banana fields (EMA, 2010). This controversial species has been the headline stories in local newspapers like the Manica-post and Sunday mail being described as adversely compromising local poor smallholder farmer's agricultural performance by altering the local agronomic ecosystem .

Traditionally, the problems associated with biological invasions have been viewed as the concern of biologists. However, invasive alien species impacts on agriculture systems have escalated beyond control and the scientific community is now increasingly calling for the input of economists (Emerton, 2008).In addition, the identification of new IAP like *Vernonanthura polyanthes* is linked to the intended consequences of economic activities, which in turn means

that economic solutions are also required. Moreover, Emerton (2008) put more emphasis on the need for greater research in economics and other social sciences to better address the objectives of multiple stakeholders. Therefore, this study aims at taking stock of the current situation on *vernonanthura polyanthes* on smallholder farmer's agriculture production in Chimanimani district ward 21 so as to be able to define, understand both the likely scale of the economic impact and ways to manage them.

1.2 Statement of the Problem

The backbone of Zimbabwean agriculture is occupied by untrained and poor smallholder farmers who have little land, little technology and rely on rain (Scoones, 2017). Invasive alien plants have worsen the situation by threaten smallholder farmers produce through outcompeting with crops and livestock. Furthermore, invasive alien plants compromise smallholder farmer's ability by increasing management and expenditure costs thereby negatively affecting their incomes. The impacts of IAP are irreversible which means they cannot be undone when an invasive alien plants fully establish. In the same vein, information on invasive alien plants (IAPs) is lacking in most African countries, thus the magnitude and severity of agricultural effects of IAPs are not clearly understood (Maroyi, 2012). Therefor policy regarding invasive alien plants management are non-existence or poorly administered.

In Zimbabwe, *Vernonanthura Polyanthes* has invaded Chimanimani district in Manicaland province compromising local smallholder and subsistence farmers. Limited knowledge regarding IAPs in Zimbabwe has hampered V*ernonanthura Polyanthes* management efforts in Chimanimani and prevailing institutional frameworks are failing to address the situation adequately. This study, therefore, intends to expose the view of smallholder farmers on the effect that *vernonanthura polyanthes* has on agriculture production.

1.3 Objectives of the study

The overall aim of the research is to determine the economic impact of *vernonathura polyathes* on smallholder farmer's agriculture production for Chimanimani district ward 21 in Manicaland province of Zimbabwe.

Four specific objectives were identified:

i. To assess smallholder farmers level of awareness and perceptions towards *vernonathura polyanthes* invasion .
ii. To assess the knowledge of smallholder farmers on *vernonanthura polyanthes* impact on agriculture.
iii. To determine the most vulnerable crop to invasive alien plant.
iv. To evaluate the contribution of local institutions towards management of *V.Polyanthes* in agriculture production.

1.4 Research Questions

i. What is the level of awareness and perceptions of smallholder farmers regarding *vernonanthura polyanthes* and its management?
ii. What is the impact of *vernonanthura polyanthes* on crop yield and productivity in infested and non-infested agricultural fields?
iii. Which crop is most vulnerable to invasive alien plant?
iv. How effective are local institutions in Chimanimani ward 21 on management of *Vernonathura polyanthes*?

1.5 Hypothesis

This study was designed to explore the validity of the assumption that proper understanding of economic impacts of IAP would lead to a better management of invasion hence poverty alleviation and agriculture sustainability is attained. In the attempt to answer research questions the following hypotheses were formulated:

i. *V. polyanthes* invasion affects smallholder agriculture production through increasing production costs and hence reduces productivity and yield.
ii. *Vernonathura polyanthes* invasion reduce vegetation diversity and structure, weakens ecological function and hampers agricultural potential whilst clearing rectify these negative effects.

1.6 Justification of the study

knowledge regarding IAPs is limited in Zimbabwe, hence this research will help in knowledge synthesis in order to augment management efforts of invaders such as *Vernonathura polyanthes*

in Chimanimani district. Moreover, in light of the evident gaps in knowledge, this study intends to highlight the perceptions of IAPs, the effect that *V .polyanthes* has on smallholder farmer's agriculture production and evaluation of the adequacy of local institutions in vernonathura polyanthes managements.

The quantification of economic impacts of *vernonathura polyanthes* is a critical step towards the goal of reducing the negative consequences of invasions on smallholder agriculture (Pimentel, 2002).Therefor, this study can contribute in identification of crops at greater risk which will be helpful for policy formulation to have more effective prevention and control measures (Dalmazzone, Silvana and Sergio Giaccaria, 2014).In addition , quantification of economic impacts can also acts as a gauge for the scale of economic loss to smallholder farmers.

Improved awareness of potential vernonanthura polyanthes threats to smallholder farmers would provide value for the production of proactive management plans. Elmer (2001) argued that some vernonanthura polyanthes invasions are caused by economics activities therefor this study will identifying the economic factors which cause the spread of vernonathura polyanthes and identifying economic tools and measures to support on management actions designed to address biological invasions.

1.7 Organization of the study

The study is organized into five chapters. This include introductory which is Chapter one. The introductory chapter presented the background to the study and statement of the problem. The purpose and significance of the study is also discussed. It went on to outline research objectives, research questions, justification of the study, limitations and delimitations of the study and finally organization of the research project. The next chapter (2) is a review of the literature related to the study.

Chapter two describes the threat of invasive alien plants on agriculture. It highlighted empirical studies on invasive alien plants impacts to smallholder agriculture. Historical aspects of vernonanthura polyanthes in southern African and management mechanism of invasive alien plants were also discussed in this chapter. The theoretical framework for valuating economic impacts of Invasive alien plants impacts were highlighted. Finally, chapter two discusses the conceptualization of natural resource Management in Chimanimani Rural District.

Chapter three of this study explained the research methodology that was used in regard to sampling procedure, data collection determination of sample size. Chapter three also focused on description of study area, data analysis techniques and tools that was employed for this study. It also emphases on the importance of validity, reliability and ethical considerations. Whilst chapter four presents research findings and discussions. Chapter five concludes the study with a presentation of the main findings of the study, policy recommendations and needs for further research.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.0 Introduction

This chapter analyses what scholars have written about invasive alien plants in agriculture with focus on subsistence farming. This chapter review theoretical and empirical literature relevant to the study. This chapter begins with defining the key terms and concepts of the study namely smallholder agriculture, invasive alien plants and their properties , relationship between economics and invasive alien plants. This chapter also discusses the various costs and benefits of IAPs in relation to smallholder agriculture. The key analytical concept that was used by other scholars and conceptualization of natural resource management in Chimanimani rural District.

2.1 Definition of key terms

There are some words which are going to appear frequently in this chapter as well as the whole thesis. Therefore to make it easier for the readers, the meaning of the words are defined as follows:-

2.1.1 Smallholder agriculture

According to Zimbabwe National Agriculture Policy Framework (2018) farming sector is argued to be dominantly smallholder-led with more than a million communal farmers who rely on rain-fed agriculture. Moreover, close to 70 percent of smallholder farmers make a livelihood on less than 2 hectares of land (FAO, 2016). Therefore, smallholder agriculture is one of the key strategies adopted by developing countries to boost the agricultural economies through linking smallholders with markets and risk reduction in production chain (Chamberlin, 2008). The World Bank Annual Report , (2009) indicated that seventy- five percent of the world's poor live in rural areas and they depend on agriculture for living. In addition smallholder agriculture is assumed to be fundamental to economic growth, poverty alleviation, and environmental sustainability. Therefore, criteria to define different types of smallholder farmers is very essential to promote proper support or assessment (Chamberlin, 2008).

Small-scale subsistence farms in Zimbabwe were created during 2001-2002 through land reform using 65,000 haters. According to Huvio and Lundstrom (2005) classification of smallholder farmers is based on landholding size which is two hectors and less in Zimbabwe whilst in Ghana it is five hectors or less. Nagayets (2005) argued that other perceived definitions such as low input use and low market engagement are negatively correlated with the characteristics of a farm. However, this does not conclude that other perceived definitions of smallholdings are without value because most smallholders farmers in developing countries are land constrained, poorly linked to markets, and more vulnerable to invasive alien plants risk than larger farmers (Chamberlin, 2008).

Moreover, FAO (2017) defined a Smallholder farmer as family-focused agriculture which mainly use family labor for production and use part of the produce for family consumption. In Zimbabwe smallholder farming sector holds most livestock production. However, the populations of most livestock species owned by smallholder farmers has been small and have declined from 2012 to 2019 due to erratic rainfall. Furthermore, invasive alien species limit agricultural productivity and efficiency and in so doing, undermine development agendas particularly in rural areas .Therefor, failure to recognize the different impacts of invasive alien plants is costly because it results in forgone agricultural output, incomes, and food and nutrition insecurity objectives. In the same vein, the agricultural sector in each country is susceptible to biological invasions due to high dependency on the available natural resources.

2.1.2 Invasive Alien Plants

More debates on invasive alien plants has led to many definitions depending on the behaviors that the alien exhibit. Blackburn (2011) took the standpoint that invasive alien plants (IAP) are those plants brought to a new range where they establish and spread often causing adverse impacts to ecology, social and economic systems. In addition Kumar Rai, (2020)supported the definition by highlighting that the impact component is very important in defining alien plants. The definition of invasive alien plant used in this study is different from the definition by Convention on Biological Diversity (CBD) Conference of Parties' where an invasive alien plant, was defined as a species outside its indigenous geographic range, whose introduction and spread threatens biodiversity (UNEP, 2022).The issue of invasive alien plants is not only a biodiversity concern but economics and wellbeing of humans and animals.

The origin of invasive alien plants is ambiguous to trace because plants have been moving from one place to another as a result of natural processes since the beginning of life on earth. According to Gren (2008) invasive aliens plants is not a new crisis and their introduction can be traced back to the introduction of agriculture 10 000 years ago. Moreover, Gordon and Witt (2013) postulated that, invasive alien species have been travelling with us for hundreds of years and like us. Previous studies come up with the consensus that most of invasive plants may be dated to 17th century. However Bebber et al (2014) argues that mass spread takes place in the 20th Century which is was characterized by high mobility and high-speed travel, trade and transportation links.

Alien plants invade crops lands through human intentional introduction and natural unintentionally introduction (Wakshum , 2018). After invasion the time lag may range from decades to centuries before fast spread. That is the plant in short time may appear to be non-invasive. Introductory causes are closely linked to the history of civilization. In the same vein, colonization led to massive trans-oceanic movements and exposed indigenous croplands to quite new stresses and threats in the world. Kumar Rai (2020) indicated that the new era of globalization is the major driver of invasion. Globalization is characterized by accelerated rate of species movements through the four Ts' which are trade, transport, travel and tourism have cause and sharply.

2.1.3 Introduction

Introduction means that the plant has been transported by humans across a major geographical barrier. Introduction pathways are the routes by which species move from one political unit to another that is either within a country or between countries. This process can be intentional that is by the purposeful "hand of man" especially for use in food production, agriculture, horticulture, forestry and agroforestry. In contrast, it can be unintentional when a species enters "by accident" as a result of movement with other commodities, as "hitch-hikers" on other species or activities, in travelers' belongings, clothes, luggage and so on. Linders (2020) argued that intentional introductions can be regulated however, unintentional introductions cannot be subject to any regulation or authority except to reduce the likelihood of their spread.

2.1.4 Establishment

Invasive alien plants establish after finding a conducive environment. Establishment takes place when an organism that has been introduced survives long enough to develop a population in its new environment and being able to reproduce. An example would be the establishment of vernonathura polyanthes that survives in Zimbabwe Chimanimani in disturbed areas like roadsides. Emerton (2008) indicated that succession in invasion usually requires that the alien taxon overcomes a different local of barriers**.**

2.1.5 Naturalization

After, successful establishment invasive alien plants spread and becomes naturalized. Naturalization take place when an established animal, plant or microorganism starts to spread and reproduce without any assistance. It becomes part of the natural flora or fauna and blends in" with native species .Naturalization starts when abiotic and biotic barriers to survival are surmounted and when various barriers to regular reproduction are overcome. Naturalized aliens plants are assumed to be harmless since they reproduce consistently and sustainable populations without direct and indirect impact to human-made ecosystems.

2.1.6 Invasion

Invasion phase further requires that introduced plants produce reproductive offspring in areas distant from sites of introduction over 50 years for taxa spreading by seeds and other propagules; 3 years for taxa spreading by roots, rhizomes, stolons or creeping stems. Taxa that can cope with the abiotic environment and biota in the general area may invade disturbed, semi natural communities. It is characterized by the naturalized alien species spread taking advantage of the two weakness. Invasive alien plants are occasioned by disruption of its new ecosystem in some way. This disruption is the major concerns of biological, social economic impact assessment. In addition, invasive alien species reproduce often in large numbers and are able to spread over a large area, damaging native species.

Moreover, climate change is argued to fuel IAS to colonize easily. Climate change can facilitate IAS as new species that may become invasive. Species are believed to entering other regions due to climate change. These, species existence in local ecosystems will change the face of the environment leading to new dominants that may have invasive tendencies. More, climate

induced stress in an ecosystem will speed up invasive pathways. Alternatively, IAS can also increases climatic stress by increasing through reducing the number of species and their functional types.

Agricultural lands are mostly disturbed trough agriculture management practices therefor offers weakest resistance to invasions (Quentin et al , 2014) .This implies that agricultural lands are susceptible to plant invasions. The level of susceptibility may depend on stability and resilience of the agriculture ecosystem. Invasive species in large agricultural lands of the tropics are under studied hence the severity of the problem is not known. It is however well known that the proportion of introduced plants that have become invasive is far higher in agricultural lands than agroforestry (Quent et al, 2014). This is because of favorable growth conditions present in the especially in abandoned lands. The plants that are more likely to invade croplands are commonly species with attributes that allow them to take advantage of recently disturbed farms.

Furthermore, some of the most important characteristics suggested by given include high reproductive rates, production of large quantities of seeds, wide dispersal ability, ability to germinate under a wide range of physical and environmental conditions. In addition, invasive species also have early reproductive maturity, as well as high growth rates and capability of vegetative reproduction (Denslow, 2002) (Denslow, 2002). These characteristics ensure that invasive plants are very successful and produces damages to agriculture productivity.

2.2 Invasive Alien Plant properties

Invasive alien plants exhibits superior growth, production and key features to outcompete the indigenous plants for full establishment. Have unpalatable foliage, Can easily establish in degraded environments, Have an ability to regenerate profusely from direct seeds, stems or roots. Martens et al (2021) find out that some invasive alien plants are superior to the indigenous plants by having deep and long taproots that draws water at lower depth and makes pulling out the plant difficult. In addition, if the plant is pulled it can break off at the base and the plant will re-sprout. Although some IAPs have shallow root systems which makes easy pull however, they might regrow from root suckers or rhizomes that connect plants below the ground (Henderson, 2001).

Wilman (2019) argued that the production mechanism of most invasive alien plants is more powerful than the native plants. That is most invasive alien plants are re-seeders which depends

on high reproduction lots of seeds. Holland et al ,(2002) highlighted that even if a parent plant is killed new plants will grow from the seedbank in the soil or from seeds released from cones which had stored the seeds in the canopy. Vernonanthura polyanthes, for example, is a serious invasive plant in Zimbabwe that produces copious of seed during the month of august which is distributed by wind (EMA, 2010).

Moreover, most invasive alien plants re-sprout after damaged by wildfire or cut down. New shoots grow from the base after the top of the plant has been removed (Martens, 2021).Vernonanthura polyanthes is an example of invasive alien plant that will grow new stems if the main trunk is felled or burnt. Re-sprouting may mean that more than one control method, including herbicide, will be required for follow-up treatment. This is because invasive alien plants like Vernonia polyanthes do not only rely on their seeds for survival. Wakshum (2018) identified four key features that characterize invasive plants as excellent competitors to native plants.

2.3 Relationship between Economics and Invasive Alien Plants.

According to Emerton (2008) humans always aims at increasing economic productivity and well-being. Most of the choices made by humans might create challenges to the environment and its ecosystem. Dalmazzone (2002) argues that the desire to maximise economic productivity and profit has contributed to introduction and vulnerability of invasive aliens plants. Moreover farmers are always faced with many choices which might cause the introduction of plants that can lead to a reduction in agricultural productivity (Dalmazzone, 2002).According to Emerton (2008) invasions are the outcome of a set of processes while many of these processes are economically motivated for instance the use of exotic species in a variety of economic activities. Perrings (2000) argued that liberalization and deregulation of markets, expansion of trade of goods and services are the major economic pathways of invasion. Furthermore, economic factors also determine the resilience of both human and natural systems to the effects of invasion.

2.3.1 Direct economic causes of invasion

According to Crompton (2006) there are many economic activities set in place and affect the movement between introductions of invasive alien plants until progression to invasion. The major economic activities which directly results in invasions involve the transport and transfer of

species into other areas. Economics is highly related to IAPs because many of the items that humans produce and consume are based on the use of inputs either introduced or imported species which have the potential to become invasive. High profitability and market demand of invasive alien plants whilst low profitability and market demand non-introduced species fuels invasion Wise (2007).

Most of biological invasions manifested due to trade and investment incentives for economic activities which utilize or depend on introduced species .According to Martens (2021) exotic species are increasingly used commercially especially in agriculture. Potentially invasive species are being used for farming, foods and governments subsidies to introduced species like caster bean for biofuel production subsidies. In addition, other intentional introductions include plants and animals which are used for biological control and landscape restoration such as frogs to reduce pests' population. Moreover, production, consumption and trade activities may also lead to the introduction of invasive species. This may occur, for example through the import of contaminated livestock, plants. Emerton (2008) alluded that invasive species "hitch-hike" in freight, packaging or travelers' luggage and clothing.

The expansion of global markets resulted in changes in human demands and consumer preferences for introduced species which increases incidence of invasions. The increase in the problem of invasive species is seen as being one of the most striking consequences of globalization (Perrings et al 2005). Activities associated with trade and travel, in particular, are frequently cited as the most important cause of the spread of invasive (Horan et al 2002). The weakness of most economics policies is the existence of inadequate penalties and fines against illegal transportation of introduced species

2.3.2 Indirect causes

Perrings (2000) argued that probability of invasive alien plants spread depends on people's behavior and on their responses to threats .Emerton 2008 noted that some invasive species are introduced unintentional but in many cases people do not introduce, establish and spread invasive species without a profound reason. Therefore, humans do so for the economic benefits and profits they yield through to fulfilling their needs, tastes and aspirations. People are in turn motivated to produce, consume and trade in particular ways due to market, price, livelihood, policy and institutional conditions.

The indirect causes of invasive alien plants invasions involves economic signals which shape people's behavior like commodity prices and input costs. They involve the use of various instruments such as subsidies, taxes and other fiscal instruments to promote production or consumption of particular products. Indirect causes also include the more general economic context within which people operate, for example the reliance of an economy on sectors which introduce or use potentially invasive species for example agriculture. Operations in a situation to generate and access food, cash and employment are limited and merely dependent on activities which utilize invasive species.

2.3.3 Invasive alien plants as an externality

According to Gren (2008) economic policies and markets often fail because invasive plants place in conditions which discourage producers, consumers, traders, investors, land managers and resource users from taking account of the risk of invasions. Invasions are associated with high costs to the economy for those whose action sets in place the steps curb invasion. Usually invasion cost are incorporated into the prices and profits on economic activities. Biological invasions become an externality when the prices and profits that people face as they carry out their economic activities do not internalize the full costs of invasions.

Essentially, invasions are usually the external effects of market transactions (Perrings 2002) where market prices do not accurately reflect the full social and economic costs associated with invasions. Organizations that introduces invasive species does not bear the costs associated with their action. However, these costs or losses are felt by others with no compensation provided for the damage caused (CABI, 2017). Thus the problem of invasion embodies many forms of economic externality and economic measures to reduce them are required to address it. What is worrisome is that that most of the financial and economic instruments that are designed to deal with invasion externalities are less well-suited in dealing with invasions.

2.3.4 Perceptions on Invasive Alien Plant

Gordon and Witt (2013) argued that it might takes up to 50 years when an non native plant establish and becames invasive. When an invasive plant is naturalized to a foreign geography it captures the concerns of society directly or indirectly benefiting from the environment. The society is a basket which consists of individuals with different values, ethos, attitudes, goals and

perceptions. According to Siges (2005) invasive alien plants have the power to divide the society into two groups of individuals. That is those who play a strong role in the generation of the discourse like scientists and those who experience its practical application,

Perceptions and attitudes towards invasive alien is a golden factor for cohesion regarding the management of invasive alien plants. Kim (2006) argued that what determine the success of invasive alien plants management is the attitudes and behavior of stakeholders. In addition, behavior of stakeholders is also fundamental important foundation to analyses the magnitude of IAP impact. In addition, the interaction of people with their natural environment is very important to examine the relationship between environmental issues and people's perceptions of the environment. Gray (2020) defined environmental attitudes as "the collection of beliefs, affect, and regulate the behavioral intentions a person holds regarding environmentally related activities or issues".

According to (Kellert, 1996) the negative perspective is the most dominant against invasive alien plants which is characterized by alienation, avoidance and even harming or destroying certain invasive alien plants. On another hand, when an invasive plants have benefits the society might incorporate it and develops a conservative perceptive towards it. In addition, perceptions of a society depends on age, social class, education and income (Binti Kari, 2014).Thus those who are poor might have an exploitative attitude toward natural resources as compared to those who are rich.

2.4 Threat of Invasive Alien Plants on Agriculture

According to Gordon and Witt (2013) invasive alien plants disturbs crop production through occupying agricultural lands and serving as a hiding place for crop pests and wild animals. The livestock feed shortage is also a challenge by the introduction and establishment of invasive weeds (Abate , 2010). Rozenberg (2017) shows that land abandonment can further induce economic impact in native fauna and flora. SEIA (2022) defined economic impact as potential changes that influence directly or indirectly in “whole or in part, for better or for worse” by sectorial activities. The economic impacts of invasive alien plants are categories into market impacts and non-markets impact. The market impacts can be expressed in monetary value using marketing prices whilst the non-market need modification through human perceptions and

preferences (Lopez et al, 2021). In the real world distortions due to monopoly practices, external economies and diseconomies, or interventions makes the market pricing fails to reflect true value (Munasinghe, 1993).

2.4.1 Direct impacts

According to FAO (2017) grain and horticulture or cash crops are very essential for smallholder's farmers however invasive alien plants directly affect their yield. For instance s invasive plants competes for light, soil moisture and nutrients with understory vegetation in its native range. Moreover, IAS also decreases the amount and quality of agricultural lands leading to lower land value (Tonnang, 2015).Increases in crop management expenditures particularly weeding cost is another negative impact of IAPs which results in damage greater than operation costs. According to Corin and Murphy (2017) smallholder farmers might undermine school age children through spending days weeding and missing key periods of education, limiting their future prospects.

According to Huvio (2005) livestock keeping is central to the culture and economy of large parts of Africa .In the African continent grasslands are widespread and the impact of IAS on these grasslands is exerting serious costs to agriculture. Although capital is held as livestock, the impact of invasive alien plants is estimated based on income derived from livestock. CABI (2015) find out that invasive alien plants reduces grazing lands carrying capacity, fodder availability and income from livestock (Linders , 2020).

2.4.2 Indirect adverse impacts.

Indirect impacts might be caused by yield loss which might makes price of food products expensive to consumers .Moreover, Maroon (2009) highlighted that invasive alien plants impact native pollinators and indirectly impact native plants via interactions with pollinator's. Thus IAPs reduce pollinator services to native flowering plants by increasing or decreasing pollinator visitation rate. Goodell (2008) argues that extremely effect of invasive plants on native plant pollinator interactions is caused by large-scale species transformation of plant communities. Russo (2016) argue that, there is strong evidence on invasive flowering plants negative impacts however it is unclear how strong these indirect effects are on native plants. In general, the effects of invasive plants on pollinators and pollination services are complex and not fully understood

(White et al. 2006).Smallholder farmer's main crops such as most grains do not depend on insects for their pollination. This does not mean that they are not highly dependent on insect pollination because many fruits, vegetables and stimulant crops depends on pollination.

2.4.3 Benefits of invasive alien plants

The total economic value of environmental resources is built up of use and non use values. Use values are often easier to assess than non use values. The outputs of the resource can be directly consumed: - a forest may yield annually a certain amount of wood that can be sold or used for heating. Many studies show. In the utilitarian (anthropocentric) concept of value, ecosystems and the services they provide have value to human societies because people derive utility from their use, either directly or indirectly (use values). People also value ecosystem services that they are not currently using (non-use values). The utilitarian approach, therefore, bases its notion of value on attempts to measure the specific usefulness that individual members of society derive from a given service, and then aggregates across all individuals, usually weighting them all equally. Second, utility cannot be measured directly. In order to provide a common metric in which to express the benefits of the widely diverse variety of services provided by ecosystems, the utilitarian approach usually attempts to measure all services in monetary terms

According Linders (2020) about 15% to 45% of invasive alien plants were Cultivated uses in eastern Africa to harvest their benefits. Emerton (2008) argues there is no economic assessment of invasive impacts which is completed without considering their positive values. Alien plants may have invasive or colonizing qualities but they might be regarded as beneficial. Bazzaz (1979) identifies that endemic plants may recolonize lands disturbed by fire, flood, soil disturbance and erosion.

Moreover, some IAPs provides the gifts of nature like foods, sources of timber and fuelwood, produces new and needed plant products such resins, fruits and edible seeds. However these benefits may be far less than the negative impacts felt by general public. Indirect use of natural recourses relates to functional benefitsAlthough the employment of individuals is essentially a cost associated with alien plant eradication, when such employment enhances the welfare of society through reduced poverty and crime levels it may also be regarded as a social benefit. Job creation arising from alien plant removal is likely to enhance living standards and social stability

in the area, and is thus of paramount importance. External social benefits of employment are difficult if not impossible to quantify.

2.5 Management of Invasive Alien Plants in Agriculture

Invasive alien plants management in agriculture sector is viewed as a weakest link or public good. It is nonexclusive, meaning incentives exist to take a “free ride” on the efforts of others and “shoulder” less than a fair share of the costs of control Cusack (2009). Moreover, the challenge with invasive species is that there is no quick solution and issues around their management and use may be put into too hard basket. In Robertson (2020) view, management of invasive alien plants is increasing and remains a major societal challenge for the 21st century.

Seebens et al (2017) point out that unsustainable exploitation of natural resources increase invasion susceptibility and expenditure to control invasion. United Nations development goals emphasis the need to manage invasive species to reduce impacts of IAS (UN2015). general principle emerging from this research is that, if the invasive species stock is initially greater than its optimal equilibrium level, the highest level of management effort should be applied initially, and then should decline over time until the steady state is reached

2.5.1 Institutions, policies and IAP

According to, Nagayets (2005) there are some barriers to the effective adoption of strategies for managing IAS in Africa .Three factors were identified which are:

- The policy environment in developing countries is weak.
- Essential information required by different stakeholders is not available.
- Implementation of prevention and control programmes is slow coupled with inadequate capacity lack of resources.

International policies have been designed to deal with the impacts of invasive alien plants and act as benchmark for individual countries to base their domestic IAPs policies. Firstly, World Trade Organization (WTO) Sanitary and Phytosanitary Agreement (SPS Agreement) have been included in global international trade and environmental policy agendas to regulate alien species trade (Rene et al, 2021). Secondly, invasive species issues are also being included into the international agenda via the Convention on Biological Diversity (CBD) .CBD urges countries to

prevent the introduction and control or eradication of non-native species that threaten ecosystems, habitats and species (CABI, 2017).

In Zimbabwe's third national Report to the CBD report cites the Control of Goods Act (Chapter 14:05) that aims to control the import of IAS. The Act itself outlines the capacity of the President of Zimbabwe to regulate the import and export of goods including species of flora and fauna and financial penalties that may be delivered "for the effectual exercise" of these regulations (EMA, 2010). A permit is required for the import export of animal and plant products which is issued once the applicant has satisfied the authorities that the plant or animal once imported will not find its way to the wild. However, the report indicates that there is no capacity for strict monitoring (CABI, 2017).

Moreover, the Zimbabwe Agenda for Sustainable Economic Transformation (ZimAsset) addresses the need for strategies and measures to tackle environmental challenges such invasive alien plants threats, pollution, poaching, deforestation, land degradation and veld fires. Today, the lack of clear evidence of impacts causes a number of problems, including not being able to adequately support proposals aimed at securing funding for research and management, and for convincing governments to take the problem seriously. EMA (2010) argued that management of invasive alien tree species is a huge expense. Therefore, control measures are largely based on individual efforts of private companies. Private campaniles estimated their annual budget for control of invasive tree species to be equivalent to US$100 000(2010).

In southern Africa at national level South Africa, have drawn up legislation that prohibits the cultivation of certain IAPs and require the compulsory removal of these IAPs from the land. In South Africa, the legal institutions, such as the Conservation of Agricultural Resources Act of 1983, have been supported by the WfW programme. The Environmental Management Agency in Zimbabwe has taken the lead in the implementation of the institutional frameworks (Environmental Management Act of Zimbabwe, 2012).

The main barriers to effective management of invasive alien plants in Africa are the lack of appropriate policies and implementation. In addition insufficient capacity especially with regard to the identification and management of invasive plants. Lack of awareness among government officials and other stakeholders as to the impacts of invasive plants on crop and pasture

production and economic development and an absence of sufficient resources to tackle the issue. Policy is also complicated by politics—the political scales of policies rarely match the ecological scales of invasions

The persistence of positive attitudes towards some invasive plants continues to hamper implementation of much-needed management interventions Witt (2017). There is still a tendency, among donors and global development and aid agencies, either to ignore the problem or to underestimate the extent to which it is responsible for so much of the poverty and suffering in Africa.

2.5.2 Management mechanism of invasions

Ross et al (2022) explained that management mechanism is the method used to prevent, control or eradicate IAS. Ahmed et al (2021) noted that management costs of invasive alien plants were last reported in 2002 with a maximum cost value of US$7.4 billion. Understanding impacts of invasive species is essential for effective management and determination of threshold to aids decision. Three approaches were established by CBD to control invasive alien plants which includes mechanical, biological , chemical and integrated management techniques.

Mechanical control involves the physical removal of the invading species. This can involve manpower alone to uproot , burn and destroy plants . It may also involve machinery and sophisticated equipment to enhance the mechanical control. This method of control is often preferred over others as it can have least impact on non-target species and ecosystem stability .However, mechanical control may take longer than required to meet the management objectives. Chemical control involves pesticides, herbicides, poisons and pharmaceuticals used to kill species of concern or eliminate them from host plants. Impacts on non-target species and habitats may be of concern with this method unless specificity of action can be guaranteed or manipulated. Biocontrol can be employed when an alien invasive species has become established without its natural controls in the form of specific plant herbivores. This method is more sustainable than the first two because once it is successfully applied.

Integrated control involves the use of more than one of the methods above to ensure management of the invasion and prevention of its spread. Classically, biocontrol would be used to reduce the population of the invading species to an acceptable level while mechanical and chemical control

would enhance this by eliminating ”outlier” subpopulations and advancing fronts or otherwise difficult-to-control areas or groups. Each of these methods has its economic costs and manpower and expertise requirements which have to be compared to each other and with the costs of “no action”.

2.5.3 Academic Research on Invasive Plants management in Africa

The previous sections have discussed economic debates related to invasive alien plants exposing the benefits and problems associated with invasive alien species. Despite the existence of growing body of literature, academic research in economic impacts of invasive alien plants is the area lacking in most African countries (Egoh et al., 2012). What is worrisome is that, most affected agricultural hotspots are located in developing countries whilst ecological research centers and scientists are mostly located in developed countries (Nunez and Pauchard, 2009).This state of affairs consequently influences the amount of research on ecological topics such as biological invasions and their management strategies (Smith et al., 2003; Nunez and Pauchard, 2009).

Nunez and Pauchard (2009) attributed this skewed relationship to the multiple competing socio-economic challenges facing the majority of African countries and low levels of industrialization. Southern Africa, in particular, recorded a significant number of alien plant invasions in the recent past (EMA, 2010). Academic research, however, is skewed towards the richer (South Africa, Mauritius, Kenya) and more industrialized nations on the continent, in accordance with arguments raised by Nunez and Pauchard (2009). However, of late, other southern African countries have also contributed to the academic debate on IAPs for example Zimbabwe (Maroyi).

The most common invasive plant in Zimbabwe is Lantana camara, with the highest incidences of occurrence recorded in Mashonaland Central and Midlands. Opuntia fulgida is predominant in the Beitbridge and Gwanda districts and affects 2,355 ha and 1,500 households. This cholla cactus has reduced the productivity of rangelands and invaded 3,000 ha in Matabeleland South. The recent recorded invasive alien plant is vernonathura polyanthes in the Eastern Highlands of Zimbabwe.

2.4.5 Conflict of interest in management of IAS

Most recorded invaders like noxious ones proved to be beneficial or please someone therefore regulation is politically and socially complicated (Baskin 2002). Because of this, restrictions on cultivation of invasive species may impose costs to local people who may have previously been able to exploit their production. As a result, there may be substantial political opposition to strict controls on the introduction and use of certain exotic species. For effective control of invasive species, management approaches need to be perceived by local people as aiming for socio-economic, as well as ecological sustainability.

People make choices that augment or diminish the chances of species becoming invasive, largely via intentional introductions to support economic activities including agriculture, forestry, gardening, and international trade (Bright, 1999). Conflicts of interest arise from time to time in cases where important tree species become invasive and spread beyond the areas where they are cultivated such as vernonathura did in Mozambique. It is thus clear that agricultural lands has been one of the major targets of alien infestation (Richardson, 1998). These conflicts have to be dealt with in a sensitive manner if progress is to be made in reducing the significant negative impacts of invading alien plants in Zimbabwe and elsewhere in the world

2.6 Conceptual model of the V. polyanthes infestation and sustainable solution.

Figure 1 depicts how the study conceptualized vernonathura polyanthes characteristics and smallholder farmers .

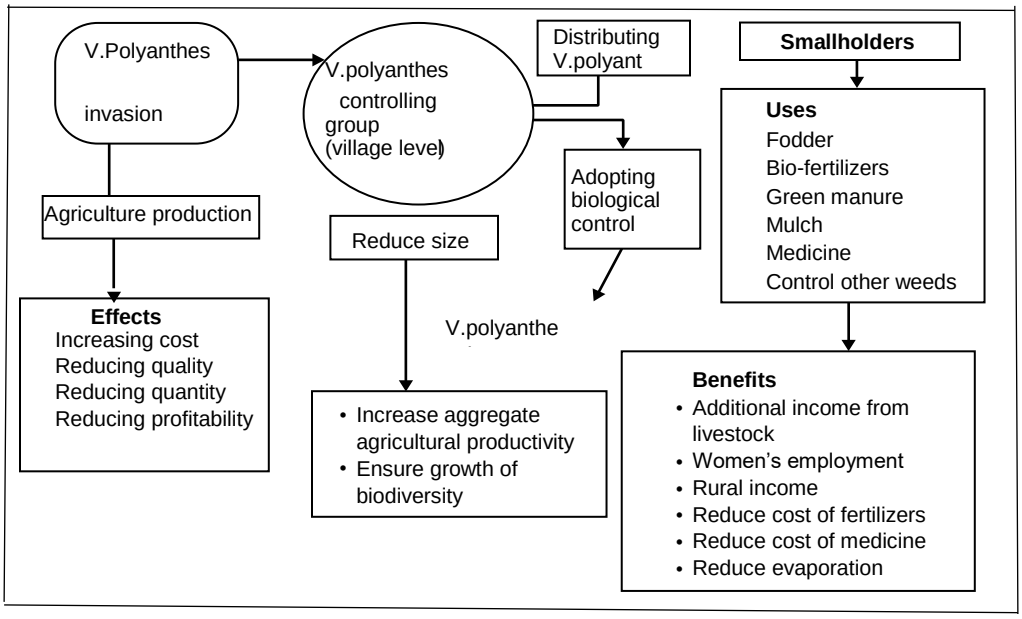

Fig 1:Conceptual model of the V. polyanthes

Source: Modified from

2.6.1 *Vernonanthura Polyanthes* as an Invasive Alien Plant

Vernonathura polyanthes is a conflict species that was introduced to agro-ecosystem for apiculture as a bee fodder. *Vernonanthura* is very useful and important economically, while on the other side they damage human interests through compromising smallholder farmers agricultural and livestock productivity. According to Vega (2010) *vernonanthura polyanth*es belongs to the plant family asteraceae and is popularly known in native country as assa-peixe. It belongs to the vernonia genus which have around 1000 species found in South America. According to Dematteis (2010) the genera vernonathura, was combined with *a vernonia polyanthes* to produce *vernonanthura polyanthes* .A species that belonging to vernonia genus can be found in a wide range of habitats of broad ecological diversity and climatic conditions, but especially in tropical regions (Vega.,2010).

The species is a shrub with oval leaves, rough and hairy spear-shaped. The white or pink inflorescences are arranged at the apices of the branches in small capitula (Alves, 2003).The shrub is shown in figure 2 below.

Figure 2: *Vernonanthura polyanthes* images

Source: (Alexander et al, 2017)

2.5.1 Historical aspects of *vernonanthura polyanthes* in southern African

Vernonanthura polyanthes is a shrub indigenous to Bolivia and Brazil (Vega and Dematteis 2010). It was deliberately introduced to Mozambique in 1990s for community apiculture at Sussendenga district by a non-governmental organization as a bee fodder. Lorenzi (2000) reported the introduction of the species in Mozambique in the 1990s to enhance honey production, as is the case in Brazil where *V. polyanthes* is a well-known honey plant pollinated by honey bees. In Zimbabwe, *V. polyanthes* blooms from June to August, and then produces copious wind-dispersed fruits.

Vernonanthura polyanthes invaded Mozambique and Zimbabwe with the worst infestation on both sides of the Zimbabwe –Mozambique in the eastern border (Timberlake J, 2011).Thereafter

it spread steadily forming dense infestations over parts of Chimanimani district .The plant in due course inevitably spread from border area from Mozambique Sussudenga Park into parts of neighboring Chimanimani Mountains. According to EMA (2012) the plant has invaded and is expanding its habitat range in the Eastern Highland Mountains of Zimbabwe at elevations ranging from 648 to 1350m above sea level, from the Chipinge, Rusitu, Chimanimani, Mutare, Burma Valley, Bvumba, Cashel Valley, Penhalonga, Mutasa, and Honde Valley areas (EMA, 2012). Ishara and Maimoni (2011) highlighted that the species is likely to become invasive in other African countries.

2.5.2 Uses of *vernonanthura polyanthes* in its native environment.

In native country *vernonanthura polyanthes* is used as medicine (Toyang, 2013). The Vernonanthura species represent the "assa-peixes" used in Brazil in the composition of syrups for the treatment of flus and colds. In addition, *V. polyanthes* leaves and roots in infusion are used in ethno medicine to treat bronchitis, persistent coughs, pneumonia, kidney stones, gastric disorders, malaria, fever, wounds, fractures, sprains, bruises and dislocation. (Temponi, 2012).Moreover, the plant presents antiulcer effect (Barbastefano et al., 2007).Moreover, *vernonathura polyanthes* is used as a bee fodder.

2.5.3 *Vernonanthura polyanthes* invasion effects in non-native areas.

Nunez (2013) argued that a single invasive species can exhibit different behaviors in different communities. Therefore, it is critical to understand invader traits in the context of the invaded community in order to characterize its impacts (Pysek et al. 2012).In Chimanimani district *Vernonathura polyanthes* is associated with heavily disturbed habitats that is maize and banana fields, plantations, and forest margins. In addition,*v. polyanthes* produces copious amounts of pollen, which has the potential to alter the behavior of pollinators in this ecosystem, and observations are that more studies are required to fully understand the reasons behind this (EMA 2010). Figure three below shows the pontential target of v.polyanthes invasion in Zimabwe.

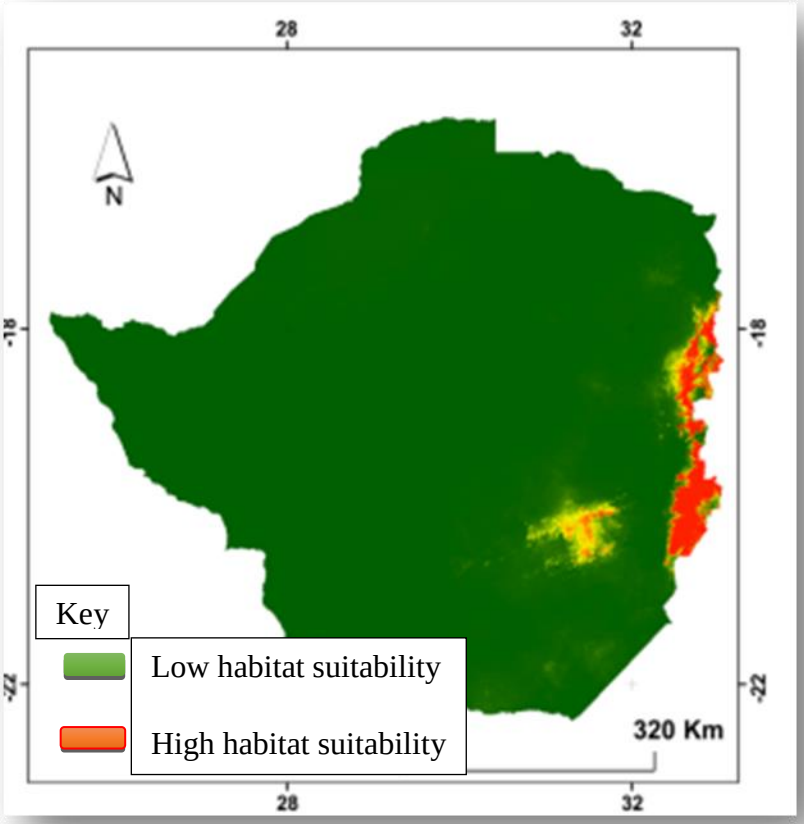

Figure 3: the target distribution of *Vernonanthura polyanthes*

Source: (Alexander et al, 2017)

The diagram above shows the target distribution of *Vernonanthura polyanthes* in Zimbabwe which was modelled using maximum-entropy approach where green colour covers semiarid regions whilst red shows areas with tropical conditions susceptible for further invasion .The potential extent of economic damages may justify regulatory actions aimed to eradicate or contain the spreading populations to slow the rate of its spread (Epanchin and Wilen 2012).Emerton (2008) indicated that biological invasions are viewed as an unwanted event therefor risk assessment framework on distribution need to be prioritize to enhance management efforts.

2.5.4 Control of *vernonanthura polyanthes* in Southern Africa

In Chimanimani district there is no rigorous control measures as farmers are only using family labour to eradication the plant and campaigns for awareness are nonexistent. Where little is being done to arrest the spread of invasive alien plant species. At the same time, little was being done to curb the destructive impacts of *V. polyanthes* on agricultural production and livestock productivity. Sibanda (2019) argued that the fact that there area was prone from disturbances due to various cyclones implies that area is highly susceptible to plant invasions. What is worrisome is that the magnitude of the problem is not known. In addition the severity of vernonathura polyanthes is further occasioned by the favorable growth conditions present in the eastern border. In the same vein high reproductive rates, production of large quantities of seeds, wide dispersal ability and ability to germinate under a wide range of physical and environmental conditions makes the plant difficult to manage.

2.5.5 Research on *vernonathura* related aspect

In considerable to research related to alien species and particularly vernonathura polyanthes has been conducted in Brazil. Limited if nothing is available for vernonathura polyanthes therefore, research output and experience put Zimbabwe in a bad position to combat the *vernonathura polyanthes* invasion .Moreover, clarity is lacking regarding the effects of the invasion on local biodiversity, the local ecosystem and local livelihoods. The situation is also characterized by the lack of critical information and limited knowledge regarding the effectiveness of the environmental management institutions in Chimanimani district and Zimbabwe at large.

2.6 Assessment Concepts of Invasive Alien Plants Impacts

Cocks (2008) argued that it is impossible to eradicate all risks of invasive plants to a region without affecting local economies, therefore economic impact assessment must focuses on the "right" amount of risk, or the "optimal amount of invaders". According to Lopez (2021) the amount of risk is valuated using quantitative economic techniques for market impacts and qualitative techniques for non-market impacts. According to Crompton (2006) economic impact can be defined as "the net economic change in the incomes and expenditures of the local residents and the jobs of the local community that results from the expenditures attributed to economic activities".

Valuation of economic impacts is an important step in the economic analysis of invasive species, and it provides key information for decision-making through predicting and measuring impacts to counter the limits of science. SEIA (2022) argued that although it is crucial to identify and distinguish many measurable impacts of a proposed development but not every impact is significant. Therefor people who are impacted either directly or indirectly have to say in whether impacts on valued economic components are significant. Impact assessment of IAS is often challenging because economic costs of invasive alien species (IAS) goes beyond the immediate impacts on the affected agricultural systems. Therefore, the valuation method include secondary and tertiary effects such as shifts in consumer demands, changes in the relative prices of inputs, loss of important biodiversity, and other natural resource and environmental amenities (Evans, 2003)

Economic impacts can be broadly classified in two that is direct and indirect impacts. Direct losses are referred to direct goods damage and practical revenue decrease to agriculture and reduction in stock breeding. Indirect losses are referred to the losses of service function of ecosystem. Emerton (2008) Indicated that valuation techniques can provide useful evidence to support habitat conservation policies by quantifying the economic value associated with the protection of biological resources so as to help and guide decision-making. However conventional measures of economic impact may give incorrect indications of the state of invasion, leading to misinformed policy actions and ill-advised strategic social choices.

2.6.2 Market price approach

Market price approach is done by surveying crops and livestock breeding of a household in combination with local market prices to measure direct value. Corin and Murphy (2017) suggested that to apply this method production quantities of marketable good must be available. According to Barbier (1994) the market price method measures how much it costs to buy and how much it worth to sell. In a well-operating and competitive market these prices are determined by the relative demand for and supply of the goods or services thus reflecting their true scarcity, and is equated to their marginal value. Market price approach is useful for valuing products that are harvested directly from agriculture (Bangsund, 1993).A major constraint is that market prices cannot in many cases be taken as accurate indicators of the value of agriculture goods and services due to market imperfections.

2.6.3 Damage cost techniques

Is used in cases where the effects of the loss of agricultural products incurs clear economic damages. Examples of their application to invasive species include looking at the cost caused to agricultural production when invasive interfere with the goods. When invasive species act as pests on plants and animals leading to increased expenditures and losses in productivity. The method focuses on costs spent in order to abate, restore or replace a previously damaged marketed or non-marketed good due to degradation of a certain environmental quality.

2.6.4 Production function approach

According to Shackleton (2007) the production function is used when agricultural products do not have or fails to reflect market value therefor they rely on basic inputs prices to produce them (Cacho, 2008). This is a method to measure the effect of an environmental externality on production possibilities, often by measuring the expenditures which individuals are willing to undertake to avert damage (Bertram, 1999). Production costs can also simply add up the direct cost for example cost of labour, machinery and costs of measures. PFM is based on the fact that many natural resources, processes and qualities are used as production factors. Improvement of natural quality may lead to a reduction of production costs for the sector making use of the relevant quality. The PFM tries to value natural qualities by valuing their impacts on production costs

2.6.5 Prevention costs approach

CABI (2022) suggested that application of preventive measures is a way to mitigate negative effects of economic developments for nature. The costs thereof can be regarded as the value of the protected area or species. A major drawback of this method, is that it gives an estimate of mitigation costs. Emerton (2008) argued that wheither the level of costs is in accordance with the societal preferences, it may underestimate the actual values of nature. The theory says that we should spend money on problems as long as the additional benefits are larger than the additional costs. However, in case of irrational decision or decisions without democratic consultation spending much money on small additional benefits may result in overestimated values. Therefore, it is recommended to use this method primary to make a first rough estimate.

2.6.6 Costs and benefits analysis

In a market costs are normally expected to be lower than benefits leading to profits that can be invested or consumed. However, as pointed out by Munasinghe (1993), such benefits are often difficult to estimate, making it at least more difficult to perform a societal cost-benefit analysis. Cost benefit analysis in environmental and nature protection is important if there is a limited amount of money available for nature development objectives. In such a case, cost-benefit analysis may guide how to spend money in the most effective way. In addition, cost benefit analysis can also be applied to non-environmental projects, to include monetary information on environmental goods and services.

2.6.7 Hedonic pricing approach

Moreover, Stutzman (2004) aluded that hedonic pricing techniques are most commonly used to examine differences in property prices between two locations which have different environmental qualities or landscape values. Thus invasive alien plants can reduce the value of agricultural land through infestation. Edward Elgar, (2002) argued invasive species have the ability to change property prices which might occur due to changes in the landscape wrought by invasive. hedonic price function is derived from real observations . A statistical relationship may arise between the wage rates including the environmental occupational risks caused by invasion. However, hedonic pricing techniques require the collection of a large amount of data, which must be subject to detailed and complex analysis. Data for hedonic pricing approach are usually gathered through market observation, questionnaires and interviews to measure the negative values .

2.6.8 Contingent valuation techniques

The contingent valuation technique is used in absence of prices or markets for agricultural products of close replacements or substitutes. Contingent valuation techniques infer the value that people place on agricultural produce (Emerton 2008) .It introduces hypothetical situations to representative sample of a population presented in a questionnaire to determine willingness to pay or willingness to accept compensation for a contingent product. Contingent valuation method use survey which consist average WTP and WTA. Contingent valuation survey is designed to ask respondents to state their knowledge of respondent, experience with invasion

and perceptions of invasion. Contingent valuation is applied through determining people's perceptions of option values for species. The major limitation is that poor people will be less willing to pay therefor income levels influence outcomes of the studies. An advantage is that it can be used to valuate difficult to measure value of non-traded goods and services.

2.7 Theoretical Models for IAP economic impact valuation.

The assessment of economic impacts from non-native invasive species often initiates from qualitative estimates based on expert judgments (Soliman et al. 2010). Expert judgments are used because of very low costs and availability of expert knowledge, but often lack transparency and rigor . From there, the application of partial budgeting, partial equilibrium, input-output analysis, and CGE is often dictated by the goal of the study, the methodology used, and the level of detail available (Holland 2007).

2.7.1Partial Budgeting

It is a cost based approach which is based on replacement costs and costs of control. This approach helps evaluate the economic consequences of small adjustments in agricultural crop production. It is based on the notion that a small change in production may reduce some costs and revenues while adding other costs and revenues (Salami, 2010). Troiano et al (2017) argued that the use of partial budgeting, partial equilibrium is less common. Partial budgeting is better suited to estimate immediate impacts of invasive species introductions. The partial budgeting methods focus on the net decrease or increase in income resulting from a change in production. Holland (2002) noted that partial method requires a relatively modest amount of data and personnel time. The drawbacks of partial budgeting is that it cannot measure multi-sectorial impacts because it relies on fixed budgets with defined prices to describe the economic activities of the enterprise.

2.6.9 Partial Equilibrium Modelling (PE)

Partial equilibrium modelling treats one particular sector of the economy as operating in isolation from other sectors of the economy. It considers only a part of the market or is based on a restricted range of data. Partial equilibrium modeling represents a technique useful when an invasion is expected to change the producers' surplus or consumers' demand value (Feather, 1999). Partial equilibrium methodology evaluates the welfare effects on participants in a market

who are affected by an introduction of a harmful non-native species. The approach defines relationships for supply and demand for the commodity of interest such as agricultural commodities that may be negatively affected by the introduction of the invader (Louviere, 2000).

Moreover, introduction of IAPs may lead to an increase in the production costs and a decrease in the quantity or quality of valuable crops which also affects the supply curve and the equilibrium price. The net changes is estimated from the aggregated changes in producers' and consumers' welfare (Just et al. 1982). Cook 2008 supported the partial equilibrium models have been used widely as policy assessment tools in agriculture, forestry, and trade. partial equilibrium models can provide insights on the changes in the production volumes and effects on commodity prices that may be affected by the introductions. Partial equilibrium models can also include many sectors so that the spillover effects between sectors can be analyzed. This method, however, requires defining the structure of the affected markets and the level of homogeneity for products from exogenous markets, and may require large amounts of data (Baker et al. 2009)

2.6.10 Input – Output Analysis (I-O)

The input-output model is also called computable general equilibrium (CGE).This model is used when impacts from invasive species are likely to affect multiple sectors of the economy. Input-output analysis assess the interdependencies of sectors in an economy and predicts an economy-wide impact of changes within a particular sector (Emerton, 2008). According Feather (1999) detailed I-O modelling is very essential in identifying key economic impacts and appropriate mitigation measures.

However, Emerton (2008) argued that I-O method has a number of limitations and may not adequately predict all the economic impacts of a project. Therefore, I-O modelling should not be used in isolation. If nationwide economic impacts or multi-sectorial effects are expected, then input-output analysis or CGE would be an appropriate choice because it recognize the feedback loops that exist within the economy and address behavioral complexities that other methods cannot deal with. However, input-output analysis and CGE also require a large amount of data and computational expertise.

2.7 Conceptualization of Natural Resource Management in Chimanimani Rural District

According to Nelson (2010), the importance of natural resources in sub-Saharan Africa is a function of the central economic role that such resources play in agrarian societies. Despite Zimbabwe's move towards urbanization, the economic foundations of the nation remain the natural resource base (Murombedzi, 2010). In addition to localized natural resource dependence in sub-Saharan Africa, global food security concerns and raw material demand by emerging markets particularly China have resulted in a scramble for African natural resources (Cotula et al., 2008).

The ever growing demand for natural resources in Africa has led to complex arrangements in the allocation of property rights for certain portions of the natural environment. Keely and Scoones (2003:91) quote an Ethiopian government policy explaining the natural resource management question stating, "If you control the land you control the people". Similar sentiments have been noted in Zimbabwe where the ruling political party (ZANU-PF5) in Zimbabwe African National Union - Patriotic Front 128 government has made natural resource access the major pillar of its socio economic transformation agenda (ZimAsset, 2013). The ZANU-PF perspective on the hegemonic position of natural resources in Zimbabwe is encapsulated in the party's motto "land is the economy, economy is the land" (Scoones, 2014).

The question relating to the allocation of natural resources with minimum conflict and economic efficiency is termed the natural resource management question in this study. The question is answered in the localized context of Chimaniamani rural using the broader Zimbabwean institutional environment as a point of departure and reference.

2.7.1 Natural Resource Governance in Chimanimani Rural District

Institutions are inherently the outcome of the political negotiations whereby people devise governance systems from local to national to global scales (North, 1990). In order to answer the natural resource management question in Chimanimani, one must understand the political processes that determine the shape of resource governance institutions and how those institutions change over time. The supreme environmental law in Zimbabwe is the Environmental Management Act of 2002.

Control of invasive alien species Section 118 of the Environmental Management Act provides for the control of IAPs in Zimbabwe. According to the Act, every responsible person has a duty to report (to authorities), clear or cause clearing of any invasive alien species growing on land for which he/she is responsible. It is an offense for any responsible person to fail to clear or cause clearing of any invasive alien species. Similarly, it is an offence for any person to place any invasive species or the seeds in any river, stream, irrigation canal, road or land. The Act defines responsible persons as any of the following people. the Environmental Management Act recognised the following as IAPs in Zimbabwe; Wild oats, Water lettuce, Dodder, Water hyacinth, Moonflower cactus, Cherry-pie, Jointed cactus or jointed pear, Azolla; and Water-fern. The list has since grown to include vernpnathura polyanthes (identified as Cactus Rosea).

2.7.2 Organizational institutions

The stakeholders in environmental management can be divided into several categories according to the services they provide and target populations they serve. There are those that are involved in capacity building within the district, namely the District Training Team (DTT), IRED and the Centre for Applied Social Science (CASS) a research department at the University of Zimbabwe. Others deal with sustainable agriculture through permaculture and improved natural resource management such as Towards Sustainable Use of Resources Organization (TSURO)

All these intermediaries are encouraged to involve women and the youth so that no section of the population is left out. All intermediaries meet at grantees meetings where they interact so they know each other and can establish the boundaries of each other's work to avoid duplication of duties and ensure complementarity.

Results from document analysis revealed that the major alternative government related organisations with a bearing on environmental management are the traditional leadership structures, veterinary services office, provincial livestock and crop departments, Forestry Commission, Department of Museums and National Monuments and the local rural district council (RDC). Some of these organisations are provided for by alternative acts of parliament and in most cases fall under ministries other than that of environment and water and climate. The major NGOs (in order of popularity and size of programmes) 133 operating in the area were

World Vision, Organisation of Rural Associations for Progress (ORAP), OXFAM, SNV and agencies of the United Nations.

The formal organizations mentioned above show that a number of actors who play varying roles that result in a localized answer to the natural resource management question. Nelson (2010) argued that interests and relative powers of different actors shape natural resource governance processes. In rural these actors include the state, state aligned organisations, national and international NGOs.

2.7.3 The Zimbabwean State

The political economy of natural resource governance in Zimbabwe is centralized within the formal institutions .The centralization was arguably influenced by the Zimbabwean colonial legacy. According to () in pre-colonial rural in Chimanimani, the communities on behalf of various centres of power managed natural resources. Under colonialism, local people lost title to natural resources and their indigenous knowledge suppressed. Although colonization created modern environmental administration and legislative structures, the natives lost localized control over the natural resources that they had been using for survival.

According to Murombedzi (2010), Africa's colonial states were established in order to control labour, capital and resources for external, European purposes. In Rhodesia (Zimbabwe), this resulted in the concentration of central bureaucratic and executive power in the state eviscerating pre-colonial independent forms of social organization (Nelson, 2010). The State claimed wide powers over natural resources, particularly land with customary rights subordinated to claims explicitly recognized by the colonial administration (Toulmin and Quan, 2000). Under British indirect rule, every native in rural Chimanimani was subject to a tribe administered by a chief recognized by customary law.

Moreover, the colonial state replaced the community based management options with an external remotely located state that was fused into an individual chief. Zimbabwean pre-colonial and colonial institutional history fundamentally shaped rights over natural resources, which are in turn central to the way those resources are used. Existing patterns of natural resource governance generally remain centralized. Post-independence leaders of Zimbabwe faced the challenge of consolidating state authority over scattered populations and pursuing ambitious modernization

agendas (Boone, 2003). In pursuing this agenda of consolidation and expansion of central authority, the colonial state was deracialized but rarely democratized (Mamdani, 1996). As such, the alienation of the community from natural resource management continued.

Government Acts analysed showed contemporary environmental governance in Zimbabwe to be complex going beyond the EMA Act and overflowing into other formal institutions and social dynamics. In line with other sources from literature, environmental governance was shown to be a function of power relations and practices common to Chimanimani rural district (Blaikie, 2006; Bulkeley, 2005; Agrawal, 2005, 2001b, 1999). As such, although people or structures may wield power (as shown in institutions such as the EMA Act), the exercise of such power is usually dependent on a number of factors found in the environment in which power operates. 135 The EMA Act is predominantly implemented through the Rural District Council (RDC), elected councillors and traditional leaders. Some of these institutions theoretically exhibit devolution of state power and the transfer of environmental governance rights to local communities. However, effectiveness of rights transfer from the state to individuals goes beyond a mere specification of rights in Government literature but touches on how such specifications mirror against praxis in everyday social practice (Gupta 1999).

Low literacy levels among community representatives (in comparison to bureaucrats) reinforce under-representation of grassroots in the RDC (Madondo, 2000). Regarding the elected councilors, lower theoretically participatory community structures owed allegiance to political parties, who endorsed their candidature. Therefore, such a system was bound to churn out councillors who are upwardly accountable to their political benefactors and not downwardly accountable to their grassroots constituencies. Consequently, the case observed in rural Chimanimani district is an attempt to make environmental governance more representative but not accountable to the grassroots. From a similar perspective, Jones and Murphree (2001) argued that in most of Zimbabwe, development proposals made at the grassroots (VIDCOs and WADCOs) largely remained on paper because decentralized planning was never considered together with decentralized implementation or decision making.

2.7.4 Non-Governmental Organizations

Local and international development agencies have been particularly active in supporting livelihoods and natural resource management in the study area. The most of the NGOs mentioned in Chimanimani are World Vision, Organization of Rural Associations for Progress (ORAP), OXFAM, SNV and agencies of the United Nations played a key role in promoting natural resource management. A critical factor shaping NGO and aid agency actions is the political reality of operating in Zimbabwe. The Zimbabwean government has often argued that NGOs are diplomatic entities furthering agendas of foreign countries (Rich-Dorman, 2003). These allegations climaxed when the Zimbabwean government disallowed the operations of NGOs in Chimanimani due to political suspicion (Chingono, 2010).

The NGOs and aid agencies operating in Chimanimani claimed to be apolitical and interested only in pursuing their core objectives. The threat of expulsion and the fear of interfering in local politics have resulted in NGOs operating in the study area towing the formal institutional lines that are blind to the grassroots community dimension of natural resource management. However, key informants from NGOs indicated that despite the associated political risks, programme success was always higher with grass roots community.

2.7.5 Informal Institutions

Informal institutions are built basing on social capital such as the requirement to attend certain social events and religious practices had allowed residents to discuss the challenges of vernonathura polyanthes and act for the common good through community initiated control programmes. Therefore, it has been through the strong social capital in the area that certain common property areas had been cleared of V polyanthes. Hardin (1968) argued that in the absence of private property rights, open access resources such as the range land of Chimanimani would be ultimately degraded. On the contrary, the results give a prime example of a situation where strong social networks allow villagers to act in union to avoid the tragedy of the commons. This is in line with observations by Ostrom (1990) who noted that in the presence of clear boundaries, social capital and slight institutional recognition; the tragedy of the commons could be avoided.

The majority of the informal institutions documented in Chimanimani aimed at regulating human behavior through African traditional religion culture. The vanguards of the informal institutions in rural Chimanimani district are predominantly the older members of society and to a lesser extent the bearers of traditional leadership positions.The most popular informal institutions relate to social gatherings such as funerals, weddings and community meetings. Additionally, the community explained that tradition required them to co-exist as kinsmen and avoid mixing with outsiders through inter-marriages.

Moreover, tradition valued the wisdom of the elders and required the younger members of society to accept and revere elderly counsel. The violation of this cultural aspect was considered one of the primary reasons for the disintegration of the common social ethos in the study area. These are exemplified by the popularity of laws that forbid the grazing of livestock at night. This rule protected the livestock from the risks related to darkness and prevented livestock from grazing crops given the absence of shepherds at night.

2.7.6 Politics of Environmental Governance in Chimanimani Distarict

According to () one of the major problems in Chimanimani is that of national politics. The district's Member of Parliament is a white farmer who is assumed to be in opposition .As such there are tensions between the parties. Mutual suspicion and rivalry between the parties spills over into developmental debates and meetings. Intermediaries and service providers have to be sensitive to these matters and transcend party allegiances if their programs are to succeed.

It is therefore necessary that people appreciate development should benefit the whole community and support those interventions which seek to meet community needs regardless of who is implementing them. However we know that development itself is a political process and is about politics. The DFA also notes that working for change at the local level is sometimes hindered by government procedures which were laid down without much broad consultation at the local level. As it is local governance structures have aspects inherited from the colonial era where control of people was more important than local self-governance.

The analysis revolves around the factors that govern the allocation of property rights to natural resources and the social capital within the informal networks. A close look at the property rights regime governing natural resource access in rural Gwanda reveals an ill-defined common

property regime. This problem of definition is rooted in the failure to recoginise the households/user communities as the lowest levels of local government. Additionally, the upholding of the colonial institutions of indirect rule has left the traditional leadership structure weak and incapable of taking remedial action in issues of environmental management. Key informants from traditional leadership in Gwanda indicated that their power was very limited and they often found it difficult to control particular isolated cases of deviant behaviour (e.g. individuals who cut trees for sale) as the forests are often considered free God-given resources for all Zimbabweans.

.Such property rights regime is clearly not common property but rather state property cascaded to lower levels closer to the communities but not to the communities themselves. This reflection is a confirmation of resource challenges that are associated with state aligned actors. Moreover, local chiefs in rural Chimanimani noted that the state restricted local people from using local natural resources while allowing outsiders to exploit the resources through permits from state agencies, bypassing village structures. This case was highlighted in the case of mineral resources where permits were obtained from higher state authorities while the negative externalities of mining affected the lowest levels of society in the form of the local villagers.

CHAPTER SUMMARY

This chapter reviewed literature on invasive alien plants in relation to agriculture and natural resources management. This chapter has shown that without adequate management IAPs may lead to losses that are detrimental to agriculture and global ecosystems. The terms "invasive" and "alien" have also been revealed to bring ambiguity to the study area prompting the need to understand what the perceptions of the public are towards invasive alien plants. The perception is intricately dependent on the observer in question. If a plant has beneficial attributes used by local rural communities its control may be viewed as a success in the eyes of national environmental interests, yet it may be unpopular in the eyes of the host community. Thus, IAPs may have uses that augment local livelihoods and at the same time may have attributes that stress local 38 livelihoods. Therefore, plant thresholds and livelihoods in question must inform control and management options. The next chapter discusses the research methodology.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 INTRODUCTION

This chapter focuses on the description of the research methods used to investigate the impact of invasive alien plant *vernonanthura polyanthes* on smallholder farmer agriculture in Chimanimani district of Manicaland province in Zimbabwe. It starts by giving a description of the study area. The study made use of both qualitative and quantitative research techniques. Academic literature and other relevant sources guided the method choice and design. The study made use of an in-depth study of a population located in Chimanimani district ward 21. The chapter also presents information on the data collection tools and techniques, the data analysis and the plans to observe ethical issues.

3.1 Description of study area

Chimanimani District

Chimanimani district is located in the south east corner of Zimbabwe, 150 km from Mutare on the border with Mozambique (Goodier, 2009). It is one of the smallest districts in Manicaland province with 23 wards characterized by multiple livelihood strategies that include small businesses, communal farms, small-scale mines and irrigation schemes (Timberlake, 2016). The District Administration is based in the small farming and tourism town of Chimanimani formerly known as Melsetter around 40 km away to the north at of ward 21.

It is a unique district in that it occurs in all agro-ecological regions I, II, III, IV and V, stretching from the Eastern Highlands to the Save river valley (Oxfam-UNDP/GEF, 2015) . In terms of ecological potential, these areas can be divided into two that is one with good enough rainfall for agricultural activities and another which is semi-arid. The semi-arid is the largest part of the district. It is characterized by food deficits as a result of erratic annual rainfall. Moreover, 17 608 households were rendered homeless and more than 50% land under maize crop, banana plantation and tubers was wiped by a tropical cyclone Idai on 14 March 2019 which creates massive land disturbances (Sibanda, 2019).

3.2 Ward 21 (Ngorima)

According to ZimStat (2022), ward 21(shown in Figure 6) has an estimated population of 11 407 people and 2 802 households with an average 4.1 members per households. Within ward 21 48 percent are males whilst 53 are females. Ngorima is a rural ward characterized by multiple agricultural activities which includes maize, beans and wheat production for consumption as well as for sale. Farmers also produce fruit in their plots such as banana, pineapples and mangoes for local consumption as well as for sale. Local people also produce honey from wild bees

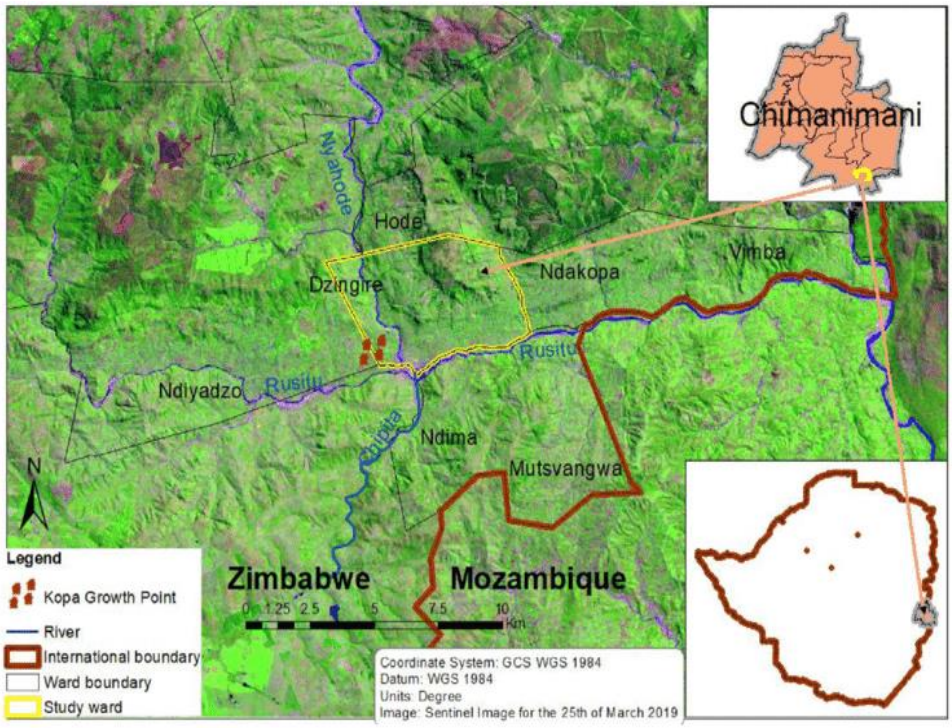

Figure 6: Map of Study area

Source: Sentinel (2019)

3.2.1 Climate

Ngorima Ward 21 of Chimanimani receives intercepts of moisture-laden air from the Indian Ocean which resulting in high levels of orographic precipitation. It is on the rain shadow from the prevailing south-easterly air flows. (Moron D, 2009)The area is under Natural Region I of Zimbabwe's Agro-ecological Zones, receiving an annual rainfall ranging from 1000 to 2000 mm and 635 mm effective rainfall. Generally, 70 to 80% of the rain falls from November to March and rainfall is also observed in the dry winter season. Rainfall is usually associated with thunderstorms that produce rainfall of long duration and high intensity (EMA, 2012). The rainfall, in general, is more than half of the potential evaporation, thus necessitates of irrigation development and more recently infield rainwater harvesting in not necessary (Ryan, 1984).

Cool season winter temperatures range from 12 to 15°C, while summer temperatures range from 18 to 20°C. The rainfall pattern is bimodal (March - June and September - October) with mean annual rainfall about 600 mm and mean annual temperature ranges between 26-42^{o}C (Ryan, 1984). Climatic conditions make the area very vulnerable to meteorological hazards such as frost, floods, lightening, gusty winds as well as epidemics during the wet seasons.

3.2.2 Vegetation

The vegetation of the Chimanimani district has been described as undifferentiated afromontane vegetation by White in his map of African vegetation (White, 1983). The main vegetation types recorded by (CEPF, 2012) were forest, woodland, scrub, grassland, aquatic community and lithophytes. Altitude is a major factor on vegetation with lithophyte vegetation and grasslands at higher altitudes and woodland and forests lower down. Frequent mist and low moist clouds or guti reduces physiological stress to the vegetation during dry season. The distinct differences within these vegetation formations also depends on soil. Trees are shorter at higher altitudes and on more shallow soils, as well as being much more open in their canopy. Grass cover dominatingly consist loudetia simplex and woodland vegetation consist of uapaca kirkiana (mzhenje), Brachystegia spiciformis (msasa) (CEPF, 2012).

3.2.3 Rivers and Topography

The main natural water sources include Nyahode, and Chipita that drains into Rusitu which drains into Save and finaly into Odzi (Ryan, 2006). These rivers and terrain creates irrigation

potentials through gentle sloping gradient and also potential for power stations. The area is subject to millions of years of erosion which resulted in exposed granite rocks. According to (Timberlake, 2016) there is no mineral of economic significance, although gold has been mined for hundreds of years. Ward 21 of Chimanimani lies at an average of 6000m above sea level in an area characterized by mountain ranges. As a result the district's terrain is not flat at all but is characterized by deep ravines, slopes and curves around mountains. Some of these features are a result of bad environmental practices such as wanton tree felling for energy, construction and for clearing farmland.

3.2.4 Economic Issues

According to (Mbetu, n.d) Mbetu there are a number of community based income generating activities and women participate in most of these activities. Some of these enterprise includes beekeeping, nutrition gardens, piggery, chickens, goat keeping, cattle fattening, pottery and crafts which are done with the assistance of Village Community Workers. However, livestock production is not a major economic activity in the study area which is evident through few households with livestock animals. Therefor livestock keeping provides a minimal contribution to GDP in this area. (Mbetu, n.d) noted that small economies of scale the returns of these projects have been comparatively small. In addition, the lack of bridges and the clayey nature of soils make the roads slippery in the rainy season and some of the roads are so rocky that even on a 4-wheel drive vehicles they are quite hard to navigate as result marketing costs are high.

The low population density is attributable to climatic conditions that cannot sustain a larger population and it is further distorted by the high numbers of young people who have moved to South Africa for various reasons (Dube, N., Sithole, M. and Nkala, P., 2012) .Of the total number of people employed, the highest proportion (64%) are engaged in agriculture and related occupations (Oxfam, 2015). The majority of the people in the district are engaged in subsistence agriculture, which is characterised by a heavy dependence on the biophysical environment, subsequently increasing the propensity for environmental degradation (Francis., 2012).

3.3 THE CASE STUDY

According to (Yin, 2003), case study research aims to explore and determine a setting with a view to increase understanding of the subject. The case study approach is concerned about how research should be carried out in a naturalistic setting to support understandings of whatever is under scrutiny in its own habitat (Cousin, 2005). This study uses an intrinsic case study, which is used for the purposes of evaluating and getting an understanding of the situation at hand in order to generalize (Hall, 2004).

This study focused on the rural households of Dzingire, Ndakopa and hode given the high populations of vernonanthura polyanthes in these areas. These villages were purposively sampled based on information from the local EMA offices in the Chimanimani district. Koppa is the community business center with a clinic, Zimbabwe Republic Police (ZRP) station which served the three villages .The villages are also serviced by Econet Wireless the major mobile phone operators in Zimbabwe with installed network boosters in the area. Nonetheless, the main languages spoken are Shona and Ndau.

3.3.1 Research design

The synthesis of knowledge through research is viewed from different criterion or paradigms. According to (Joubish, 2011) a research paradigm is defined as a framework in which research is performed. Major research paradigms are inter alia, positivism, post positivism, critical theories, constructivism and participatory-cooperative paradigms (Lincoln, 2005). The nature of reality determine the paradigm which research falls under. Qualitative research is based on multiple realities as the smallest units that formulate the bigger picture whilst quantitative research involves an inquiry into a research problem through testing a theory and statistically analyzing it to evaluate if predictive power of the theory hold true (Joubish, 2011).

The study for assessing the impacts for vernonathura polyananthes uses a mixture of qualitative and quantitative research approaches. According to (Mertens, 2013), mixed methods approach extend understandings of how to understand complex phenomena and also emphasizes on how to use research to develop effective interventions to complex problems. Lincoln and Guba (2005) observed a traditional association of quantitative research to positivism and qualitative research towards post positivism. In this regard, this research study therefore adopted a post positivist

paradigm, to analyses the relationship between theory and practice and the use of new knowledge gained from research to challenge and add to theory (Ryan, 2006). Due to the essence of the problem in the study, limited available knowledge and resources availability, the study followed a non-interventional descriptive design. Moreover, the study made use of a case study approach to investigate the subject under discussion.

3.3.2 Deductive reasoning

Thus, in this situation, deductive reasoning was employed to analyze field data so as to support evidence or challenges to the theoretical framework. The study also employed a disintegrated approach which was acknowledged by (Jagger, 2012) as a powerful tool to avoid respondent strategic behavior and solving limited cognitive abilities of respondents to enhance the ability to obtain data on a broader range. Moreover, deductive reasoning allowed household primary data from horse mouth.

3.3.3 Study design in detail

Pilot Study

The term pilot study is believed to be used in two distinct ways in social science research. Firstly, it may refer to test so that to see if the expected results can be obtained prior for the major study. In this regard, it is designed to test and gather information before a larger study is done to improve the major study quality and efficiency (Jagger, 2012). Secondly, a pilot study may also be used as a pre-testing or 'trying out' of a research instrument of interest like a questionnaire (Berg, 2009). In both cases, the pilot study gives give the advantages of early warnings concerning possible research problem hindrances that include research requirements and cultural factors.

In this study, prior to major field work activities, a preliminary pilot was conducted to study the status of the Chimanimani ward 21 in relation to invasive alien plant impacts on agriculture. In addition it was also done to factor out issues concerning feasibility assessment with the central goals of familiarizing the researcher with the research problem in the context of Chimaniamani district. This enabled the developments of networks with ward 21 communities and assessing the economic impact of the *vernonathura polyanthes* in the study area. Instruments used were

personal observation and key informant interviews to collect preliminary information regarding the vernonanthura polyanthes problem in Chimanimani district. Snowball sampling was used to sample key informants with the most crucial information to build networks and information database. After the pilot study, information was collated and analysed before main study begins. Findings of the pilot study confirmed that the impact of vernonan polyanthes had exceeded alarming levels and it was recommended that a study must be carried out to assess the present and potential impacts of vernonathura polyanthes with a view of determining possible management options.

3.3.4 Major study

In order to explore the impact of vernonathura polyanthes towards smallholder agriculture production, the study used a predominantly qualitative approach in line with other studies that investigated similar phenomena (Fischer, 2011). The choice of qualitative approach was due to the internal and personal nature of individual farmers perceptions. Fischer (2007) Observed that qualitative methods were suitable for gathering public views and perceptions given that these views are best understood in their cultural, social and individual contexts. In the same vein literature noted that members of the public may hold rich mental conceptions of the nature but lack familiarity due terminology used. Therefor qualitative methods gives room for alternative expression Fischer (2007). Qualitative methods also enabled the researcher to avoid confrontation of study through conceptualization.

The study also used focus group discussions so as to concentrate on attributes and attitudes of smallholder farmers towards IAPs to investigate their impacts on yield and growth performance of crops and livestock. The study area is characterized by a patriarchal society therefor it was likely that gender challenges would be a challenge during group discussion (Bless, 2006). To resolve these challenges the group discussions were sometimes conducted using single gendered. The group discussions were conducted in the local languages with the aid of assistants from the study. Move rover, key informants and documents were analyzed and the available key informants were officials from Chimanimani Rural District Council (RDC), Environmental Management Agency (EMA), the Livestock Department, the Veterinary Department, the Forestry Department and local traditional leaders.

3.3.5 Population and sampling

The target population was 11 407 individuals resided in Chimanimani rural district ward 21.This included 2 802 households (ZimStats 2022). As highlighted earlier, the research used a case study of Chimanimani district in three villages to draw a sample of respondents for the study. In this regard sampling covered a cross-section of the respondents from a wide range of backgrounds thereby giving fruitful data (Fischer, 2011). The Sampling technique use standard formula to calculate a sample size of smallholder farmers in study area. The formula presented below.

-Sample size $= \frac{N Z_{\frac{\partial}{2}}^{2} P(1-P)}{e^{2}(N-1)+N Z_{\frac{\partial}{2}}^{2} P(1-P}$

-N=population size

-e=margin of error

z=z-score

p=standard deviation

The target population is 2 802 households and this study allowed a 8% margin of error and thisd means that

-N=2 802

-z=2.58

-e=0.05

p=0.5

Sample size$= \frac{2802*2.58*0.5*0.50}{0.05^{2}(2802-1)+2802*2.58*0.5*0.5}$

n=258

This technique has an advantage to the researcher by increasing degrees of accuracy and determination of sample size to ensure considerable accuracy of results (Kothari, 2004).Therefor 258 smallholder farmers were selected and were interviewed using semi structured household questionnaires . The sample size was large more 100 interviews to meet statistical demands and challenge of respondents refusal to participate. The characteristics of a sample with large sample size enables the results of the sample can be magnified to the whole population. The research relied on 4 key informants from the various stakeholders that played a significant roles in the subject matter.

The study used multistage sampling techniques. Firstly, the rural business Centre Koppa and key informants were purposively sampled where infestation was high and the impact was severe. Secondly, stratified random sampling was used to determine the household survey and to select group discussion participants. Stratified sampling can be used whenever the population can be categorized into smaller sub-populations, each of which is homogeneous according to the particular characteristic of interest .To understand the impact of vernonathura polyanthes on the three different villages, the ward was stratified into infested and non-infested parts.

Male and female group discussion participants were selected through the village head based on their local agricultural performance. The three rural communities gave the four strata for the survey. The survey was conducted first while the group discussions and key informant interviews were conducted. Group discussions and Key informant interviews were conducted using recording to reduce time consumed during notes writing. The fieldwork concerning pilot study and major study was conducted in September 2022

3.4 Data collection instruments and techniques

Data collection was conducted using questionnaires, focus group discussions, key informant interviews and document analysis. Data collection was done in the respondent's basing on language of choice predominantly Shona and English.

3.4.1 Questionnaire

To achieve the aims of this study, the questionnaire method of investigation was employed. In the first stage of questionnaire design, great efforts was engaged to ensure that the questions asked specific questions addressed the objectives stated in chapter two. The questionnaire was prepared in English language and translated to local language. The purpose of these interviews was to identify the most significant impacts and capture information concerning the actual costs and benefits associated with vernonathura polyanthes.

The study used a semi-structured questionnaire to collect quantitative data. Semi structured questionnaires uses predetermined questions with possible answers to choose from, and open ended questions that allows for detailed explanation from the respondents. The questionnaire was conducted face to face to the sampled household representatives given absence of household head in three village within ward 21. During the data collection exercise, the household head was the targeted respondent .Face-to-face interviews were prioritized because they can be used with illiterate respondents and they allow for real time explanations from the interviewer regarding challanging questions (Berg, 2009).

The questionnaire covered household information on demography, perception on invasive alien plant, household agriculture production, benefits of invasive alien plant, threats of vernonathura polyanthes, control measures to combat invasive alien plant. Adopting Babbie (2008) suggestion, the questionnaire was pretested to enable adjustments concerning repetition, lack of clarity and wording.

3.4.2 Focus Group Discussions (FGDs)

Focus group discussions was used to collect certain qualitative data. Berg (2009) alluded that group discussions allow the researcher to obtain shared views while Bless, Smith and Kagee (2006) noted that focus group discussions allows the researcher to pinpoint the most important research issues rather than individual personal atributes. Focus group discussions was supported by (Mohammed Mussa, 2018) It is one of the most important research methods to get varieties of information from different segments of the community for qualitative data which was conducted to get general information about the impacts of invasive plant species on pastoralist livelihood.

However, group discussions is subject to lack of confidentiality which may give pressure to participants thereby rsulting in respondents failing to express themselves fully in public especially on sensitive issues (Denzin and Lincoln, 2000). According (Fischer, 2007) gender dominance and group leader dominance syndrome is believed to be a plague group discussions .Topics for discussion include issues on lAP's perceptions, the use of vernonathura polyanthes in agriculture, major crops affected by the invasion alien plant and management practices and institutions.

3.4.3 Key informant interviews

Center, Education Development (2004) Referred key informant interviews as a loosely structured conversation with individuals who have specialized knowledge about subjects one aims to understand. Bless (2006) Key informant interviews had its roots in cultural anthropology, although (Dellinger, 2007)Dellinger also highlighted their (KIIs) extensive use in other academic fields such as sociology and economics. Key informant interviews allows for the verification and clarification of quantitative data.

The key informants comprised five purposively selected individuals from the EMA, the RDC, the Forestry department, livestock department, the veterinary department and the traditional leadership .A key informant guide was used in the interviews, to ascertain the wishes of the researcher to gather information regarding IAP perceptions, the use of invasive alien plant to enhance agriculture production and basing on observed effects of invasive alien plants. Two the key informants' were included in the study from each selected village

3.4.4 Field observation

The method employed during the whole period of field work activities through informally discussing with the people. The observations was done through visiting different activities carried out by the community to control the impacts of invasive plant species. Field observations were also done to supplement the interviews. During observation, field note was taken and issues were raised during focus group discussions and key informants interview to get insight about the issue under investigation.

3.4.5 The secondary data sources

Data sources that were used in this research were both hard copies and online materials such as published articles, unpublished documents, proceedings and project reports available at district, regional, national and international levels.

3.5 Data Analysis techniques and tools

The impact of invasion on smallholder agriculture production was evaluated by comparing cost and benefits occasioned by the species in uninvaded, invaded sites. Uninvaded sites were regarded as representing pre-invasion state. Data was collected and were coded, entered and analyzed using statistical package for social sciences (SPSS v.20). For data that does not require analysis, simple descriptive statistics were employed. Descriptive statistics such as mean, percentage and standard deviation were used to present the results in tables, charts and graphs. ANOVA was utilized to get levels of significance between the pre-invasion and invasion conditions. The research build two models to determine damage costs and management costs of vernonanthura polyanthes,

3.5.1 Statistical modelling

Regression Analysis

The research built two models to examine the predictiveness for total management or damage cost incurred by smallholder farmers. To do this, we first summed our cost data like weeding and yield loss. All factors hypothesized to influence economic impacts of biological invasion were included to measure the total invader burden to subsistence farmers .This allowed the researcher to explore potential relationships between cost and respondents demography. key descriptive statistics on the population interviewed. By means of statistical analysis techniques (regression for example), the results of the questionnaire can then be interpreted In addition, the researcher also calculated the mean difference between invested and non-infested villages. Overall, two full models were built with total damage costs and total management spending. Predictor variables were damage cost, management spending, household size, experience and education. The study also applied the cost model that was developed by Ahmed et al. (2021), which predicts damage costs caused by IAS by fitting cost curves to management cost data.

Relative to the study the researcher also used multiple regression analysis to predict future yield losses basing on research findings. Multiple regression analysis is more flexible to ceteris paribus analysis because it allows the researcher to explicitly control for many other factors that simultaneously affect the dependent variable. This is important both for testing economic theories and for evaluating policy effects on non-experimental data. Thus, multiple regression analysis can beused to build better models for predicting the dependent variable.

Econometric model of vernonathura polyanthes impact to smallholder agriculture

Given the function

Y=f (income + household size+ land holding size+ occupation)

$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_i$ (i)

Where:

Y_i =damage, β_0 =y-intercept, β_1 =income, β_2 =household size, β_3 =occupation , β_4=land size and ε_i – Random error term

Econometric model on management of vernonathura polyanthes

Y_i=f (age + income + expenditure + education levels + household size + occupation+ land holding size +support services)

$\mathbf{Y_i = \beta_0 + \beta_1 X_1 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots + \beta_n X_n + \varepsilon_i}$ (ii)

Y_i =management of vernonathura polyanthes, β_0 =Population y-intercept, β_1 =age or experience, β_2 =income, β_3 =education levels, β_4 =household size, β_5 =occupation , β_6=land size +, β_7 =support

ε_i – Random error term.

Farm size: Land size in hectares is expected to increases with the cost of vernonathura polyanthes management. That is for large land holders suffers greater invasive alien plants

impacts whilst small land holders can effectively manage their lands and bear small amount of expenditures .

gender: influences farmers participation in agriculture and development programs .Smallholder farmers in rural areas are dominantly women their gender may influence participation in *v. polyanthes* management.

Education: is likely to have a positive impact on farmers ability to respond invasion problems because well-educated farmers are more likely to have the skills and networks necessary to start manage invasions (Wuthnow 2002)

Household size: accounts for family labor supply, the level of household consumption, and physical dependence ratios (Alene et al. 2008, Mathenge et al. 2010). Large household sizes are expected to have a positive impact on one's decision to eradicate challenges of invasive alien plants.

A and experience:

3.4.3Ethical considerations

Ethical issues were critically planned prior to fieldwork and observed throughout the research process. Before commencement of fieldwork, permission was obtained from relevant authorities public officials in Zimbabwe and Traditional leaders. The researcher designed a comprehensive consent forms to be signed by a respondent before the interview begins. The completed questionnaire was devoid of respondents' identity particulars, used only for the purpose of academic research and kept safe at all times.

3.4.5 Validity and reliability

Validity is defined as dependability of the study and reliability refers to trustworthiness of the study (Creswell, 2000). Testing for validity and reliability is critical in qualitative research. As such, triangulation ensured validity, reliability and consistency of the data while questionnaires were completed and recorded in real time. Furthermore, end of interview summaries verified accuracy of data collected in the presence of the respondent.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter focuses on analyzing the findings gathered during field research. The main thrust of the study was to assess the economic impact of vernonathura polyanthes to smallholder agriculture production. The researcher utilized key informant interviews, questionnaires and focus group discussions in order to collect data. Chimanimani rural district ward 21 was used as the case study. The research was guided by the research hypothesis that Vernonathura polyanthes invasion reduce vegetation composition, diversity and structure, weakens ecological function and damage agricultural potential whilst clearing reversed these negative effects.

Results and discussions are presented as follows the general characteristics of the sample are presented in section 4.3, then follows findings and discussions on objective one in section 4.4, objective two in section 4.5, objective three in section 4.6, objective four in section 4.7 and possible implications of the findings on the development of programmes and policies to manage invasive plant species with particular emphasis on vernonanthura polynathes in Chimanimani.

4.1 Pilot Study Findings Summary

A pilot study was conducted in November 2022 with the major aims of familiarizing the researcher with the research problem, creation of networks with the local rural community and assessing the magnitude of the v.polyanthes densities in the area. Five key informants from the environmental management agency (EMA), rural district council (RDC) and traditional leadership participated in the pilot study.

With regard to the pilot study, the major environmental management stakeholders in the area are EMA, RDC, local provincial government and the traditional leadership. With specific reference to vernonathura polyanthes, results showed the livestock, forestry and veterinary departments proved to be key stakeholders as well. The pilot study indicated that the Hode,Ngorima and Dzingire were affected by v.polyanthes invasion. The most dominant languages in the three

villages are Shona and Ndau. The pilot study also revealed that that obtaining trust of villagers was a perquisite to propel smooth progress of the major project. Therefore, the researcher firstly identified traditional leaders in three villages and made essential contacts.

Moreover, results shows that there was a need to make use of research assistant's enumerator to the community who spoke the local languages only. In addition, the pilot study provided guide to research when requesting for permission to conduct the study, designing data collection tools. More essentially, the pilot study results gave a general foundation of v, polyanthes threat in Chimanimani ward 21 and the case study villages with regard to location, history, population and leadership.

4.2 Fieldwork Summary

In use of the sampling methods highlighted before, 258 respondents for survey respondents, 20 FGD participants and 4 key informants were selected for the study. The research study used a survey, focus group discussions and key informant interviews. The survey collected mostly quantitative data whilst key informant interviews and focus group discussion collected qualitative data. The relevant stakeholders allowed the researcher to carry on the study whilst all respondents were free to air out their consent preliminary to data collection process. Through the key informants 4 participants and focus group discussion 20 participants data was collected about smallholder farmers invasive aliens perceptions.

Village heads were paramount as they organized group discussions carried out at the convenience of the villagers. The village head also selected focus group participants based on convenience sampling that streamline gender sensitivity. The participants were not categories in different strata such as levels of age, income and education. Mostly members of the royal local traditional leadership were present in the group discussions. Focus group discussion consisted of males and females and women were supported to guard against biases created dominant member syndrome (explained in Mikkelsen, 1995).

Moreover, the researcher controlled the discussion thorough being the operationist encouraging all participants to air their options. The discussions were conducted in the comfort of community's languages of choice which was Shona and Ndau. The group discussions takes an average of one hour and forty-five minutes.

Participants from focus group discussions provided that they was the most affected villages due to proximity to Mozambican Boarder which was indicated to be the potential source of the invasion. However, personal observations also revealed that Dzingire was characterized by conducive institutional environment of all the case study villages shown by multiple business centres, tarred roads, availability of electricity and cellular network connections. Mansuri and Rao (2004) indicated that community participation initiatives was dependent on an enabling institutional environment. Therefore, the institutional environment in Dzingire villages gives the village a competitive and development advantage in comparison to the other villages.

Village	**Sex**	**Number of participants by sex**		**Total number of partcipants**
Ngorima	Uni sex	Men	4	8
		women	4	
Hode	Males only	men	6	6
Dzingire	Females only	women	6	6
Total			20	20

All focus group discussions began with an introductory question on which every participant was given chance to respond. The first question was what comes to your mind when you think of the v .polyanthes? This broad question allowed the participants to express themselves with respect to their perceptions and level of awareness. The discussions then proceeded to ask questions which deal with issues of environmental management institutions, IAPs impacts and management methods the communities had employed.

In comparison to other qualitative research on people's views regarding the natural environment issues for example, Schuttler et al., 2011, n = 20, Selge et al., 2011, n=4) the group discussion participants in this study constitute a rather extensive data set. The group discussions aid in provision of qualitative data that aimed at understanding the ways in which participants reasoned with regards to natural environment and the major crops affected by vernonathura polyanthes in

in Chimanimani rural community. The discussions were also used to support data collected from the survey and for triangulation purpose

Key informants

Key informant interview were held in three rural villages with representatives of relevant organizations that were thought to have an influence to environmental management in the district. The researcher choose participants based on the relevance of the organization to the subject under investigation. Organizations were therefore purposively sampled and key individuals were identified with the help of reference from senior management or a senior traditional leader. Additionally, gender dimension was overlooked when choosing participants for key informant interviews as it was believed it did not play an important role in the knowledge or experience that an informant possessed. The discussions were also conducted in the informant's languages which was Shona and Ndau. The interviews took an average of one hour. KII participants are summarised in in table below.

Organisation	Position	Number of participants
hode	Councilor	1
ngorima	Village head	1
rural district council (RDC)	Chief Executive Officer	1
AGRITEX	Extension Officer	1

The table above shows that high-ranking officers and traditional leaders that were available to give information pertaining to the challenging situation. The provided information was more significant as it indicated need for urgency to resolve the current situation problem given the multiple challenges discussed in previous literature (Francis, 2012). The key informant interviews collected specific qualitative data that was much critical at exposing related variables IAPs effects in the district. All key informant interviews began with the same general question as that of the group discussions to which every key informant responded. The introductory question allowed unrestricted responses from the key informants. Then discussions proceeded to deal with issues of environmental management but with particular focus on the informant's area of specialization. The conversations were recorded through verbal and quotes that represented majority and minority perspective are presented.

4.3 General characteristics of the sample

4.3.1 Gender of the respondents

In this study, the analysis is by gender because the way gender is operationalized in this context affects respondent's response. In this research gender is embodied in sex of the respondents. The distribution of sex in the sample is as presented in Table 1.Results reveal that males were more than females resultantly survey 62.90 % and 37.10%, respectively.

In

Gender of respondents	**Infested)**	
	Frequency	Percentages (%)
Males	162	62.90%
Females	96	37.10
Total	258	258

consideration that this study was targeting household heads as desired respondents, the results are in fair agreement with the Zimbabwe national household survey (2022) figures of 57 percent and 43 percent female headed households respectively. Further still, in respect of the Chimanimani ward 21 where the study was conducted male headed households are reported to be more than female headed ones (ZimStat, 2022). This suggests that the distribution of gender in the sample reflects that of the population.

4.3.2 Marital status of the respondents

The study explored the marital status of respondents and the results are as presented in table 2. These findings indicate that the majority of respondents were married (64.5%), which is in fair agreement with the findings of Kachena (2021) in which it is reported that the majority of Chimanimani residents (73.2 %) were married.

Marital status	**Respondents**	
	Frequency	Percentages (%)

Single	33	12.90
Married	166	64.5
Widowed	4	3.22
Separated	6	4.84
Total		

4.3.3 Occupation

The sectoral distribution of the actively employed is believed to provide insights into a number of issues related to the labour market in the study area. As expected, results presented in Table 3 indicate that subsistence farming was the major sector of employment with 93.55 % of the entire sample.

Occupation	**Respondents**	
	Frequency	Percentages (%)
Farming	116	93.55
Other jobs	16	5.64
Unemployed	2	0.81

This is fairly in agreement with (Roser, 2013) reporting that more than two-thirds of the population in poor countries work in agriculture. FAO (2016) indicated that (73%) of the rural population are employed in the agricultural sector and specifically in subsistence farming.Other jobs represent 7% constituted by informal jobs like artisanal mining. What is worrisome is that farming is constituted by unpaid family workers, which might cause poor development, limited job creation, widespread poverty, and often a large rural economy directly impacts on the way the people treat the environment

4.3.4 Age structure of the respondents

Table shows the age structure for the sample, where the age-groups was categorized. The results show that the productive age group of 15-62 years had a percentage response of 97.58%.

Age	**Respondents**	
	Frequency	Percentages (%)
15-30	146	56.69
31-46	52	20.16
47-62	54	20.97
62-77	6	2.42
Total	258	100

The results further indicate that the age group of 62 -77 is fairly consistent with the findings of Statista (2022) in which it was reported that the age group more than 62 years was 3.065 % of the population. Respondents indicated that elders plays most crucial roles in environmental management despite having a lower population. In respect of the entire sample, the mean age taken as a continuous variable was 31 years.

4.3.5 Education level of the respondents

One of the most outcomes of basic education is literacy. The study explored literacy levels of the respondents. Those who had completed primary and above were considered literate. Results are presented in Table 4.

Education	**Respondents**	
	Frequency	Percentages (%)

Never went to school	36	13.9
Primary	118	45.78
Secondary	87	33.87
University	17	6.45
Total	258	100

Results indicate that most respondents had some level of schooling, with 44.35% having only primary schooling and 33.87% having secondary schooling. Some had either no schooling 13.9. These results are also in agreement with the findings of ZimStat (2018) in which it is reported that about 94% of Zimbabweans are literacy. This might suggest that such phenomena encountered in the study areas might assist in intervention.

4.3.6 Household size

The household size varies amongst and within the villages. The smallest households in the study area consist of one individual while the largest is in Hode village consisted of 15 individuals. A household size of between three and four individuals is most common across all the villages. The mean household size in the study area is 3.89 individuals which is lower than the official average of ward 21 (4.1), the district average of 4.3 and the national average of 4.2 individuals / household (ZIMSTATS, 2022). The most common household composition accounting for 46% of the study population is that of a father, mother and children. Families living with at least one relative account for 17% of the population while cases of non-relatives found within households are not common in the study area.

4.4 :Objective 1:To assess smallholder farmers level of awareness and perceptions towards *v. polyanthes* invasion .

Apart from Zimbabwe V. polyanthes has also been recorded as being invasive in Mozambique (CABI 2017).Knowledge of the present and potential for spread of IAS in the present case of vernonathura polyanthes is critical information for use in risk assessments underpinning

prevention, early detection, and prioritization (Poorter and Browne 2005).Results are presented in Table 7.

Local knowledge on polyanthes	**Respondents**	
	Frequency	Percentages (%)
Awareness on IAP introduction (No)	198	77
Reason for introduction (No)	232	90
V.polyathes spread mechanism (No)	30	12

Over two thirds of respondents (77%) did not know when V. polyanthes arrived in their area. For those who did have an idea, thought that V. polyanthes arrived before 2010. The majority of respondents (90%) did not know the reason for introduction, but some believed it to have been introduced as a bee fodder and for medicinal purposes. Most respondents were unsure about how it spreads (12%). Of those who did have an idea about its spread they said it spreads naturally by wind and water and argued that people were responsible for moving it around and said that it was spread by harvested grains. The parts of the landscape that were prone to invasion as highlighted by respondents in order of importance were croplands, areas around homesteads, along roadsides, on hills and rangelands.

4.4.1 Perceptions on vernonanthura polyanthes invasion

Despite the fact that residents recognized the negative impacts caused by invasive plant species, only 27% of respondents mentioned that they had attempted to remove or control the spread of invasive plant species from their cropping lands. This shows the lack of awareness of the local communities regarding the invasive plant species. Table 6 shows perceptions of smallholder farmers on invasive alien plant (v.polyanthes)

Perceptions on invasive plant species	**Respondents**	
	Frequency	Percentages (%)
Disadvantage (Yes)	198	77

Advantage (Yes)	31	12
Nuetral (yes)	28	11
Should be completely removed (yes)	232	90
Attempted to remove or control (yes)	57	22
willingness to pay for vernonathura polyanthes control programmes (yes)	34	13

Table 6 presents the perceptions of local community on invasive plant species. The result of this study showed that most of respondents (77%) blame invasive plant species for economic problem facing them, and most of the respondents (90%) need complete removal of invasive plant species. The rest of the respondents (12%) mentioned the plant has important economic importance as discussed earlier. However, 11% of respondents indicated that they are unsure whether v.polyanthes is an advantage or disadvantage to them. 13% respondent were willing to pay for control programs and argued to pay $2 which was equal to other payments on local proagrammes.

Table 5 below shows local names that was used by respondents to refer v.polyanthes. Three names were used which were mupesepese, mucyclone and mu2010.

Local name	Translation and definition
Mupesepese	Available every where
Mucyclone	Thought to have been brought by cyclone Ellen in 2009
Mu2010	Thought to have been discovered in 2010

4.4.2 Discussion of results

V.polyanthes has been initially recorded in Chimanimani on lowers parts of Chimanimani Mountains. In eastern part of Chimanimani it is wide spreading and abundant in areas like Hode, Ndakopa (Tadesse 2004). Although no bioclimatic models are available for vernonanthura

polyanthes, it almost certainly that it has the potential to spread further.According to (Rejmánek, 2016) it appears to be spreading rapidly in Chimaniamani where it was recorded in 7 vegetation types surveyed. Vernonathura polyanthes has expanded its broad distribution in Chimanimani between 2008 and 2010.

That vernonathura is probably unlikely to invade large areas in arid and semi-arid countries such as Botswana and Namibia. We therefore postulate that V. polyanthes could become established more widely in semi-arid provinces in Zimbabwe. Zimbabwe is an indication that it is adapted to local conditions and has the potential to expand its range. Hybridization between this species with vernonia polyanthes to produce vernonanthura polyanthes which is a hybrid that may also influence future spread. This is in light of the argument that hybrid invasive alien plants absorbs more nutrients and fertilizers.

4.5 Invasive alien plant impact on smallholder farmer agricultural production.

According to Linders, (2020) the threat of IAPs to food security in African region is real and growing. Subsistence farmers yield losses to IAS directly increase the risks of malnutrition and hunger. Linders argued that it is important to view the losses of invasion in the context of far-reaching impacts. Vernananthura polyanthes exert intense pressure on income and food security. Many news articles promote growing bananas due to the suitability of climatic conditions and potential income benefits, but the productivity of this crops is threatened by V. polyanthes.

4.6 :Objective 2: To assess the knowledge of smallholder farmers on *v. polyanthes* adverse impact

The total impact on crop production dependent on area which a crop is grown and the extent of invasion of invasive alien plant. Crop yield loss was the key negative aspects raised by respondents characterized by.

	Respondents	
	Frequency	Percentages (%)
Movement and Access	139	52
Reduced agricultural quantity of produce	194	75
Reduced agricultural produce quality	47	38
Absorbs fertilizers	27	22
Reduces profitability	165	64
Increased weeding costs	142	55
Reduces Livestock productivity	214	83

More than half (55%) of respondents said that vernonathura polyanthes increased weeding cost and respondents indicated that V.polyanthes is the most problematic weed in croplands followed by witch weed. Key informant respondent highlighted that as the size of the land holding increases manual weeding becomes more difficult and more costly. For respondents who mentioned impacts on crop yields they said that it can reduce crop yields by 25%- 75% if not managed in fields. According to field observations vast majority of smallholder's farmers grows maize and bananas and they lack the finance and equipment required for herbicide application to manage invasion. It is likely that changing and unpredictable climatic conditions will further challenge crop production and food security in the study area.

With regard to this assessment respondents considers V. polyanthes as unpalatable to livestock. This suggests that V polyanthes infestation does not enhance livestock production in the study area. However, livestock production in the study area add very small contribution to agriculture GDP. More than two third of respondents (72%) agreed that invasive plants reduces livestock productivity through adverse effect on grazing lands. Lemma et al. (2015) and Belayneh et al. (2016) has also reported similar harmful impacts of invasive plant species on pastoralists and agro-pastoralists. More than half of respondents 62% reported that V.polyanthes forms dense

thickets which hampers movements and accessibility of croplands. According to Dematteis (2010) the genera Vernonathura, was combined with a vernonia polyanthes to produce vernonanthura polyanthes which is a hybrid. Respondents provided that v. polyanthes is characterized by vigorous growth and 22% of respondents suggested that V.polyanthes absorbs fertilizers.

4.6.1 Discussion of results

Costs of vernonathura polyanthes outweighed the benefits for the majority of those interviewed. In particular, costs associated with movement, access and reduced croplands were regarded as high, with additional negative impacts on crop yields, livestock health and tree cover. Many invasive plants form dense stands that inhibiting to grazing lands (Shackleton et al. 2017). Dense stands of vernonathura polyanthes are also known to reduce the mean number of flowers, fruits, seeds per fruit and mean weight of seeds and stunted the growth of agricultural crops (Agboola & Muoghalu 2015).

Vernonathura polyanthes invades and competes with agricultural crops and reduces yields as highlighted by respondents in this study (Tables 1). This is in agreement with Imeokpara and Okusanya (1994), who found vernonathura polynathes to be one of the most ‘underestimated’ problems in Zimbawean agriculture, especially in maize and banana fields. Some farmers in invaded areas have abandoned their farmlands because of invasions byvernonathura polyanthe. The plant is a prolific seeder, it can rapidly colonise crop fields and increase labour costs (Jama et al. 2000.It contains allelochemicals ((Ilori, 2010)), which may inhibit germination and growth of some plant species (Otusanya, Ilori & Adelusi 2007), posing phytotoxic threats to agricultural crops

Many respondents in this survey were also unsure about the relative benefits and costs V .polyanthes (Table 1). This is quite different to the findings of other economic surveys, where the costs were significantly higher than the benefits for most issues and respondents were more certain of different impacts. For example, C. odorata in Tanzania (Shackleton et al. 2017 (Shackleton, 2017)c), L. camara in Uganda (Shackleton et al. 2017b) and Opuntia stricta in Kenya (Shackleton et al. 2017d) all had very few or no benefits and high livelihood costs.

Respondents highlighted that detrimental impacts comes out to failure to engage proper field mantainance.

However , The plants and animals we depend on today for the bulk of what we eat, wherever we may happen to live, are nearly all derived (through selective breeding) from alien species. ecrease the mass of edible pasture plants. Wheat, for example. ananas, native to the jungles of India and South-East Asia, came to Africa with Indonesian and Arab seafarers, probably in the First Century, together with mangoes and these plants brought benefits and proved to benaturalised.

4.7 Objective 3: To determine the most vulnerable crop to invasive alien plant.

The economic losses to each crop by each IAS are variable but two of those susceptible crops are on maize and banana as they contribute 80% and 72% of the total losses from all five IAS amongst six major crops.

Least Susceptible crops		Highly Susceptible crops	
Crop name	Area (%)	Crop name	Area (%)
Mango	12	Maize	30
Sweet potatoes	8	Banana	27
Irish potatoes	6	tea	10.4
Sugar beans	5	coffee	o.8
macadamia	0.5	pineapples	0.3
Total	31.5	Total	68.5

Maize, banana, pineapple, tea and coffee are the most susceptible crops, together constituted 68.5% of the total cultivated area of highly susceptible crops. None the less, farmers continued to invest in these highly susceptible crops for a number increasing market price, increasing demand; • for self-consumption.Research findings were in accordance to EMA discovery that v.polyanthes is associated with heavily disturbed habitats like maize and banana fields.,According to CABI (2017) toxic weeds and harmful shrubs are significantly shrinking grassing lands and lowering the productivity of major horticultural foods such as bananas by 45%.

4.8 Objective 4 :To determine benefits occasioned by vernonanthura polyanthes invasion.

Hettinger (2001) and Baskin (2002) assert that while invasive alien plants may have numerous negative impacts, it is important to remember that there are substantial advantages of utilizing these species in different context. Table 8 below present's benefits occasioned by V.polyanthes.

Economic benefits	**Respondents**	
	frequency	percentages
Nectar	85	33
Banana proper's	49	19
Hedge (live and dead)	36	14
Green manure	26	10
Compost	13	5
Mulch	49	19

The results of this study showed that, 33% of respondents uses V.polyanthes as a source of nectar, 14% uses it as a live hedge, green manure (10%), compost (5%), as bananas proper's (19%) and used for mulch (19%).Apart from the main benefits that the local dependent

households obtain from V.polyanthes the invasive alien plant is also used as fuel wood and medicine.

4.8.1 Discussion of results

. Respondents also identified medicinal properties as benefits of which is used to treat infections, amoebic dysentery and diabetes .Although short-term use may be beneficial, prolonged ingestion vernonathura polyanthes is assumed to be toxic. However, there are few reports of these characteristic properties being used and any utilization taking place. Some respondents also said that they used vernonathura polyanthes as a hedge plant, as seen elsewhere (Nginja et al. 1998). The use of vernonathura polyanthes for fuelwood, compost, soil erosion, control, manure was also confirmed by any respondents in the study. In Brazil V. polyanthes is used for bee honey; animal feed in Brazil. Most farmers cannot afford modern equipment

Some respondents also mentioned that vernonathura polyanthes is also occasionally used as a green manure (Table 1), (Olayeni, 2006). One of the key informat reported that vernonathura polyanthes is widely promoted throughout Chimanimani as a green manure, as its leaves have high concentrations of nitrogen, phosphorous and potassium, and they decompose rapidly in the soil. Its use has been reported to improve soil fertility in Mozambique (). The application of 1.5 tonnes of leaves per hectare increased maize yields by between 39% and 162% when compared to unfertilised fields (Ganunga et al. 1998) and in some instances resulted in higher crop yields than when inorganic fertilisers were used (Jama et al. 2000).

The practicality of using vernonathura polyanthes as a green manure to increase crop yields is opposed to chemical fertilisers over large areas is considered. In many cases, the effort required may well outweigh the benefits gained, or alternative approaches may be less costly. Harvesting and transport costs could be reduced by growing vernonathura polyanthes as a hedge around croplands, but this would reduce available land for crop production. Farm boundaries are also used for crops and trees of higher value than vernonathura polyanthes. According to Jama et al. (2000) small landholdings cannot produce sufficient biomass to meet the nutrient requirements for crop production. This is supported by Palm et al. (1997), who also found that organic materials cannot reverse soil fertility declines because they are usually not available in sufficient quantities, are often low in nutrients and their processing and application are labour-intensive .(

Apart from green manure respondents V. polyanthes is used for to make compost.Respondents indicated vernonanthura polyanthes is assumed to have higher nitrogen content that is more that embodied in leguminous crops.The IAP decays fast and is used to make thermal composit,dry leaf composit and green leaf compost and deep litter commposit. Group discussion respon dents reported that they are making a biological fertilizer called bhokashie. Bhokashie is made from, lime, corn and vernonathura polyanthes harvested material. I n the study area fertilizer cost $50 and bhokashie is assumed to reduce cost of agricultural production and enhancing nutrient reclyling.However, harvesting costs and suitable for small scale holding.

In the study areas banana production is the major agricultural crops .The stem of banana plant sis pseudo stem susceptible to wind .some farmers suggested they are conserving minimum amount of vernathura polyanthes in theirr farms because so as to harvest proppers and woods for household as wind breakes and boundaries.

For fencing farmers use what they describe as 'live fences" in the form of sisal. They also use an indigenous acacia-like creeper and has small dense thorns locally called rukato. These fences deter thieves and problem animals like goats from entering the gardens. They also act as windbreaks and help to prevent soil erosion because of wind and water. The windbreaks also protect young plants. To reclaim gullies and stabilize the soil farmers told us that they plant a wide variety of grasses such as bamboo, sugar cane and bananas.

In this study, farmers reported that vernonanthura polyanthes produced is used as a bee fodder and farmers indicated that honey from V.polyanthes taste better than wild bee honey.Despite that honey from V.polyanthes have medicinal significancy frspondents argued that However, respondents suggested that honey from vernonathura polyanthes nectar has limited market.This is because the honey has short shelf life and is said to clear like water.

4.9 **Objective** To evaluate the contribution of local institutions towards management of *V.Polyanthes* in agriculture production.Despite divergent views on the benefits and costs of V polyanthes, the majority of respondents actively managed to reduce its impacts .Respondents were asked to state whether they were willing to control V.polyanthes for the foregone benefits from vernonathura polyanthes .The results of this analysis are presented in Table 10.

Management Practices	**Respondents**	
	Frequency	Percentages (%)
Slashing and cutting	39	15
Ploughing	196	79
Biological	4	1.61
Burning	21	8
Hoeing	25	9.68
Hand pulling	27	10.48
Herbicides	62	24.2

Table 7 presents control methods of invasive plant species in Chimanimani district ward 21.Most of the respondents (24.2%) agreed that, herbicides is a controlling mechanism for invasive plant species. On the other hand, 43.16% of the informants perceived that, mechanical methods such as burning, slashing and cutting and hand pulling are the best mechanism to eradicate invasive plant species. Whereas 2% of the informants reported that, biological methods should also be used to minimize invasive plant species (Table 7).Consistent with this study on pastoralists and agro-pastoralists and farmers uses mechanical controlling mechanisms (Lemma et al., 2015).

In pasturelands, 89% of the respondents attempted to control V .polyanthes through primarily though slashing (Table 4). The majority of respondents (79%) also removed it from their croplands to reduce its potential negative impacts on crops. Cavendish (2000) showed that age and education levels of the household head had a bearing on household management towards environmental management. Respondents said that crop losses would be higher if V.polyanthes

was not controlled. Most respondents (84%) thought that management of vernonathura polyanthes would not make much difference to their livelihoods at current rates of invasion

(Table 4). However, 41% said that control would benefit crop yields.

4.9.1 Discussion of results

The majority of respondents were of the opinion that the costs of vernonathura polyanthes outweigh any benefits, which suggests that the species should be managed (Tables 1 and 4). Management will have almost no negative impacts on farmers crops and livestock and could have substantial social and environmental benefits (Table 4). There has been very little effort, outside of Zimbabwe to control V polyanthes because of limited information about its negative impacts, or because active promotion avoids information about negative impacts (Sanchez 1999). For example, many publications are available for Chimanimani but only one for native describes negative impacts of V.polyanthes (Muoghalu, J.I., 2015). However, based on people's responses in in Chimanimani V. polyanthes have negative impacts (Table 1) and is considered to be the plant with the biggest negative impacts by most respondents (Table 4).

On the other hand, investments are typically most commonly made only when IAS-associated impacts become noticeable in colonised or otherwise protected areas, i.e. often when invaders are already well-established and their impacts are high and hard to minimise (Simberloff et al., 2013).As spread and densify, management costs will increase steeply, leading to the possible abandonment of productive cropland when the cost of control becomes prohibitive (Shackleton et al. 2017). Widespread and abundant invasive alien plants are best controlled by integrated management strategies (Kaplan et al. 2017), which involve a combination of manual, chemical and biological control best suited for the prevailing conditions, followed by restoration. Of these, biological control is arguably the most cost-effective and sustainable option.

Research in South Africa has led to the identification of the tortoise beetle, Physonota maculiventris (Coleoptera: Chrysomelidae), which is sufficiently host-specific to be released for the control. Assuming that the negative impacts of Polyanthes are similar to those of T. diversifolia, the establishment of these agents should contribute to biodiversity conservation and improve crop yields. Finally, utilisation projects can, and often have, generated unintended consequences, including spreading of the target invasive species by people who want to benefit

from utilisation projects where the species does not yet occur (Nuñez et al. 2012). Management costs for IAS have totalled at least $95.3 billion worldwide in the last 60 years (1960–2020),

Statistical analysis and are potentially as high as $307.9 billion — at least one order of magnitude lower than damage costs over the same period ($1130.6 billion to $5118.6 billion). While these cost figures derived from the InvaCost database should not be perceived as exact totals (Diagne et al., 2021a), they represent the most up-to-date and exhaustive overview of management costs globally and allow us to investigate largescale patterns. Our results reveal largely disparate, inadequate and rarely proactive management investments for addressing current and future IAS impacts.

There is also a broader human nature and morality argument to IAS management, whereby it is difficult to motivate proactive investment given intrinsic inclinations to react where impact becomes apparent. In particular, it is difficult to convey a need to invest to decision-makers when impacts are seemingly absent in the short-term, incurred by other sectors or in different regions, and when other demands on limited funds may seem more pr

4.9.2 Summary of the findings

Results revealed that by and large, the majority of respondents could identify V.polyanthes and knew its invasiveness as but few knows origin and introduction purposes for which Sussedenge district was reserved and therefore its conservation values. This could be attributed to differences in literacy levels and years of experience of working with vernonathura polyanthes. With regard to perceptions of smallholder farmers on the costs and benefits to smallholder farmers by V. polyanthes invasion, results revealed that the majority of the opinions from both respondents on both infested and non-infested conditions reported V.polyanthes to be unpalatable to livestock.

As found out earlier with other groups of stakeholders, some respondents perceived V.polyanthes to be good in agriculture for green manure, bee fodder, live hedge and compost. More than half, of the respondents were advocating for limiting V.polyanthes to where it is and none opted for the do nothing option.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the general premise of the study

The study was carried out in Manicaland and covers parts of Chimanimani districts ward 21 in eastern highlands of Zimbabwe. The study focused on impact of invasive alien plant to smallholder farmer's agriculture production. One hundred twenty four households were interviewed. These respondents mentioned above were from the v. polyanthes infested parts. An earlier survey for socioeconomic impacts of vernonathura polyanthes conducted in Makoni area in 2021 had indicated that most parts had severe v polyanthes encroachment which appeared to interfere with the normal functioning and productivity of the ecosystem.

This study was motivated by the magnitude of v.polyanthes invasion in the area, the level of public concern about the invasion, and the magnitude of the IAS problem across Manicaland.. The general objective of the study was to assess the impacts of V.polyanthes invasion on the productivity of smallholder farmers .Specific objectives aimed at assessing levels of awareness of vernonathura polyanthes invasion and invasiveness, perceptions and knowledge of the original purposes of v.polyanthes., respondents' knowledge on the benefits and costs of living with vernonathura polyanthes, impacts of v.polyanthes on smallholder farmers,

Comparison of means and tabulations were used to analyze the data.The Statistical Package for Social Scientists (SPSS) was used to analyze the data. Results presented in chapters four, and indicated that V. polyanthes has both benefits and costs to all groups of stakeholders although the distribution of benefits are not the same across the same stakeholder groups. Conflict of interest in Polyanthes management therefore becomes apparent and solutions to it are as suggested in the closing part of the study.

5.2 Conclusions of the study

Irrespective of invasion condition, respondents' ability to identify V.polyanthes, knowledge of its invasiveness and perceptions of the conservation values of were generally high. Among the local dependent households, findings indicated that v.polyanthes invasion in croplandst led to increase in bundles of fuel wood collected, number of construction poles harveste and substituted artificial fertilisers which are costly in Zimbabwe.These were the major benefits associated v.polyanthes. The major cost occasioned by v.polyanthes was reduction in crop quality and productivity,increase in weeding expenditure .It was found out that v.polyanthes invasion led to a reduction in the quantity of livestock products like milk. Removal of Polyanthes therefore, could be said to have caused agriculture development through increasing levels agriculture and livestock productivity. In respect of the apiculture respondents reported Polyanthes to be of some benefits. However, respondents indicated athuogh from v.polyanthes is more sweet it vhas low quality and small shalf life as compared to wild bee honey.

Findings indicated that, This could later have a downbeat effect on the number of tourists received since their numbers depend on the number of chimpanzees in the forest which determines the chances of viewing. Basing on the results of this study, is thus clear that V.polyanthes adversely affect the local dependent communities and, albeit uncertainly, may be considered a net loss to the timber production and tourism sectors basing on the extent of this study. S. spectabilis was reported by all groups of stakeholders as having both positive and negative attributes which is the reason for the apparent conflict of interest in its management.

5.3 RECOMMENDATIONS

Based on the findings of the study, particularly challenges and theoretical contrasts, a number of policy recommendations can be suggested. Different parties have to play supporting roles, in order to effectively manage biological invasions and limit their negative impact on sustainable development and poverty. Zimbabwean authorities could consider a series of options summarized in the sub-sections that follow.

Surveys have revealed that vernonathura are already well established in many parts of Zimbabwe and have the potential to significantly increase their distribution, exacerbating biodiversity loss. Although Bindura was not part of the study area but the researcher accident identified

v.polyanthes in Bindura town outskirts.Further promotion of these species, especially V polyanthes by various development agencies, should be discouraged as the costs of invasions to livelihoods will rapidly outweigh any benefits that accrue from their use, considering their potential for further spread and densification.

The issue is not whether to undertake control operations to remove alien invasive plants, but rather how to plan and execute sustainable control operations to ensure that the resources allocated to this activity are used as effectively as possible. Greater policy emphasis on and funds for curtailing widespread invasion by alien plants in Zimbabwe are required in order to correct for the inefficiency associated with sporadic clearing. Create awareness for stakeholders about the history, cause and impacts IAPS is very important. Institutions should join the efforts to better understand IAS and devise mechanisms for better prevention and control.

5.3.1 Recommendation to policy makers

The need for stakeholder involvement

The residents of the study area have managed to undertake community based vernonathura polyanthes management projects through harnessing social capital. Given the weak Zimbabwean economy and the advantages of grassroots environmental management initiatives (Ostrom, 2000, 1990), supporting community efforts (by authorities) would save scarce resources and increase unity of purpose in the community. Such support was shown to exist for example Tsuro trust in the study area and its enhancement can only lead to more positive results.

It became apparent that the findings of our study are consistent with the widely accepted view that the human dimension is critical for successful IAS management. When we consider the importance of social perceptions, knowledge and stakeholder attitudes in relationship to invasive species, various issues emerge from our study that are relevant to IAS management. Our study findings indicated that different stakeholder groups have outstandingly different perceptions about the impacts and benefits generated by IAS (V.polyanthes), and different attitudes toward their management and control. This fact deserves special attention and should not be ignored in the decision-making process

Above all, the positive or negative effects on stakeholders by the 86 introduction of IAS should be addressed from the beginning of any decision-making process in order to consider the trade-offs involved in IAS management and facilitate the successful implementation of management practices. It should be noted with emphasis that most stakeholders and decision makers have a limited perception of the problem occasioned by invasive species and, therefore, mass sensitization and public awareness campaigns are vital for any successful management problems associated with IAS. In addition, if educational and informative campaigns are to be effective, the design should be targeted at specific stakeholder groups. Therefore, these programs must include elements regarding stakeholder interests, personal socio-demographic characteristics, environmental behavior, and personal experiences. There is need for continuous sensitization on the dangers and magnitude of the problem posed by invasive species on the socioeconomic livelihoods of stakeholders, the environment and biodiversity. Only then can we achieve a sustained fight against the problem of IAS. It is important to note that the efficiency and sustainability of forest management can be improved if local communities are involved in the management of forest resources in their vicinity.

Engaging locals to monitor instead of regular national staff, together with increased tangible benefits to the local communities will greatly improve the conditions of the forest. It is reported in a study by Ssembajjwe and Banana (1998) that forests resources are more likely to be sustainably utilized by putting in place an effective structure of institutional arrangements that gives rise to an authority system meaningful at the local level. Regardless of the attendant property regime, all forests can be de facto open access regimes if there are no effective institutions and mechanisms to enforce the rules. In the absence of institutional arrangements and associated organizational mechanisms to monitor and enforce rules, a government forest reserve can be as degraded as a communal forest.

Removal of externalities

The lack of alien plant eradication is an example of a negative externality which imposes costs on non-users and is a result of the marginal private costs (MPC) consistently falling short of the marginal social costs (MSC) borne by society. In order to ensure the efficient allocation of resources it is necessary to close the gap between MPC and MSC. There are two appropriate strategies which may be adopted by government to internalize these costs namely, the

introduction of a tax or a subsidy. Before these two measures are discussed it is essential to consider the socially optimal level of alien invasive plants.

Definition of the optimal alien plant level Eradication of alien plants is economically worthwhile as long as the costs of clearing are outweighed by the (total) benefits. Thus, although this study has posited the complete eradication of alien plants in the study area, as a general point it should be noted that the optimal level of infestation in any given area is not necessarily zero. Rather, the socially optimal level of alien invasive plants is site-specific as well as species dependent, since site and species characteristics will impact on both costs and benefits of clearing. Policy-makers would need to take this into consideration in trying to defme an appropriate level of a tax or subsidy to correct for the prevailing distortion in output levels.

Levying of a tax Government can either levy a tax on individuals who are currently not engaged in alien plant clearing or alternatively, on those individuals engaged in sporadic clearing. It is important to ensure that the tax imposed for non-eradication exceeds the MPC of clearing, since only in this event will such a charge be effective in inducing individuals to remove alien plants in the long-term. Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2009). 468 SAJEMS NS Vol 5 (2002) No 2 Furthermore, the tax levied must be site-specific and charged per dense hectare of invaded alien plants.

Introduction of a subsidy Government can subsidise those individuals that have been engaged in alien plant clearing on their properties. Subsidisation of those individuals currently engaged in clearing can be in the form of either monetary incentives or subsidising of certain costs (besides labour) incurred in clearing (e.g. herbicides). The subsidy, like the tax, should be site-specific and paid per dense hectare of invaded alien plants cleared. Subsidisation of costs or monetary measures require on-going monitoring by government officials to ensure that the resources provided are being used for the appropriate purposes.

Fire insurance premiums

The fire insurance premium is one measure which could be used to encourage private individuals and companies to engage in regular alien invasive plant clearing. Where individuals have removed or are in the process of removing alien plants from their land, their fire insurance premiums should be reduced because the spread of fire is much easier to control. Similarly, fire

insurance premiums should be augmented where individuals have not attempted to eradicate alien invasive plants from their properties. The change in fire insurance premiums proposed will act as an incentive for individuals to engage in alien invasive plant clearing.

Formulation of a weed management plan

All those individuals owning large areas of natural land which are prone to alien plant invasion should be encouraged by government to fonnulate a weed management plan. This plan would entail the establishment of benchmarks which can be used to measure trends and progress towards achieving some reduced level of alien plant infestation. Such a plan is an important means of communicating infonnation about progress towards goals set. The formulation of this plan might be encouraged by only offering subsidies to those individuals who have fonnulated weed management plans.

5.3.2 The need to resolve conflict of interest in vernonathura polyanthes management

As alluded to in various parts of this study, everything that exists on earth has a value. For this very reason, the term "existence value" was coined by environmental economists to mean the value of something by nature of its existence. This value could be known, unknown or both. Proponents of strict agriculture conservation would be against any plans to destroy V.polyanthes even if it has been branded invasive and therefore counterproductive in the broad sense. On the other hand, farmers a driven by profit objectives thinking would advocate for eradication of vernonathura polyanthes so as to save the livestock and crops thenceforth ensure sustainable production

On the contrary, eradication of S v polyanthes would come at a cost as various groups of stakeholders would lose all the many benefits they obtain from V.polyanthes as reported in earlier chapters such as organic manurepoles, medicine, feed and habitat for wildlife, shade, wind brakes, fence, climate regulation and carbon sequestration. Because of the antagonistic interests and reasons of different groups of stakeholders, S. spectabilis is both being fought and planted at the same time which exposes a glaringly difficult challenge in its management.

With the above background, the study sought to find out some of the possible approaches to resolving the problem of conflict of interest in IAS management as discussed hereunder. A

careful strategy to resolve the apparent conflict from the economic efficiency point of view would be a national cost-benefit analysis (CBA) on V.polyanthes and other IAS in their respective ecosystems whose findings would pronounce a final course of action as to whether Vpolyanthes should be eradicated or controlled through strategic plantations that are location specific or even still, adoption of the do-nothing option depending on the results of the investigation.

The need to harness role of economics in IAS management

The problem of invasive species has presented a serious challenge in an era of increased globalization and trade liberalization. The undeniable fact is that the problem has as much to do with economics as with ecology. Any solutions advanced must be firmly grounded in both ecological science and economics. Needless to say is that the economics discipline possesses the capability of valuing various market and non-market impacts and provides a means for assessing important trade-offs among various management alternatives, which can improve greatly the decision-making process for managing such problems.

Also, through figures generated, it can improve the transparency of the decision making process by providing justifications for the measures implemented. However, the true value of economics should not be seen solely in the precision of the numbers generated, but also in the extent to which the discipline aids decision makers to formulate consistent and rational decisions. As was the case in South Africa the main strategic approach to raise significant funding for control programmes of IAS must be through a combination of economic argument and strong political support. 6.3.7 Further research area

5.3.3 Recommendations to farmers

Vernonathura plyanthes is characteraised with higahly disturved plats .their the need to the need for farmers to engage in sustainable and smart agriculture practices like crop rotaion.There is allos a need to engages in serious feld management.

5.4 Limitations of the research

There were three main limitations encountered in this research: unwillingness of some respondents to provide data (particularly key informants), time and financial limitations. Therefore, the results of the study are limited to the key informants who were willing to provide data. Thus, the unwillingness of some key informants to provide data for the research reduced the sampling frame, and probably introduced bias. In order to increase reliability of results, in-depth interviews were conducted with those who responded. Thus, the results can still be generalized to the whole population, although distinct features among different people and areas have to be considered. Data collection was over a relatively short period due to time and financial limitations. However, secondary data and the group discussions were useful and mitigated this limitation.

5.5 Further research areas

Important to note is that there is terrible need for more research on determining the real magnitude of environmental and economic losses and benefits caused by invasive species and the possible implications on the ecosystems that they inhabit as well as on the national economy. This is necessary as an initial step towards formulation of possible control strategies that are affordable by the affected stakeholders. The desired goal would be to reduce invasive species control cost so as to enable stakeholders improve their production efficiency. This would possibly require establishment of on farm research trials managed by both farmers and researchers. Findings of such trials can be easily disseminated and adopted by other farmers.

Furthermore, research into possible biological vectors would also be a way of reducing the risk of unwanted invasions. Nevertheless, practical solutions to the actual implementation of these options, and to the equitable sharing of costs, still need to be explored

(ii) the utilization of local communities for cheap labour and support in 89 such activities; (iii) the sustainable management of the country's natural resources; and (iv) best management practices.

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APPENDIX1: VERNONATHURA POLYANTHES IMPACT REGRESSION MODEL

APPENDIX 2: FIELDWORK PHOTOGRAPHS

Photos: *Vernonanthura polyanthes* invasion in banana field

Photo: Deep litter compost for Polyanthes

Photo: V. polyanthes bio-fertilizer (Bhokhashie) synthesis

Photo: Bhokashi ready for use

Photo: V. Polyanthes management (cutting)

Photo: V. Polyanthes growth after fire

APPENDIX 3: DATA COLLECTION TOOLS

Bindura University of Science Education

DEPARTMENT OF AGRICULTURE ECONOMICS, EDUCATION AND EXTENSION

HOUSEHOLD SURVEY QUESTIONNAIRE

A DEMOGRAPHIC DATA

Good morning/afternoon, my name is Armton Mutendera and I am studying for a Bachelor of Science honours degree in Agriculture Economics and Management with Bindura University of Science Education. As part of my degree program, I am carrying out a research study on the economic impact of vernonanthura polyanthes on smallholder farmers in Chimanimani district ward 21

Confidentiality and Consent: Your answers to this interview will not be released to anyone There will be no economic, financial benefits or any hand-out resulting from this interview. This is voluntary interview and you are free to answer or not. You do not have to answer any questions that you do not want to answer, and you may end this interview at any time you want to. However, your honest answers to these questions will be helpful for us to better understand level of impacts which would help us draw well informed conclusions. We greatly appreciate your help and apologize for time taken in responding to this survey. It will take about 40 minutes of your time. Would you be willing to participate?

Yes		No	

I certify that the nature and purpose, the potential benefits and possible risks associated with participating in this research have been explained to the volunteer.

Enumerator's signature_____

i. **Questionnaire Number __/ __/ __/**
ii. **Name of Enumerator**_____
iii. **Date of interview __/ __/ 2022**
iv. **Ward** _____
v. **Village** _____

A1	What is the gender of the household head(HH)	**1=**Male **2=**Female	|___|
A2	What is the marital status of the household head	**1** = Single **2** = Married **3=**Divorced **4** = Widowed	|___|
A3	Occupation/ employment of household head	**1** = Farming **2** = other jobs **3**=Unemployed	|___|
A4	What is the age of the household head in years (Number)	**1** = 15-30 **2** = 31-46 **3** = 47-62 **4**= 62-77	|___|
A5	What is the level of education of the household head	**1=**Never attended school **2**= Primary **3**= Secondary **4**= University	|___|
A6	Household size (No of People)_____ (Residing for a period longer than 3 months)		
A7	Household composition		

Members	**Gender**	**Family position**	**Age**	**Education**

Key
Gender
Male = 1 Female= 2

Family position
Father= 1; Mother=2; Child=3; Relative=4; Non relative=5
Age
1= Under 5, 2=5-18; 3=19-35; 4 =45-65; 5=>65
Highest educational qualification of the household head
1 = Never went to school, 2 = Primary School, 3 = Secondary School, 4 = Vocational Training, 5 = Tertiary Education

B: **PERCEPTIONS ON VERNONATHURA POLYANTHES**

B1	Have you heard of vernonanthura polyanthes	1 =Yes	2 =No	|___|
B2	What is own opinion over vernonathura polyanthes invasion	1=Yes	2 =No	|___|

B3 If the answer to B1 was yes state local name

Local name	When did you first see the plant	Do you know where it came from
……..	……..	……..

Key
When did you first see the plant
1= < a year ago; 2= 12 years ago
Do you know where it came from
1=Yes; 2=No

B4	What is own opinion over vernonathura polyanthes invasion	1=Advantage 2=Disadvantage		|___|
B5	Should Polyanthes be completely removed	1=Yes	2=No	|___|
B6	Have you attempted to remove or control	1=Yes	2=No	|___|
B7	Are you willing to pay for vernonathura polyanthes control programmes.	1=Yes	2=No	|___|
B8	If you answered Yes to B7, How much are you willing to pay as a household annually USD.....			
B9	If you answered No to B3, who should pay.	1 = The government 2 = The EMA 3 = The chiefs 4 = NGO		|___|

C HOUSEHOLD AGRICULTURE PRODUCTION

C1	Does your household have access to arable land?	1 = Yes	2 = No	|___|
C2	What is the type of ownership of the agricultural land you cultivate?	1=Owner 2=Sharecropped 3=Tenant/Leased to somebody 4= Other (specify)		|___|

C2

Crop name	What area of land you have under cultivation (Ha)?	How much did you harvest?	What proportion of your production is consumption	Which percentage of the harvest did you sell?	How mu did you

	Maize						
	Banana						
	Tomatoes						
	Sugar beans						
	mango						
	Sweet potato						
	Irish potato						
	tea						
	coffee						
	macadamia						
	pineapples						
	Other						

C3	Where did you get your inputs	1=Market 2=Friends 3=relatives 4=Assistance (gov., humanitarian actors 5=Other	|___|

C4 What is the uses of vernonanthura polyanthes in agriculture production

Use	
1	
2	
3	
4	
5	
6	
7	
8	
9	

D IMPACTS OF VERNONATHURA POLYANTHSES IN AGRICULTURE PRODUCTION

D1	Has any of your land been invaded by the plant	1= Yes	2= No	|___|
D2	If yes what was the primary use of the land invaded 1= Grazing; 2=Agriculture; 3= Aesthetic value; 4= cultural activities; 5=livestock shelter; 6=Other_____			|___|

D3 What are the positive and negative attributes of vernonathurea polyanthes in order of rank

Positives	Negatives

D4	Did the plant causes damages to your crops		1=Yes	2=No	|___|
D5	Did the plant causes damages to your livestock		1=Yes	2=No	
D6	Which crop is most prone to vernananthura polyathes ……				
D7	Which have been the main impact in agriculture since the existence of vernonathura polyanthes	1= Standing crop destroyed 2= Standing crop abandoned 3= Losses of agricultural tools / machinery			|___|
D8	**Indicate challenges that you are facing due to polyanthes invasion by ticking the correct box**	1=Movement and Access ☐ 2=Reduced quantity of produce ☐ 3=Reduced produce quality ☐ 4= Absorbs fertilizers ☐ 5=Reduces profitability ☐ 6= Increased weeding costs ☐ 7=Reduces Livestock productivity ☐			
D9	Indicate in the table below if you have lost crop and livestock production due to vernonathura polyanthes				

Crop	**Annual crop production loss in hectares**	**Annual crop production in k.gs**
Livestock	**Annual Livestock production loss (heard**	**Annual livestock production**

	size)	(heard size)

D10	Who does most of the agriculture related labour in wedding	1=Men 2=woman 3=children	|___|
D11	Household income spent on :hiring labour to control, investment in tools and other thing	Annual income 1= < $100, 3 = < $200; 4 = < $ 300; >400	|___|

D12 What crop management practices are now complicated

Activity		

E	**MANAGEMENT OF VERNONTHURA POLYANTHES**		
E1	What type of agriculture support would you need most to control vernonathura polyanthes	1= tools 2= access to agricultural services 3= credit 4= draught animals 5= repair / replacement farm machinery	|___|
E2	Which control measure is most appropriate	1=mechanical 2=biological 3Intergrated	|___|
E3	What are the vernonathura polyanthes control programmes that you are aware of	1= Community programmes; 2 = NGO program mes; 3= Government programmes 4 = Private programmes; 5= Other	|___|
E4	What type of services does NGOs and Government provide	1=Training 2= Technical advice	|___|
E5	Are you involved in any of these control	1 = Yes 2= No	

	programmes		|___|
E6	Have you been given an education on the plant?	1 = Yes 2= No	|___|
E7	Where do you get information regarding vernonathura polyanthes	Government(EM A& RD C); 2= Radio; 3= N G O s; 4= Television Schools 5= Other	|___|
E8	Do you think informal institutional positively contribute to invasion control	1 = Y e s very much; 2 = Y e s but minimally; 3=No	|___|
E9	What are the major challenges you have faced in controlling the plant	1= Finance; 2=Technical support; 3=Technical knowhow; 4= Tools; 5=Injury 6=other	|___|

Focus Group Discussion Guide

Date_____

Ward Number_____

Village Name_____

Group composition

Females		
Males		
Total		

A. Perceptions of smallholder farmers on IAPs

i. Have you ever heard of IAPs
ii. Are you worried about their origin?
iii. Would you introduce plant species into your farm?
iv. Have you heard of vernonathura polyanthes (historical aspects)
v. What are the positive and negative attributes of vernonathura polyanthes
vi. What changes to crops and livestock population do you observe in your farms?
vii. How vernonathura polyanthes contribute to these changes?
viii. What makes you dislike the plant
ix. How should IAPs and plant species in general be managed
x. Who should manage them?

B. V. polyanthses in agriculture product

i. What are the major positives of V.polyanthes
ii. What are the major effects of V.polyanthes
iii. Are there any activities that are no longer undertaken because of the presence of vernonathura polyanthes
iv. What major activities are under threat?

C. Environmental management institutions

i. Which environmental management institutions are you aware of in Chimanimanui?
ii. Do you think informal institutional have positively contributed to invasion management?
iii. What have been the major contributions?
iv. What are the major short comings of institutional frameworks in place? Key informant interview guide

Key Informant Interview Guide

Date_____

Organization _____

Position of key informant_____

A. Perceptions on IAPs and the environment

i. Have you heard of IAPs?

ii. Do know historical aspects of vernonathura polyuanthes

iii. Does their origin matter?

iv. What are the positive and negative attributes of Cff?

v. How should IAPs and plant species in general be managed?

vi. Who should manage them?

B. Environmental management institutions

i. What are the major institutional frameworks (by categories) that have impacted on environmental management in rural Zimbabwe?

ii. Do you think institutional frameworks have positively contributed to environmental management?

iii. What have been the major contributions