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SMALLHOLDER FARMERS' PERCEPTIONS AND ADAPTATION ON CLIMATE CHANGE: THE CASE OF WARD 6 CHIPINGE DISTRICT

BY

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Dissertation submitted in Partial Fulfilment of the Requirements of

the Master of Science Degree in Economics

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DECLARATION

This Dissertation is entirely my own work and references have been made where other sources are used. I do hereby declare that this Dissertation has not been previously submitted for the award of another degree at any University.

Signed________________ Date________________________

Fortunate Sithole

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DEDICATION

To my amazing family for their love and support.

ACKNOWLEDGEMENTS
Firstly**,** would like to thank the Almighty God who gave me strength and grace that enabled me to write this dissertation because if it wasn’t for Him I wouldn’t have done it.

I gratefully recognize my supervisor, Dr. C. Mumbengegwi, am greatly indebted to your insight and valuable supervision that made this dissertation to be what it is. The completion of this work would not have been possible without your support and guidance throughout.

My sincere appreciation also goes to Mr C Pindiriri and Mr E Muhoyi for their support and guidance. I would like to express my hearty appreciation to my MEC 20172 colleagues for their encouragement as well. Special credit also goes to my parents, for their love and unwavering support throughout this journey.

ABSTRACT
Agricultural production in Chipinge is highly vulnerable to the impacts of climate change. The study focused on understanding farmers' perceptions on climate variability and change and linking it to different strategies adopted by farmers to deal with it. Farmers perceived a change in the general climate, decrease in annual rainfall, and also temperature increase. It was found that this concur with meteorological data. Different crop varieties that mature early and drought resistant, staggering planting dates, storing water in big tanks or filting pits, planting more than one crop, and livestock ownership were the commonly preferred adaptation strategies to deal with climate variability. With this, it is plausible to conclude that perceptions cause farmers to adopt strategies to cope with climate variability, and among them are integration of nutrient and time management, increased farmer access to timely weather information, particularly with the starting of rains, which all are very critical in enhancing adaptive capacity to increased climate variability and change.

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LIST OF ACRONYMS

CPU	Civil Protection Unit
CwDCCP	Copying with Drought and Climate Change Project
FAO	Food and Agricultural Organization
GoZ	Government of Zimbabwe
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
MoA	Ministry of Agriculture
UNDP	United Nations Development Program
USD	United States Dollar
USAID	United States Agency for International Development
ZIMSTAT	Zimbabwe National Statistics Agency
ZMSD	Zimbabwe Meteorological Services Department

CHAPTER ONE

INTRODUCTION AND BACKGROUND

1.0 Introduction

Moyo *et al*. (2012) have argued that in Zimbabwe, climate change is likely to have adverse environmental, economic and social impacts, particularly among smallholder farmers. Given the widespread poverty, droughts, over reliance on rain fed agriculture and low adaptive capacity (Jiri *et al*. 2015; Traore *et al.* 2013). Due to climate change, the areas that where traditionally fit for agriculture, the length of growing seasons and crop yields are decreasing and varying from year to year. In other instances, floods and dry spells have been experienced during the same season. Decreases in rainfall are also expected across all seasons, other potential changes include increased temperatures, decreasing or varying river flow (Moyo *et al*. 2012). These changes have serious consequences on household food access, income and nutrition security on these farmers (Jiri *et al*. 2015). By 2050, average temperatures over Zimbabwe are anticipated to have increased by 2 to 4 degrees Celsius and rainfall to have dropped by 10 to 20 % than the 1961 to 1990 baselines (Jiri *et al*. 2015).

Adaptation is essential to reduce the impacts of climate change and variability on food security and to protect the livelihoods of the poor rural farmers (Bryan *et al*. 2009). Ericksen *et al*. (2011) defined adaptation to climate change as adjustments of process, practices and systems to minimize current or future adverse effects of climate change and take advantage of available opportunity to maximize benefits. As noted by Intergovernmental Panel on Climate Change (IPCC), 2007, adaptation is the process of maintaining various farming objectives through modification of the systems, which can be natural or human, following expected inducements or their effects. Efficient use of these adaptation strategies offer viable solutions to some of the challenges posed by climate change in the agricultural sector. Past studies (Bryan *et al*. 2009; Maddison, 2006; Adger *et al*. 2003) suggest that effective adaptation somehow alleviates some of the many problems caused by climate change and variability through the improvement of crop yield and livelihoods. Feasible adaptation can vary from relatively low cost changes in crop or farm management for example changing to another existing crop variety, crop diversification, mixing crop and livestock, conservation agriculture, use of mineral fertilizer and staggering of planting dates to more costly measures, such as irrigation. Although changes in social and institutional structure are also vital when it comes to adaptation to sever climate change (Howden *et al*. 2007)

However, perceptions[1] regarding climate change can play an essential role in influencing adaptation measures (Makate *et al*. 2017). Maddison, (2006) noted that adaptation involves two stages where you first perceive that the climate has changed and then deciding whether you adopt or not. Adger *et al*. (2000) also supported Maddison, (2006) that the first stage requires the farmer to notice a change in the climatic variables and its effects on the farming objectives. The second stage involves making a decision on what strategy to respond with and evaluating its efficacy on farming objectives for instance food security. As such this study tries to see if there is a relationship between perceptions on climate change and adaptation.

There is a unique relationship between climate change and agriculture, well documented in literature. This research notes that while it is clear from other studies that climate change is impacting, and that farmers are adapting, it is not clear in the face of Chipinge district as to what extent do perceptions influence the farmers whether to adapt or not to climate change as it is noted that these farmers are failing to adapt according to United Nations Development Program (UNDP), 2014. Chipinge is one of the most vulnerable districts to climate variability and change. Land degradation and water shortages have become looming problems. United States Agency for International Development (USAID) (2014) confirmed food security, poor input/output market and natural disasters including floods and drought as priority problems of the district. This situation worsens the vulnerability of smallholder farmers who depend on rain fed farming for food and income security. The literature on adaptation also suggests that management style adapted by the farmer is determined by farmer's perceptions to a larger scale. Furthermore, individuals' degree of worry about climate change threats has been proved somehow to be an influencing factor in climate action. Therefore, in order to improve adaptation among farmers and promoting effectiveness of adapted strategies, farmers' perceptions must be well incorporated into these adaptation strategies.

[1] Perceptions can be defined as a range of beliefs, judgments and attitude (Slegers, 2008).

However, very little is known regarding farmers' perception on climate change and how these perceptions relate to adaptation in Chipinge. The focus of previous studies used meta-data analysis to see the link between farmers' perceptions on climate change and meteorological data (Moyo *et al*. 2012; Debela *et al*. 2015; Deressa *et al*. 2009; Abid *et al*. 2015). This study intends to capture the role of farmers' perceptions of climate change on the adoption of different strategies in Chipinge. Farmers' perceptions on climate might strongly influence the decision to adopt different strategies and draw policy implications for climate change adaptation in the region.

1.1 Background of the study

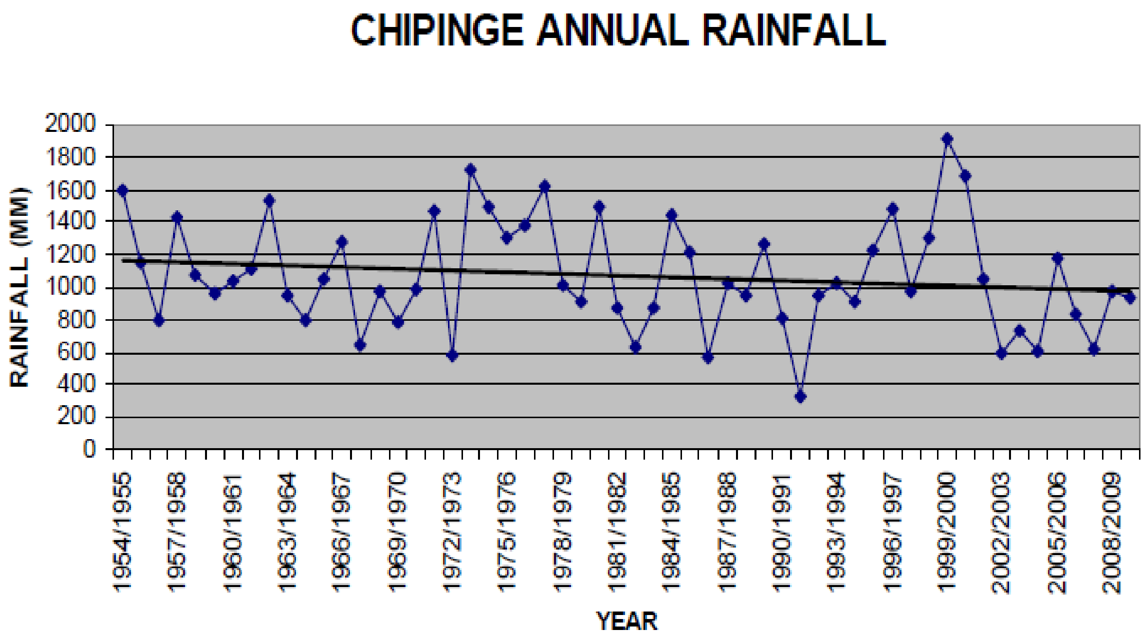
The Zimbabwe economy and livelihoods are under stress due to a number of socioeconomic, environmental and political factors according to Government of Zimbabwe (GoZ, 2014). Climate variability and change are compounding the impacts of these multiple stressors on people's wellbeing and livelihoods. Research shows changes in the agro-ecological zones due to climate change, for instance Chinhoyi and Chivero have moved from region II to III, furthermore natural region I has reduced in size, and natural region II has shifted further east and natural region III has shifted to the north (GoZ, 2014). These changes have significant impacts on people's livelihood strategies, especially within agriculture.

Chipinge district is located in Manicaland province, in southeastern Zimbabwe, close to the international border of Mozambique. The district sits at an elevation of 3,635 feet (1,108 m) above sea level. The average annual rainfall in Chipinge is about 1,105 millimeters (43.5 in). The local farmers grow tea, coffee macadamia nuts maize and dairy cattle. The surrounding mountain slopes are covered with pine and acacia plantations. The population census of 1992 indicated that the population for the area was 11,582. The population continued to grow to 18,860 in 2004, before it ballooned to 25, 675 in 2012 (ZIMSTAT, 2012).

The agricultural sector of Chipinge is almost paralyzed as crops are wilting due to excessive heat livestock production has been affected as pastures have become a problem in the area (Madhuku, 2011). According to Coping with Drought and Climate Change Project (CwDCCP) in 2012 most communities were now increasingly dependent on donor handouts as fields no longer produce enough to sustain farmers to the next season. In Chipinge there are two parts the first one in region five is the semi arid Save valley part and is characterized by low rainfall 400- 600 mm per year and sandy soils of low fertility. The farming system in this area is dominated by 'mixed crop livestock' farming. The second part lies in region one where rainfall ranges from 800-1000mm for example Chirinda forest. This study is more concerned with it since it has been greatly affected as rainfall has declined overtime.

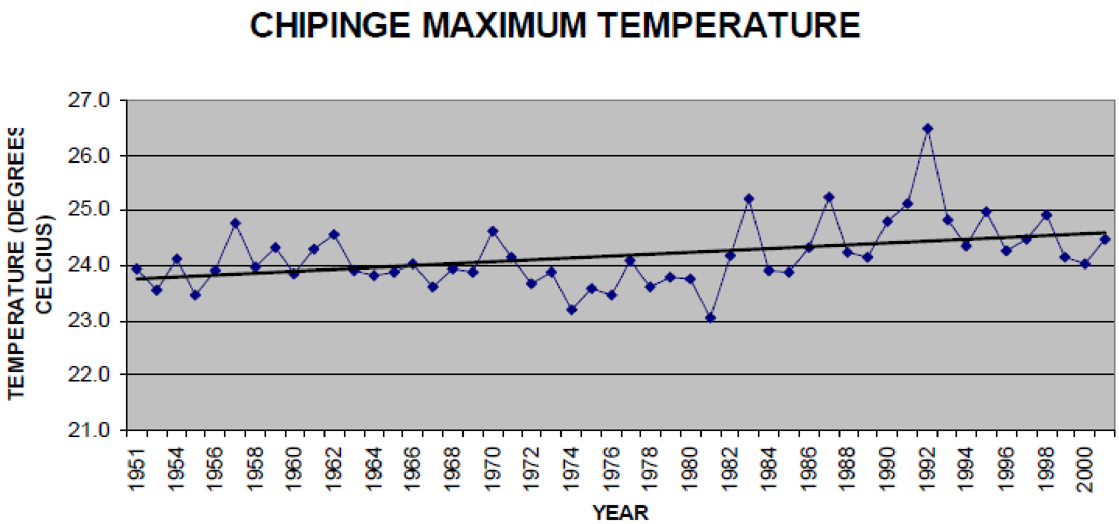
This can be illustrated by the graphs below. The main question being, have the farmers been able to notice or perceive this change? What has been the reason for not copying?

Figure 1: Chipinge annual rainfall



In the above graph show a downward movement since the 1950s till the 2000s. In addition, during the same period the length and frequency of dry spells during the rainfall season has been increasing while the frequency of rain days has been decreasing (ZMSD, 2010). This decline in rainfall has serious consequences on the food production of smallholder farmers in Chipinge.

Figure 2: Chipinge Annual Temperature



Source: *Zimbabwe Meteorological Services Department (ZMSD), 2010*

For temperature, positive trends can be seen from 1961 to 2000 as shown in figure 2. There was however fluctuations in the temperatures in Chipinge, with the lowest recorded in the year 1982 and the highest recorded in the year 1992.

More evidence that climate has changed can be illustrated by the table which shows that the rainfall has decreased in the main catchments in the country where Save river in Chipinge is among the top with the highest decrease in rainfall of 14.7% after Mzingwane

Table 1: Rainfall in Zimbabwe during 1900-2000

Catchment	Current Average Rainfall (mm)	% Decrease in Rainfall between 1900-2000
Mzingwane	473	15.3%
Save	778.7	14.7%
Sanyati	716	12.5%
Runde	591.9	11.1%
Gwayi	608.3	7.7%
Mazowe	825.7	5.3%
Manyame	806.4	3.8%

Source: Moyo E.N., 2013, Evidence of Climate of Change in Zimbabwe, Presentation made at the Parliamentarian Workshop, Harare. [Data source: Met Office]

Responses to counter the climate change effects are mitigation and adaptation. De Jonge, (2010) argue that risk of climate change to human and natural systems can be reduced by either mitigation or adaptation strategies. This is also supported by Gbetibouo, (2009) who argues that climate change is harmful without adaptation to the agricultural sector. Of late farmers in Chipinge have been growing bananas to sustain them. The residents of Chipinge have been suffering and not copying to the climate change. Their food security has been compromised and therefore it is key to know their perceptions and their surroundings factors as to how it is affecting their adaption so as to reduce the impact.

1.2 Problem Statement

How farmers and societies respond to climate change can been closely linked to community perceptions of climate variability and change. Therefore, trying to understand smallholder farmer's perceptions towards climate variability and how it influences their farming practices is of critical importance (Makate *et al*. 2017). As noted by UNDP, (2014) farmers are failing to adapt/ cope to changes in climate and this has affected their yield and overall their livelihood.

Chipinge is one of the districts that receive high rainfall but over the past years this has changed, seeing shorter rainy periods, increase in temperature, droughts and cyclones which have been horror to these farmers (Madhuku, 2011). According to FAO, (2008) the estimated food insecure persons in Manicaland had been increasing from 285400 to 535100 then 713400 in the same year which among other factors can be attributed to climate change. While adaptation is an essential strategy to enable farmers cope with adverse effects of climate change and variability which in turn increase the agricultural production of the smallholder farmers (Yesuf *et al*. 2008). Nhemachena *et al*. (2008) and Legesse *et al*. (2013) noted that adaptation has the potential to reduce or soften the impacts of climate related risk in human managed systems within a short to medium lead time and these include use of new crop varieties, irrigation, crop diversification, mixed crop-livestock systems, conservation agriculture and staggering of planting dates.

However, there seems that there is a gap between the rate at which climate is changing and the response to reduce its impact through employment of adaptation strategies that ensure sustainable food security by smallholder's farmers in Chipinge. It is therefore critical to understand farmer's perceptions which usually influence their judgment on whether to, or not adapt as perceptions can be a major determinant of adaptation.

Numerous studies have made an attempt towards the analysis of the impact of climate change and the factors influencing the farmers' choice of adaptation ways in livestock and crops in Africa at a regional level (Maddison, 2006; Seo and Mendelsohn, 2008; Kurukulasuriya and Mendelsohn, 2008; Hassan and Nhemachena, 2008). This study examines the role played by perception in influencing adaptation.

1.3 Research Objectives

The broad objective of this study is to investigate the role of perceptions in influencing adaptation among smallholder farmers in Chipinge

The specific objective:

- To study the effects of perceptions conditioned on other variables on adapting to climate change

1.4 Research Questions

The research questions relating the above specific research objective:

- What is the effect of perception on the adaptation strategies?

1.5 Hypothesis of the study

- Farmer's perceptions on climate change significantly explain adaptation strategies.

1.6 Justification of the Study

Knowing the role of perceptions in influencing current adaptation strategies will enable us to formulate appropriate policies since adaptation helps farmers achieve their food, income and livelihood security objectives in the face of perceptions and other variables. This has great policy significance since it provides empirical evidence that would inform policy makers on the most important measure to take. If this is not addressed the huge population will remain in their state of not coping and this will affect their livelihoods. In this regard, the study does not only allow the assessment of outcomes that facilitate policy consideration and decision making in the face of future uncertainty, it also builds the knowledge base to guide adaptation of agricultural systems. This will reduce the vulnerability of rural households and increase the opportunities for sustainable development. Chipinge was chosen because it has a huge decline in rainfall with a large number of small scale farmers. Analyzing perceptions and adaptation is therefore important for finding ways to help farmers adapt in the rural economies.

1.7 Organization of the rest of the study

The organization of this dissertation is as follows: Chapter 2 presents the theoretical and empirical literature. Chapter 3 focuses on the methods and procedures of how the study was carried out. Chapter 4 presents the econometric estimation and interpretation of the results. Chapter 5 concludes with a summary of the study's findings and the policy recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter is an elaboration and citation of relevant literature on perception and adaptation to climate change. It reviews theoretical knowledge along with empirical evidence on the previous studies. Theoretical literature is reviewed to enable understanding of the conceptual framework if there is a relationship between perceptions on climate change and adaptation by smallholder farmers in Chipinge. To this effect, this study reviews the Innovation diffusion model, Adoption perception model and induced innovation theory as they are applied in climatic economics. Empirical literature is also reviewed to help further understand the objective of the study by focusing on past studies done. All this would be the basis of this study's argument in its theoretical and empirical model specification.

2.1 Theoretical literature review

The study of perceptions and adaptation to climate change is a new area in economic research. Economists who have done studies in this area have likened to the area of adoption of new agricultural technologies, since no economic theory has been developed yet on this subject (Deressa *et al*. 2010).

2.1.1 Induced innovation (Hicks, 1932)

The theory postulates that as factor prices change it still stimulate innovation to reduce the use of the factor whose price has increased compared to the other. This theory can be applied in the area of climate change, as exposited by Netra *et al*. (2004) the theory guides us in investigating the role played by perceptions on climate change as a motivator of smallholder farmers to innovate and the adapt to climate change in Chipinge district. The fundamental of induced innovation is that investment in innovation is a function of change that enters into the farm's production function. Whereas innovations in agriculture do not evolve climatic variable only by also non climatic factors, for example political and economic environment, have a noteworthy implication for innovation and adaptation to new agricultural practices.

The theory analyses the effects of climate change and how the perceptions each individual farmer has on this changes trigger the farmer to be innovative in adapting. The assumption of this theory is that when farmers experience some changes due to climate, they are likely to look for other means that can help them to overcome constraints arising. Therefore this changes act as a catalyst in adaptation responses, in this case farmers adjust crop management, and land uses and farm management strategies so as to offset the adverse effects of climate change.

It is thus assumed that perceptions of the variability in climate prompt the adaptation process among the households so as to cope with the negative impacts of climate change in the farm (Ndambiri *et al.*, 2015). The study noticed that climate change in Chipinge district is an important limitation towards the productive capacity of smallholder farmers and that adaptive responses would minimize farming risks stemming from climate change. It can also be noted that when pressure to grow food from climatic stressed environment, the marginal cost of production goes up. Eventually, the farmer gets to a point where adaptation becomes the only means to enhance farm incomes. This may entail the creation and use of knowledge that accommodates climate change through a combination of land use and farm management practices such as water harvesting, irrigation or through the adoption of area specific crop varieties and livestock. Therefore, undertaking this study in Chipinge district would provide important insights about the relationships between farmers' perceptions of climate change and adaptations to climate change, which would safeguard the local people against adverse effects of climate change.

2.1.2 Innovation diffusion model (Rogers 1962)

Adaptation behaviors may be influenced by knowledge and attitudes of an innovation. The model looks at the factors affecting adoption of technology by different stakeholders and it was found that access to information was key in determining adoption decision. Therefore for one to perceive that climate is changing information regarding the subject matter is key. Adoption is treated as a process whereby innovation is communicated through certain channels over time among the society, this gives them full information on the innovation and increases the likelihood of adapting.

The major obstacle is uncertainty when it comes to adaptation decisions, people tend to adapt when it enhances their utility. Thus they must be convinced that the adaptation strategies yield some improvement to the idea it substitutes. In considering costs brought about by the innovation, they take into account how the innovation disrupts the day to day functioning of life. This implies that uncertainty negatively impacts the adoption of technology. The fact that people are generally risk averse, uncertainty will induce people to postpone the use of innovation such as new maize varieties until they have gathered enough evidence that it really works. Each innovation decision is largely influenced by personal traits and also how the society thinks hence the rate of adopting new innovation is different.

According to Makokha *et al*. (1999) noted that the innovation diffusion model emphasized on the use of extension contact, use of mass media as means of influencing adoption of new technologies. While Adesina and Zinnah (1993) also argued that the use of extension or by the use of experimental station visits and on farm trials, skeptic non adopters can be encouraged to adopt. This research will borrow the key variables in this model which are access to information through different media, extension services in relation to climate change these services influence the way one's view and also how the society reacts also affects their behavior to adapt or not.

However this theory has been criticized of its top down approach and lacks other variables that are also key in influencing adaptation. As noted by Makate *et al*. (2017) perceptions have an influence on adaptation but there are also other factors that influence these perceptions such as extension services, education among others. Perceptions on its own can influence adaptation and this study will include it as its main variable among others. Legesse and Drake (2005) also found that direct personal experience about hazards or how climate is changing and indirect knowledge derived from fellow farmers and development workers also influences farmers in decision making. According to Makokha *et al*. (1999) it also ignores the existing poor research extension linkages and weak farmers' linkages particularly in developing countries. However the strength of the theory is that it regards diffusion as a process that involves collecting information about an innovation, revising opinions from social leaders and evaluating decisions. Osbahr *et al*. (2011) point out that a perceived decline in rainfall could be because of other factors, such as higher temperatures and increased evapotranspiration. For farmers who have limited access to information and skills, less adaptive capacity or an underestimation thereof, this will likely result in fewer response options.

2.1.3 Adoption perception model (Kivlin and Fliegel 1966)

This model assumes that farmers hold specific perceptions regarding the effects of an innovation, and these personal evaluations can be significant factors in their adoption decisions. When a potential adopter is exposed to new technology, he/she will seek information about the attributes of this technology. The first step in the adopter perception model is the perception of the need to adopt due to changes in the surrounding environment. These perceptions are dependent on individual characteristics such as education, experience and the human values of the potential adopter according to Mudzonga, (2011). Sarker *et al*. (2008) describes adoption as a mental process where farmers go through stages of being aware of a new technology, forming positive or negative perception towards the technology and ultimately deciding whether or not to adopt.

Considering the above theoretical analysis one would understand the impact of perception on adaptation. The theory appropriately enables perceptions to be linked to a number of factors when studying the impact of these factors on adaptation. Makate *et al.* (2017); Madisson, (2006); Mtambanengwe *et al*. (2013) included perceptions variable measuring farmers perceptions of a problem for example climate change in their analysis, thus by being concerned primarily with the farmers perceptions regarding severity of the problem to be solved the studies take the innovations as appropriate for farmers to the changing climate whether farmers are noticing it and then adapt. While this theory focus on the perceptions on innovation. In the same vein this study focuses on the perceptions of the problem in this case climate change whether farmers perceive or not and how it influences adaptation strategies.

However this model has be criticized on the fact that unfamiliarity of a new technology makes the returns of the new innovation uncertain.

2.2 Empirical literature review

There is considerable literature on the factors that influence farmer's decisions. Due to use of different methodologies, as well as differences in areas understudy and their findings, this has left research on this area an ongoing concern. It was important to examine previous studies that have been carried out on farmers' perceptions and adaptation measures to climate change before investigating the factors that influence farmers to do so in Chipinge district.

Early studies focused on the impacts of climate change, farmer's perceptions and identified adaptation options that the farmers were using (Mtambanengwe *et al*. 2012; Mutekwa, 2009; Gwimbi, 2009; Mertz *et al.* 2009; Mano and Nhemachena, 2007). From these studies useful insights where provided on how farmers perceived climate change and the strategies being employed by these farmers however they do not explicitly show what influences the choices of the different adaptation strategies. As noted by Deressa *et al*. (2009) an understanding of the factors that influence the choice of different adaptation strategies, inform policy markers on enhancing through investing in the factors

Regional studies on climate change adaptation identified socioeconomic factors that influence smallholder farmers choice of adaptation strategies (Maddison, 2006; Kurukulasuriya and Mendelhson, 2008; Hassana and Nhemachena, 2008; Seo and Mendelson, 2008) which focused on more than eight countries Zimbabwe included. These studies pin pointed socioeconomic factors that influenced adaptation strategies such as good health, age, farm income, household size. Despite the useful insights, aggregated output and parameter estimates may not be suitable for a specific country given the heterogeneity of countries involved.

Empirical literature submitted similar results on the effect of socioeconomic and institutional factors on adaptation the likes of Deressa *et al*. (2009); Abid *et al*. (2015); Legesse, (2013), despite the differences in methodologies. Better access to markets, credit services, farm assets and technology are critical for helping farmers to adapt to climate change. However countries where aggregated into one category and hence the results may not relevant for area specific adaptation to climate change. Moreso, electricity and heavy machines where included as explanatory variables however this are not applicable in the case of Chipinge district since communal farming is neither heavily mechanized.

Acquah and Onumah, (2011) assessed farmers perceptions and adaptation to climate change to deal with challenges posed by climate change on farmers in Ghana. The probit regression indicated that the probability of willingness to pay for climate change increases with age, years of education, farm size, access to markets. These farmers perceived that there has been an increase in temperature and decrease in rainfall. The level of adaptation was found to be high among the farmers with most of them changing planting dates, soil and water conservation as the major adaptation measures. These perceptions affected the type and strategy adopted. However, lack of credit, knowledge, information, access to water where found to be the major barriers to adaptation. As opposed to Legesse *et al*. (2013), who used the Multinomial logit model, the results are the same though they used different methodologies. Also, these past researchers examined impact of socioeconomic factors only that is they had a narrower focus, thus making this broader study that also includes perceptions in determining adaptation strategies by farmers. This enables a more comprehensive understanding.

Tesso *et al*. (2012) examined the copying mechanisms done by farmers as a result of climate change induced shocks using a survey of 452 households in north *Shewa* Zone. Just like Maddison (2006), a two steps process of Heckman model was used to analyze adaptation to climate change, which initially requires farmer's perception that climate is changing and then responding to changes through adaptation. The analysis of determinants of perception to climate change revealed that a number of factors ranging from socioeconomic to natural have contributed to the increase in perception level of farmers to climate change. Awareness creation on climate change, credit availability, investment on non-farm engagement, improving good mix of livestock holding, encouraging adult education, dissemination of indigenous early warning information, diversifying crops, and improved frequencies of agricultural extension contact is made so as to ensure farmers well perceive climate change and then adapt to the changes. This also agrees with Tossou (2015) and Hadgu *et al*. (2014), these studies basically looked at factors affecting perceptions and therefore determine how they will adapt, this is against the backdrop of this study which is slightly different where the study is looking at the role of perceptions conditioned on other variables in influencing adaptation by smallholder farmers in Chipinge.

Deressa *et al*. (2010) used the Heckman model to the same data where a Multinomial model was used in the study by Deressa *et al*. (2009), to assess how farmers' adapt to changing climate in the Nile Basin of Ethiopia for mixed crop and livestock farmers during the 2004/5 production year. A household survey was conducted. Similar results to that of Hadgu *et al*. (2014) were obtained, that most farmers perceived that temperatures had increased and that precipitation had decreased. The most adaptation methods used were irrigation, water and soil conservation, changing planting dates and also in other cases no adaptation. Some of the reasons for not adapting were land shortages, lack of financial resources, information to mention a few. The levels of education, age, sex, household size of farmers' were to be significant determinants of adaptation to climate change in the study area. Contrary to Deressa *et al*. (2010), household size was found to be insignificant in influencing the farmer's decision to adapt to climate change. The Multinomial logit model used analyses a dependent variable that takes more than two values. In this study, a binary is adopted there the farmer indicates whether or not has used different adaptation strategies. The strategies adopted in this study are changing planting dates, use of different crop varieties, water conservation, livestock ownership and crop diversification, any analysis was made to see how perceptions influence the adoption of this different strategies.

Makate *et al*. (2017) the study assessed the impact of farmer perceptions regarding climate change on the use of sustainable agricultural practices as an adaptation strategy in the Chinyanja Triangle, Southern Africa. In this empirical approach it adopted methods that account for the plausibility that unmeasured characteristics exist, which are correlated with perceptions and the adoption of Sustainable Agricultural Practices. The results indicated that farmer's perceptions significantly influence the use of sustainable agricultural practices. Specifically, farmer's perceptions considerably impact the use of grain legume rotations, inorganic fertilizers, compost, and farmyard manure. In the same vein this study is similar though the adaptation strategies are different and the methodology.

Studies on the role of perceptions given other variables on different adaptation strategies have not been done in Zimbabwe. There are however a few related studies that have focused factors influencing adaptation in semi areas most in Masvingo province (Moyo *et al*. 2012; Mudzonga, 2012; Simba *et al*. 2012) leaving out high potential agricultural areas such as the eastern highlands. On the other hand a number of studies looked at the factors affecting famers perception on climate change for example education level, livestock holding and then linking it with the associated impact on the local agriculture (Debela *et al*. 2015, Moyo *et al*. 2012). The analysis followed in this study is different from other adaptation studies in that consider farmers' actual adaptation measures being taken by farmers. This study is different from others in that it tries to link perceptions and other socioeconomic and institutional factors to different adaptation strategies being adopted by the farmer.

2.3 Conceptual Framework

This framework has also been used in previous related studies (Makate et al, 2017; Negatu and Parikh 1999 and Abid, 2015). Generally, the framework of utility maximization encompasses the decision by an economic agent of whether or not to use any adaptation option. An economic agent (farmer in this case) will always seek to maximize their present value of expected benefits, from which J adaption options are available to them over a specified period. In essence, the economic agent (farmer) will always choose the option of adaptation say j given that the utility from the particular option is greater than the utility they would have got from other options. This random utility model is commonly used as a framework in determining of farmers' choice for different adaptation options based on what they perceive. We can specify a common formulation of linear random utility model as:

$$U_{ij} = \beta_j X_{ij} + \varepsilon_{ij} \qquad \text{for } j \epsilon J \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, $i = 1 \ldots\ldots\ldots..N$ are the individual farmer and

$j = 1 \ldots\ldots.J$ are the alternative adaptation methods,

X_{ij} vector is the perceptions and other factors that influence farmers' choice on adaptation method to climate change and ε_{ij} is the random error term /disturbance term.

To elaborate the model, we assume that farmers' are rational decision makers who maximize the utility from adaptation strategies in their farming activities.

2.3.1 Justification of the theoretical model

Five main adaptation strategies have been selected from both literature and theoretical review are more essential for farmers in Chipinge to mitigate or are expected to adopt to curb the effects of climate change. The adaptation strategies are crop diversification, crop varieties, water harvesting, early and late planting dates, livestock ownership. Our main focus is on perceptions and analysis will be done to see its influence on each adaptation strategy. Since the different strategies of adaptation are binary that it can assume only two values, which for convenience and without loss of generality, we denote by 0 and 1 the Logit model is opted for.

The logit and probit models are superior to the linear probability model (LPM) in that while estimates in the LPM are unbiased, the standard errors are usually biased and the probabilities lie outside the conventional 0 and 1 range. Ordinary least square method cannot be used in such studies as it ignores the discreteness of the dependent variable. In this study the logit model was selected because of its simplicity over the probit model but still meeting the objective of the study. The data was be analyzed using the STATA 10 statistical package. A logit model analyses the relationship between a binary dependent variable and a set of independent variables. Several studies have used this method to study farmers adaptation to climate change (Seo and Mendelsohn, 2006; Apata *et al*, 2009 and Fosu- Mensah *et al, (*2010).

2.3. 2 Logit model

The logit model uses a logistic cumulative distribution function to estimate probabilities as shown in equations (1) and (2). The logit function is presented as follows:

$$P = \frac{e^{\beta' X}}{1 + e^{\beta' X}} \dots\dots\dots\dots\dots (1)$$

$$1 - P = 1 - \frac{e^{\beta' X}}{1 + e^{\beta' X}} = \frac{1}{1 + e^{\beta' X}} \dots\dots\dots\dots\dots\dots (2)$$

Where, P is the probability of adapting any strategy given a vector of explanatory variables, X_i
e denotes the base of natural logarithms, which is approximately equal to 2.718
X_i represents the i^{th} independent variables and
β_i represents the vector of parameters to be estimated

The logistic regression model is used to examine the relationship (odds ratios) between the dependent variable and a set of pre-selected independent variables. The ideal and standard procedure of estimating a logit model is Maximum Likelihood Estimation (MLE) technique. Due to the fact that the logit model is non-linear, it uses maximum likelihood estimation method to obtain the logit parameters. The maximum likelihood function will exhibit normality, consistency and asymptotic functions if the model is correctly specified.

2.4 Conclusion

Both theoretical and empirical models show that adaptation is determined by education of the household head, age of the household head, household size, and access to extension services, access to credit, wealth, farm size, soil fertility and climate change variables. Theory says that all these positively influence the farmer's decision to adapt. However, there have been some mixed results in empirical literature particularly on variables such as household size, farm size and high annual average precipitation. Different methodologies and data sources have been used to analyze the factors that influence farmers' adaptation to climate change. Empirical literature is necessary to compare results of previous studies on the factors that influence the farmer's decision to adapt to climate change with those from the current study.

CHAPTER THREE

RESEARCH METHODOLOGY

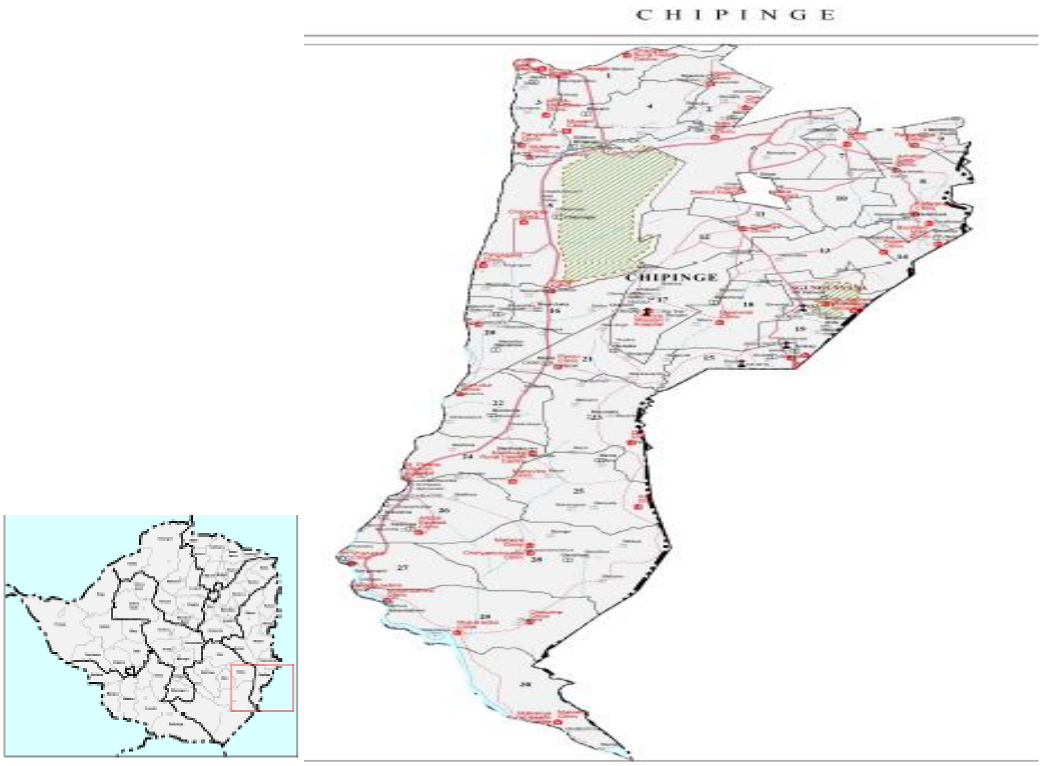
3.0 Introduction

This chapter seeks to model the relationship between perceptions and adaptation in Chipinge district. It highlights and justifies the approaches and techniques used to collect primary data for model estimation. The chapter presents the empirical model, definition and justification of variables and data sources. It gives the full description on how the study was carried out, methods and techniques, logic behind methods and their justifications.

3.1 Study Area

Chipinge is a district located at the southeastern Zimbabwe at an elevation of 3,635 feet (1,108 m) above sea level. The total population is estimated around 298 841 (ZIMSTAT, 2012). Chipinge falls under region one (1) according to agro ecological zones. Rainfall ranges from 500-1000mm and annual temperatures 15-18C (GoZ, 2014). The region is characterized by seasonal droughts, dry spell, floods, earthquake to mention a few. Main crops cultivated are coffee, tea, potatoes, macadamia nuts, maize, since these are high value crops and would translate to more income. Other activities include dairy cattle.

Figure 3: Chipinge map



Source: *Office for the Coordination of Humanitarian Affairs (OCHA) 2010*

3.2 Empirical specification of the model

To relate farmer's perceptions of climate change to the use of different adaptation strategies in farming a model was borrowed from theory as well as from Makate *et al*. (2017), Abid *et al*. (2015) and Deressa *et al*. (2009).

$$adaptation_i = \beta_0 + \beta_1 percep_i + \beta_2 X_i + \varepsilon_i$$

Where:

$\boldsymbol{Adaptation_i}$ is a binary variable of 1 if the farmer i adopts a certain strategy and 0 otherwise. The strategies include early and late planting dates, different crop variety, crop diversification, water conservation, livestock ownership.

$\boldsymbol{Percep_i}$ measures the respondent's perceptions on climate change a general question was asked, if they think climate has changed over time? (1 = yes; 0 = no). So this question[2] was used to measure the general perception of the respondent when considering climate change. A follow

[2] See questionnaire

up question was asked on the perceived trends of temperature and rainfall in the past two decades. The most cited events are temperature increase and rainfall decrease.

$\boldsymbol{X_i}$ is a vector of observed characteristics believed to influence a farmer's adoption decision

Educational level of the household head (***educ)***,

Household labour ***(hhlb)***,

Non-farm income ***(nfinc)***,

Access to credit ***(cred)***,

Access to climate change information (***climinfo)***,

Farm size ***(fsize)***,

and the household head's farming experience ***(fexper)***,

ε_i is the error term, which has a standard logistic distribution

3.3 Definition and Justification of Variables

Dependent variables (adaptation variables)

Early and late planting dates:

This means that farmers would change the date of planting crops with respect to the change in the climate (early or late planting) that survive in adverse climatic conditions. It was usually known that farmers should start planting around October to early November but as time goes by one should wait for the rains to start planting. Therefore, it is captured as 1 if the farmer has delayed or planted early than the usual and 0 if farmer was using the traditional timing.

Different crop variety:

It is a new type of crop adjusted to suit a specific location given the climatic conditions. This includes planting of short duration crop, drought tolerant crop or a crop that requires more water. The forecasted declines in the produce or output of stable crops indicate that changes in climate will have adverse impacts on the ability to grow the food required, and these impacts will be particularly severe in Chipinge. In this regard, there is need for new varieties which would withstand the challenges posed by the change in climate. Therefore crop varieties that can cope with heat, drought, flood and other extremes may well be the single most important step we can take to adapt to climate change. Varieties that are resistant to pests and diseases reduce the need for application of pesticides that are harmful. Thus vigorous varieties complete with weeds and thereby reducing the need for applying herbicides which are also expensive. Drought resistant plants also save water given that irrigation will not be necessary, deeper rooting varieties can help stabilize soils and are efficient in their use of nutrients given they require less fertilizer. In this case there has been new maize varieties from different manufactures which suits the change in climate in this case SC 403 by Seed Co, 30 G19 by pioneer, ZAP 61 by Agriseeds were considered. This were the new varieties which were modified to suit the current climatic situation in Chipinge so any farmer has adapted any one of the new breeds takes 1 and 0 otherwise.

Crop diversification:

This is where a farmer plants more than one crop to spread risk in this case drought tolerant crops such as millet and sorghum, alongside the usual crop maize. This had considerable advantages. Among other things it was a method of insurance the farmer who grows a single crop runs the risk that conditions in a particular year might not be appropriate for it. The weather may not be right or his crop might be subject to pest infestations. This means that the more different crops the farmer grows, the lower must be the risk, since at least some of his crops are likely to tolerate the weather conditions. Growing maize alongside sorghum is the common practice where maize requires more water as compared to sorghum. So if a farmer practices this system to spread risk is coded as 1 and 0 otherwise.

Water conservation:

These are methods used to safeguard the water as the climate become more unpredictable so as to protect the crop. This study will consider water harvesting where by the farmer place big tanks and collect water from the roof and use it when low rainfall is experienced or infiltration pits[3] to

[3] Filter Pits handle large volumes of rainwater

store water. This is also a binary dependent where 1 if the farmer was involved in water harvesting and zero otherwise.

Livestock ownership

This is a binary variable if the farmers own any livestock taking 1 or 0 otherwise. As the climate changes in terms a securing income one adapts livestock in case the crop fails. This acts as mitigation against the adverse effects of climate change and also as a source of livelihood.

Independent variables

The study focuses on three variables to measure farmer's perceptions on climate change among other variables. General question was asked, to see how the farmer feel about climate change (whether they notice a change or not). This question was used to measure the general perception of the farmer when considering climate change. A follow up question, more specific on the changes in climatic variables[4]was then asked. The two most common events cited where temperature increase and rainfall decrease.

Climate change perceptions

Perceptions have been described as a range of beliefs, judgments and attitude (Slegers, 2008). Farmers can be influenced by peers perceptions and values within their community in terms of climate change (Maddison, 2006). Maddison (2006) found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making. Several studies have found that farmers' perceptions of climate change problems positively and significantly affected their decisions to adopt (Seo and Mendelsohn, 2006; Apata *et al*., 2009 Fosu- Mensah *et al.,* 2010; Makate *et al*., 2017). We expect that farmers who notice and are aware of changes in climate would take up adaptation measures that help them reduce losses or take advantage of the opportunities associated with these changes. Therefore if the farmer perceives a change in climate takes the value of 1 and 0 otherwise.

Temperature perceptions

[4] In this case temperature and rainfall

These are perceptions towards the trend of temperature over the past 20 years, how have the farmers perceived it. It is a dummy variable measured as increase or otherwise. It is expected that as it gets hotter, the farmer is likely to opt for livestock and conserve water (Deressa *et al*. 2009; Nhemhachena and Hassana, 2008) among other strategies available.

Rainfall perceptions

This is in relates to how farmers have perceived the changes in rainfall trend over the past 20 years. Studies show that there is a positive relationship with decrease in rainfall and most adaptation strategies including the one adopted in this study. Results from the rainfall perceptions enable us to see the extent to which these perceptions affect adaptation behavior. This variable is a dummy measured as decreased or otherwise (change in times of raining, Increase in frequency of drought, I don’t know).

Level of education of the household head *(edu)*

This is the level of formal education one has researched, and it’s a dummy the expected sign is positive. As the number of education of the household head increase the farmers’ proximity for new information and the probability of accepting new technology also increase (Abid *et al*. 2015; Deressa *et al*. 2009). Empirically, education has been proven to be related to early adopters and to greater productivity of improved varieties. Maddison (2006) argues that education diminishes the probability that no adaptation is taken.

Farming experience *(exper)*

Farming experience is the total number of years the household head has spent doing farming decisions and the variable is continuous. The more experienced the farmer is, the more he/she is better informed about temperature and precipitation changes in Chipinge and the more he/she is likely to employ adaptation measures that reduce the impact of climate change on agricultural activities. Hassan and Nhemachena (2008) contents that it is farming experience that matters more than merely the age of the farmer when it comes to adaptation to climate change. Studies by Maddison (2006) and Hassan and Nhemachena (2007) indicate that more farming experience increases the probability of a farmer adapting to climate change.

Household labour (*hhlb*)

Household labour is the total number of household members who provide labor in the fields. The larger the number the more easily it becomes to adopt. In this study we assume those that lie between the ages of 15-65 are available for work. This variable is included in this study to ascertain if it influences the probability of a farmer to adapt to climate change in Chipinge district.

Off farm income (*offarm*)

This is the income that a household obtains from outside of farming venture the expected sign is positive. For example, remittance, piece jobs, vending, and earnings from formal jobs are among others. Such income makes the farmers not to follow up or motives properly to agriculture. Responses to climate change through adaptation require sufficient financial wellbeing (Deressa *et al*, 2009). In support to this argument, CIMMYT (1993) notes that higher income farmers may be less risk averse and have more access to information and longer planning horizons. The effect is to boost the farmer's financial resources and hence his/her ability to adopt new and better technologies. However employment somewhere else can be a constraint to adaptation because it tends to compete with farming activities and time (Deressa *et al*. 2010). Non-farm income variable is continuous and measured in United States dollars in a year.

Access to credit service (*credit*)

This refers to the accessibility of credit (for example loans) by the farmer in order to make adaptation strategies. Credit is key to the farmers to introduce new technology, to buy modernize crop, fertilizers and oxen. Access to credit easies the financial constraints faced by the farmer in adaptation to climate change. This is also supported by Gbetibouo, (2009) indicating that credit plays a role in influencing adaptation. The expected sign is positive and this is a dummy variable coded 1 if the farmer has access to credit and zero otherwise.

Access to climate information (*climinfor*)

This is a formal service and plays a great role in educating and informing farmers on climatic issues. Access to information and extension services is postulated to be positively related to adaptation since farmers are being exposed to new information. Thus it increase the likelihood of adaptation based on the innovation diffusion model (Adesina and Forson, 1995). This variable is a dummy which represent 1 if farmers have access to climatic information 0 otherwise and the expecting sign was a positive. Hassan and Nhemachena (2007) found that access to information about climate change forecasting, adaptation options and other agriculture activities remain important factors determining use of various adaptation strategies.

Farm size

Farm size is the total landholding of the farm the household uses for the farming activities. This variable is measured in hectares. Farm size determines the land allocation of the crop varieties. The bigger the size of the farm, the greater the proportion of land allocated for crop varieties the adaptation strategies that the farmer is likely to adopt (Abid *et al.* 2015). The bigger the farm size, the more likely the farmer is to adopt suitable strategies. The expected sign is positive and the variable will be continuous recording the number of hectares of the farm.

3.4 Sampling

According to Bogdan and Biklen (2003) sampling is when a number of individuals selected from a population for a certain study, in such a way that they represent the population of study. The targeted population from which a sample was drawn is from all the smallholder farmers in Chipinge ward 6 from the period 2015-2016. To identify the role of perceptions given other factors in affecting adaptation strategies among the rural farmers, purposive sampling also known as judgmental selective was used. According to Kothari (2004) deliberate sampling is a purposive or non-probability sampling which involves deliberate selection of the units of the universe for constituting a sample. The researcher chose the sample based on who they think would be appropriate for the study. Purposive sampling starts with a purpose in mind and the sample is thus selected to include people of interest and exclude those who do not suit the purpose.

3.5 Data Type and Sources

Primary data was collected from smallholder farmers in Chipinge. The focus was to estimate the relationship between farmer's perceptions of climate change and adaptation. The data was collected by means of self-administered questionnaires[5]. The survey was conducted between March and April in 2017 and 100 farmers were interviewed irrespective of gender, farm size or tenancy status through a farm household survey. Interviews were conducted for the crop year 2015–16. A fully structured questionnaire was used to gather information on institutional, socioeconomic characteristics, any knowledge of climate change with the adaptation that was done and any limitations to adaptation. A pretesting was done to avoid any missing information on the questionnaire. Training was done for the enumerators on the objectives of the study and farm household survey

3.6 Model Estimation Procedures

3.6.1 Model Specification test

This is a test for appropriateness of the functional form of the model, omitted variables, irrelevant variable and measurement error. If the model is mis-specified, then it will be biased and inconsistent. This study uses Ramsey RESET test to detect misspecification, if any. This would be done before interpretation of individual coefficients. For individual coefficient significance test of independent variables, we make use of the p-values. P-value is the least probability value at which the null hypothesis can be rejected.

3.6.2 Multicollinearity test

This is a test for correlation between explanatory variables, that is, to check if they are not highly correlated. This study uses the pair wise correlation matrix approach to test for multicollinearity. Using the pair wise correlation matrix, the absolute correlation coefficient between two independent variables should not exceed 0.8, otherwise multicollinearity would be a serious problem (Gujarati, 2004). In the case of such multicollinearity, one of the highly correlated variables should be dropped.

3.7 Conclusion

This chapter has described the empirical strategy to be used in analyzing the impact of perceptions given other variables on the adaptation to climate change by the smallholder farmers.

[5] See appendix 1

Thus, in the next chapter, methodological procedures outlined in this chapter will be carried out to generate estimated results for economic interpretation and discussion.

CHAPTER FOUR

ESTIMATION, PRESENTATION AND INTERPRETATION OF RESULTS

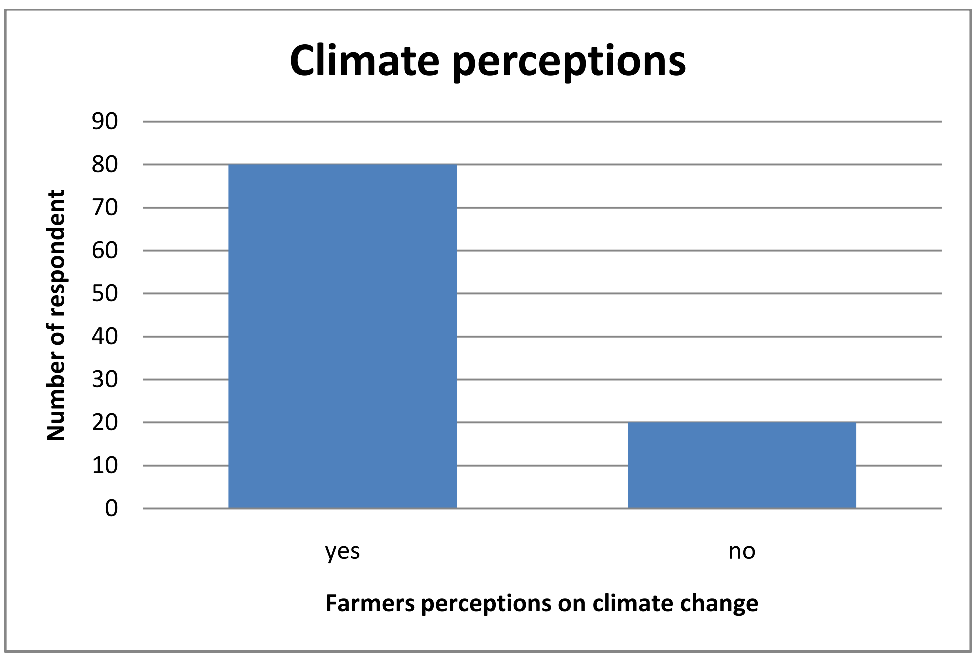
4.0 Introduction

This chapter estimates the empirical model presented in the previous chapter, and also interprets the estimated results. In answering the research question posed in chapter one, a binary logit model is used. In this vein, descriptive statistics, model diagnostic tests and regression results would be presented.

4.1 Descriptive statistics

The sample showed that, about 80% of farmers perceived that the climate had changed in the past decades; about 85% believed that temperatures in the area had increased, while about 71% believed that rainfall had decreased. The adaptation strategies 51% of the sampled farmers were practicing water conservation, 53% were using a new variety, 78% owned some livestock, and 72% were changing planting dates, while 53% were diversifying their crops.

Figure 4: Farmers perceptions of climate change



The majority of farmers (80%) perceived a change in climate while the remaining perceived no change at all.

Figure 5: Farmers perceptions of changes in temperature

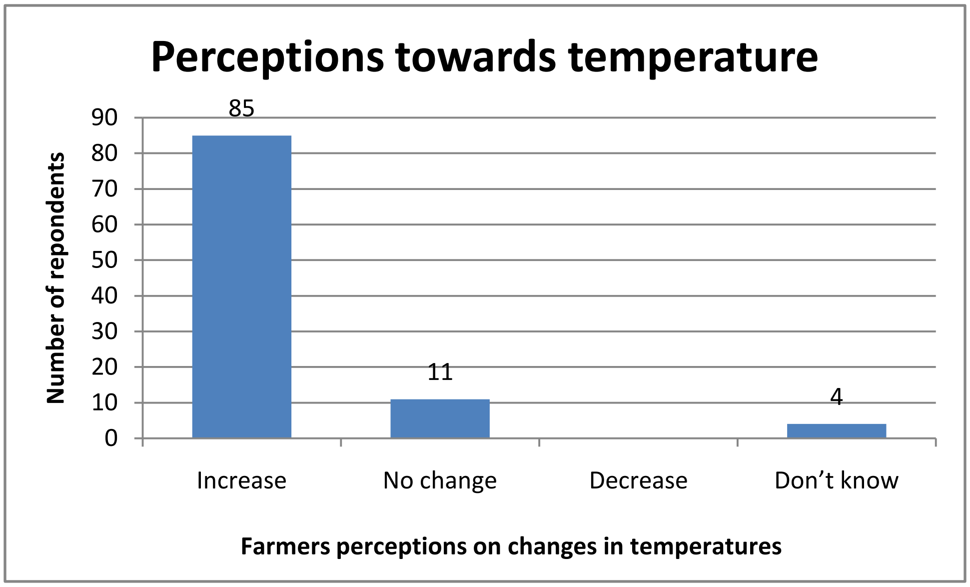
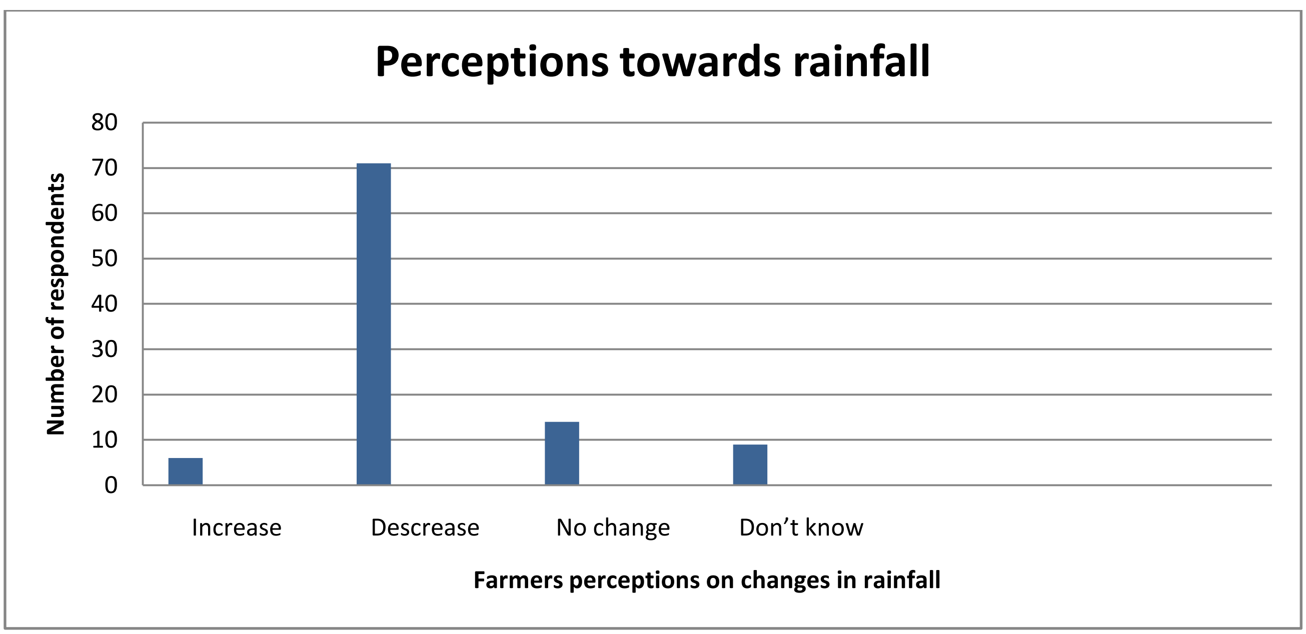


Figure 5 shows that more than half (85%) of farmers indicated that there was an increase in temperature in both the rainy season and the dry season while 11% notice no change at all in temperature the reminder no clue to what is happening.

Figure 6: Farmers perceptions of changes in rainfall



Some farmers felt that the cropping period had shortened and 71% reported a decrease in rainfall patterns. Most of the farmers indicated that one of the characteristics of the change in the rainy season was the late onset and an early thus explaining the shortening of the rainy season and increase in drought frequency.

Table 2, presents the variable measurement and summary statistics for the variables used in our analysis.

Table 2: Statistics Summary

Variable	Obs	Mean	Std. Dev.	Min	Max
No education	100	.97	.7447459	0	2
Primary education	100	.45	.5	0	1
Secondary education	100	.26	.440844	0	1
Household labour	100	4.28	2.327178	1	11
Farming experience	100	7.18	5.621711	2	30
Nonfarm income	100	1585	1178.029	0	4000
Farm size	100	4.68	2.970835	1	13
Access to climatic information	100	.62	.4878317	0	1
Credit	100	.34	.4760952	0	1
perceptions on Climate change	100	.8	.4020151	0	1
Perceptions on rainfall decrease	100	.71	.456048	0	1
Perceptions on temperature increase	100	.85	.3588703	0	1
Water harvesting	100	.51	.5024184	0	1
Crop diversification	100	.53	.5016136	0	1
Early and late planting dates	100	.72	.4512609	0	1
Livestock	100	.78	.4163332	0	1

ownership					
Crop varieties	100	.53	.5016136	0	1

Table 1 show that most smallholder farmers have attained level one of education which is the primary level. On average, each household had at least four members which were fit and able to provide labor in the fields, at the time of the survey. The number of years of farming experience was on average 7 within the sample. The mean non farm income was $1600 and the mean farm size was 5 hectares. Regarding access to information, our descriptive statistics reveal that 62% of the farmers had access and on average, only 34% could access credit.

4.2 Normality Test

For testing normality Shapiro Wilk test was used. When p value is less than 0.05 we may reject the null hypothesis that residuals are normally distributed. Crop diversification, crop variety, water harvesting, early and late planting dates were found to be normally distributed on the dependent variables while livestock ownership wasn't. The other side of independent variables educational level, access to climatic information, access to credit and perceptions on rainfall were found to be normally distributed while the rest which were labour, farming experience, nonfarm income, farm size, climate perceptions and perceptions on temperature were not normally distributed (see appendix B).

4.3 Multicollinearity check

Multicollinearity implies the existence of a linear relationship between two or more explanatory variables. Multicollinearity makes it difficult to differentiate the individual effects of the explanatory variables and regression estimators may be biased in that they tend to have large variances (Greene, 2000). Pearson correlation matrix show that correlation coefficients are less than 0.8, the limit or cut off correlation percentage commonly suggested by prior studies after which multicollinearity is likely to exist (see Gujarati, 2003). Appendix C shows those relationships.

A Pearson's correlation test was carried out for all the variables. According to the test, variables are correlated if the statistic for the test is more than 0.8 or less than -0.8. The results of the test showed that there was low correlation among explanatory variables. From the pairwise correlation matrix there is a positive correlation between water harvesting and household labor, farming experience, nonfarm income, farm size, access to credit, perceptions on climate change and perceptions on rainfall However negative correlation was found on education, access to climatic information and perceptions on temperature changes. Crop diversification was positively correlated with all independent variables.

Furthermore early and late planting dates was only negatively correlated to access to climatic information while positively related to all other independent variables. However livestock ownership was positively correlated to household labor size, farm size, access to credit, perceptions on temperature change, perceptions on climate change and perceptions on rainfall while negatively correlated with the rest of the variables. Crop varieties were negatively correlated with education, nonfarm income, farm size climate change perceptions while positively correlated with other independent variables. There is no problem of multicollinearity on all variables of the five models since the absolute values of the pairwise coefficient are all less than 0.8 (see appendix C).

4.4 Goodness of fit test

Hosmer-Lemeshow goodness of fit test was used to test for the overall goodness of fit of the model. The overall goodness of fit of the model is reflected by non-significant p-values. The models estimated sowed 0.0911, 0.6340, 0.4395, 0.6210 and 0.4240 as the p-values of water harvesting, early and late planting dates, crop diversification, livestock ownership and crop varieties (see appendix D).

4.5 Econometric Results

Table 3: Regression Results

Variables	**Early and late planting dates**	**Livestock owned**	**Crop varieties**	**Crop diversification**	**Water harvesting**
Level of education No education		Reference category			
Primary education	1.215	35.49**	0.456	1.246	0.804
	(0.850)	(49.18)	(0.257)	(0.751)	(0.513)
Secondary education	1.190	0.389	0.332*	3.134	0.521

	(0.971)	(0.434)	(0.216)	(2.223)	(0.414)
Household labour	1.308	0.924	1.144	1.314*	0.913
	(0.221)	(0.178)	(0.135)	(0.183)	(0.126)
Farming experience	0.972	1.195*	1.010	1.065	1.178**
	(0.0581)	(0.126)	(0.0499)	(0.0603)	(0.0840)
Nonfarm income	1.000	0.999***	1.000	1.000	1.000
	(0.00028 3)	(0.000549)	(0.000231)	(0.000245)	(0.000260)
Farm size	1.052	1.539**	0.898	1.049	1.014
	(0.123)	(0.293)	(0.0762)	(0.101)	(0.0983)
Access to climate info	0.690	5.674*	1.495	1.167	1.387
	(0.421)	(5.331)	(0.716)	(0.606)	(0.753)
Credit	2.202	0.148*	2.254	2.657*	18.96***
	(1.482)	(0.169)	(1.148)	(1.485)	(13.11)

*** p<0.01, ** p<0.05, * p<0.1

Level of education

Smallholder farmers in Chipinge have 35.49 times odds of adapting using livestock as a strategy to curb the effects of climate change than those with no education. On the other hand secondary education is inversely related to crop varieties. The higher the level of education reduces the odds of using a different crop variety by 0.332 times. This is inconsistent with the results observed by Abid *et al*. 2015; Deressa *et al*. 2009 which suggests that as one has higher levels is likely to adapt. In this case the reason might be that most of the educated might be laggards in that they might wait until they are sure that this new variety really works. Maddison (2006) argues that education diminishes the probability that no adaptation is taken.

Household labour

For most of the adaptation methods, increasing household labour did not significantly increase the likelihood of adaptation, expect for crop diversification. The results show a positive relationship between household labour and diversification which imply that as the labour increase it increase the odds of diversification by 1.314 times. So as the family labour increase they are more likely to plant more than one crop as they will be division of labour and avoids boredom. Findings of the study by Deressa *et al*. (2009) also support our findings of a positive relationship between household labour and adaptation to climate change.

Nonfarm income

In addition nonfarm income also significantly decreases the likelihood of livestock ownership as an adaptation options. A dollar increase in nonfarm income decreases the odds of livestock ownership. Farmers may prefer other means of storing income of other properties, or start other form of businesses outside farming activities.

Access to climate information

As expected the odds of adapting to livestock on a more informed side is 5, 674 times higher than those with no access to climatic information. Operating on a more informed side gives a higher chance of mixing crops and livestock so that if crops fail at least there is an alternative to rely on. Although there is a positive relationship with other variable and not significant it can be inferred that the more information you get the better the chance of adapting to climate change. This confirms with the postulations of induced innovation theory and studies by Abid *et al*. (2015); Deressa *et al*. (2009); Mudzonga, (2012).

Access to credit

Table 3 indicates that the coefficient of credit has a positive and significant impact on the likelihood of using crop diversification and water harvesting with odds 2.657, 18.96 times respectively. This could be an implication of the importance of a substantial institutional support in promoting adaptation options usage in order to alleviate the negative impact of the change in climate. This is inconsistent with the findings by Gbetibouo (2009), Mensah *et al.* (2010) and Deressa *et al*. (2009) which indicate that adaptation to climate change is significantly influenced by credit. However as credit increase it decrease the odds owning livestock by 0.148times.

Farm size

The farm size was found to have a positive relationship with livestock ownership again. Therefore as the farm size increase by one hectare it increases the odds ratio of owning livestock to mitigate climate change by 1,539 times. Comparing to one owning a small piece of land it might be difficult to balance the two which is keep animal and crop since there are higher chances of getting your crop destroyed.

Farming experience

Farming experience of the farmer has a positive and a significant effect on livestock owned and water harvesting. The smallholder farmers of Chipinge have 1,195 and 1,178 times odds of adapting using livestock and water harvesting respectively. A one year increase in experience of a respondent will lead to a 9, 5 % increase in adapting livestock and 1.78% in adapting to water harvesting. Thus, as one gets more experience in the farming and climate exposure the more likely they want to adapt livestock. Consistent with the findings are the results by Maddison (2006) and Nhemachena and Hassan (2007). Their studies found a positive association between farming experience and climate change adaptation. It can thus be concluded that, farmers with more farming experience are likely to have knowledge of past climatic events and in a better position to ascertain how best to adapt their farming to curb for extreme weather events.

Table 4: The impact of climate change perceptions on the adaptation strategies

Variables	**Early and late planting dates**	**Livestock owned**	**Crop varieties**	**Crop diversificatio n**	**Water conservation**
Perceptions on Climate change	9.464***	1,241***	0.753	0.937	11.33***
	(6.375)	(2,140)	(0.433)	(0.611)	(10.29)
Perceptions on rainfall decrease	4.181**	9.719**	3.125**	6.282***	2.778*
	(2.531)	(9.554)	(1.587)	(3.701)	(1.706)
Perceptions temperature increase	4.992*	12.73*	4.507**	3.870*	0.283*
	(3.687)	(16.54)	(3.185)	(3.028)	(0.215)
Observations	100	100	100	100	100

Standard Errors in parentheses. *** p<0.01, **p<0.05,*p<0.1

Moving on to focus on the main variable which is perceptions on its impact on adapting, the results are shown table 4. Our results indicate that farmers' perceptions on climate change have a significant influence on the use of adaptation strategies at the farm level. Moreover, different perceptions on changing climate variables, such as temperature and rainfall, can also have different effects on the use of individual strategy and the overall level of adaptation strategies used at a farm level.

Perceptions on climate change were found to have a significant effect on staggering planting dates, livestock ownership and water harvesting. Precisely, the odds of adapting through staggering planting dates, livestock ownership and water harvesting increased by 9.464; 1.241 and 11, 33 times as one perceive that the climate is changing. This finding is possibly explained by the fact that, when farmers perceive climatic changes, they anticipate poor yields in the future, and hence, they may try to boost their current production by water harvesting, altering planting dates thus productivity is improved. However perceptions on temperature increase were found to have similar effects as perceptions on rainfall decrease although temperature has an adverse effect on water harvesting. From the regression results perceptions on rainfall decrease, increased the odds of using staggering planting dates by 4.181 times, livestock ownership by 9.719 times, crop varieties by 3.125, crop diversification by 6.282 and water harvesting by 2.778 times.

However, when they anticipate rainfall decrease, they may be encouraged to practice water harvesting, crop diversification, trying new varieties and livestock ownership. With water harvesting crops may survive from lack of water since there is stored water in the tanks or pits which can be used to water crops this can improve crops, and hence, its benefits to farming. When farmers perceive decline in rainfall, they expect poor yields in the future, and hence, they may try to boost their current production by using new existing crop varieties, diversification of crops to guard against future adverse impacts from climate change. Farmers might also shift them planting date as they notice that climate is changing. To avoid rotting of crops or premature harvesting on has to notice the shifts in the rains and temperature. The findings are consistent with results by Cooper *et al*. (2008), Simelton *et al.* (2013) and Deressa *et al.* (2010). It is important to note that the relationship between farmers' climate perceptions and the response undertaken by farmers in their farming activities is not always a simple one (Bryant, 2000).

Moreover, perceptions on temperature increase showed the odds of adapting through staggering planting dates by 4.992 times, livestock ownership by 12.73 times, crop varieties by 4.507, crop diversification by 3.870 increase as the farmer notices changes in temperature however this is not so with water harvesting where the odds decrease by 0.283 as one perceive increase in temperature, this is unusual. While climate perceptions and perceptions on decrease in rainfall had a positive relationship whereas with perceptions on temperature was negative this could be that they will be no rainfall or little to actually store for meaningful watering. This finding could imply that, as temperatures rise, farmers anticipate a high aridity, which may result in water shortages for their rain fed crops by this, smallholder farmers may be discouraged to practice usual maize farming, as they may prioritize cereal production and other drought tolerant crops such as millet in each season, so they might try diversification of crops and also trying other maize varieties that are more heat tolerant, early maturity or any that suit the current climate variability. This finding is likely a result of the point that, when farmers perceive the possibility of extreme events, such as temperature increases, which threaten their crop production, they respond by seeking some form of insurance to diversify their livelihoods through keeping livestock units at the farm. In the case of total crop failure, they can resort to livestock sales (especially small livestock) for income.

The relationship between a farmer's climate change perceptions and adaptation options can even be further complicated, since perceptions regarding rainfall patterns do change over time. For example, the perceptions on rainfall can be driven by perceived changes in other climatic variables, such as temperature or precipitation Osbahr *et al.* (2011). This observation suggests that farmers with a low adaptive capacity, limited information, and skills to perceive changes accurately, may respond less (i.e., no significant change in their use of adaptation strategies) when compared to more informed farmers. Since farmer perceptions and adaptation responses are not linear and obvious, our results can be interpreted as associations applicable to the sample of farmers in Chipinge, and thus, may not be generalizable to other contexts or regions.

4.6 Conclusion

The chapter gave the estimation, presentation and analysis of results. The study found that general climate perceptions, temperature perceptions and rainfall perception given other variables were statistically significant in explaining the adaptation strategies. Perceptions on climate change were found to have a significant effect on the use of early and late planting dates, water conservation, and ownership of livestock units. Perceptions on temperature increase were found to have effects on all other strategies similarly this also applies to perceptions on rainfall.

The proceeding Chapter will present summary and conclusion of the findings from the study, policy implications and recommendations.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.0 Introduction

This chapter presents summary of the study results on the role of farmer's perceptions in Chipinge and their influence on different adaptation strategies. The chapter also provides policy implications and recommendations derived from the findings. The chapter is concluded by enlightening some areas which future research effort might need to be focused on as far as the theme of this research is concerned.

5.1. Summary of the main findings of the study

Climate change is a reality which is expected to have significant impact on the livelihood of Chipinge smallholder farmers. This study analyzed the linkages between smallholder farmers' perceptions and climate adaptations, using representative data gathered from Chipinge district, in Zimbabwe. Results showed some essential linkages between farmers' perceptions regarding climate change and the adaptation strategies. Perceptions on climate change had only a significant positive effect on early and late planting dates, livestock ownership and water harvesting. While perceptions on both temperature increase and rainfall decrease where found to be significant on all dependent variables. The results show that, when farmers perceive events, such as temperature increases and rainfall decrease, which threaten their crop production, they respond by seeking some form of insurance to diversify their livelihoods through keeping livestock units at the farm and diversifying crops. In the case of total crop failure, they can resort to livestock sales for income or the other crop that survived. The findings also suggest that if farmers perceive climatic changes, they foresee poor yields in the future, and hence, they may try to boost their current production by using improved maize varieties. Thus, we conclude that farmer perceptions ceteris paribus have an impact on the use of adaptation strategies at the farm level. Smallholder farmers in Chipinge are experiencing climate change (rainfall and temperature changes) and responding to these changes through alterations in their strategies. From the results, it is also found that education influence the adaptation of livestock units but negatively influences crop varieties, labour on the other hand influence crop diversification. Farming experience influence livestock ownership and water harvesting while non farm income influence livestock negative and farm size and access to climatic information influences it positively. Credit encourages water harvesting and crop diversification while it discourages livestock ownership.

5.2. Policy implications

These findings on farmer perceptions are very useful for policy makers, development partners, researchers and other stakeholders concerned with the area of climate change. Therefore understanding climate change perceptions and how it links with the use of different adaptation strategies are key for policy, targeting to shape adaptation options of smallholder farmers. With a clear understanding of the perceptions being held by smallholder farmers can improve the promotion of these strategies. If farmers perceive significant variations in the climate it will lead them to find ways of guarding against the unpleasant effects of climate.

The results imply that all concerned parties have to first understand and match farmers perceptions with the scientific evidence, failure to match the two can undermine the effectiveness of interventions. On the other hand livelihood can be enhanced through improved crop management, the viability providing climate related information and training farmers on aspects like onset of rains is critical so that farmer's adaptive capacity is improved. It has been noticed that the extension officers are selective at times in areas that are remote they won't bother go there and this farmers are left out and are less informed on what to do. There is need for support from local institution like agritex should focus on reaching every farmer on the new or existing crop varieties, on how the climate is changing, drought resistant and early maturing varieties that have improved chances of surviving and encouraging laggards to make hay while the sun still shines.

Policies should also try addressing barriers for adaptation at farm level such as finance, more credit from institutions,

5.3. Limitations of the study and suggestions for further research

This paper is not without its limitations. There is a possibility that these estimates might be influenced by endogeneity bias associated with the perceptions variables. Endogeneity may arise because of unobserved characteristics that might compel farmers to perceive in a certain way while also influencing adaptation of a certain strategy. The study was limited to Chipinge and as such it is limited in applying to other regions. Therefore, the succeeding researchers are encouraged to carry out a typical research on the whole of Zimbabwe and other region in order to have a more comprehensive understanding on climate related issues. More so, succeeding researchers may consider the use of other research methodologies like the probit and also the use of another functional form such as the log-log or log-linear. For by using different methods of analysis, different results can be obtained and more accurate estimates that cater for endogeneity. There is also room to include other variables which capture perceptions at the same time affecting farmers like soil fertility.

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APPENDICES

Appendix A: Questionnaire

My name is Fortunate Sithole. I am writing a dissertation entitled "smallholder farmers' perception and adaptation to climate change the case of Chipinge district" in partial fulfillment for MSc in Economics. The objective of this study is to identify the role of perceptions in adaptation decisions to climate change. This research has a significant contribution in an effort to reduce the climate change relate problems of the farmers in Chipinge. Therefore, your valid contribution by giving accurate information is highly valuable in achieving the objective of this research. The information we will collect from you will serve only the academic purpose and it will be kept confidential. Thus, please feel free to convey the required information honestly.

Thank you in advanced for your cooperation.

General Directions

Put (**x**) marks in space provided for closed-ended questions and write your response on space provided for open ended questions.

A) Household Survey

I. General information

1. Household number…………….

II. Demographic and socio-economic characteristics

2. Gender of the head of household: 0. Male (…) 1. Female (...)

3. Age of the head of household:………..

4. Marital Status: 0.Single (…) 1.Married (…) 2. Divorced (…) 3.widowed (…)

5. Educational level: 0. None (…) 1. primary education (…) 2. Secondary School, 3. Graduate/tertiary education (…)

6. Household size _______

a), below 15 years of age (children)?___________.
b), above 15 and below 65 years of age (adult)? ___________.
c), above 65 years of age(old)?_________

7.Farm experience of household head (in years)----------------------

8. What is your source of livelihood: 0. Cattle rearing 1. Crop production 2. Mixed 3. Other (specify)---------

9. Do you have any form of non-farm income (income from remittance, petty trade, formal employment or private enterprise)? 0. Yes(…) 1.No (…)

10. If yes to question (10), how much money did you make during last production year from off-farm activity? Please specify in US dollars: ....

11. How much area in ha is the cultivated area:__________.

12.What was your total output (number of bag/tones)…………………………

III, Institutional factor

13. Do you have agricultural extension services in your area (number of visits/conduct) 0.Yes (…) 1. No (…)

14. Do you have access to climatic information? 0. Yes (…) 1. No (…)

If your answer is yes, which medium do you posses? 0. Radio (…) 1. TV (…) 2.journal/newspaper (…) 3.extension agents (…) 4.Other (specify)………………………

15. Do you have access to credit? 0. Yes (…) 1. No (…)

16. If yes specify source of credit

bank	Friends/relatives	cooperatives	others

IV, Climate Change Perception Assessment

17.Are you perceiving that climate is changing; 0.Yes(…) 1.No(…)

18. What do you say about the trend of hot days over the last 20 years;

0. Increase (…) 1. No change (…) 2. Decreased (…) 3.the same, but with altered climatic Range (…) 4. I don't know (…) 5. Other (specify)…………………………………….

19. What do you say about the trend of rainfall over the last 20 years? 0. Increased (…) 1. Not changed (…) 2. Decreased (…) 3.change in times of raining (…) 4. Increase in frequency of drought (…) 5. I don't know (…) 6.Other(specify)……………….

VI, Assessment of Adaptation options and Barriers.

20. Have you made any adjustments in your farming practices to climate variability and change?

(a) Yes (…) (b) No (…)

21.What adjustments have you made in your farming practices to these long-term shifts in temperature and rainfall?

Practice	tick
Have you used ZAP 64 new maize variety	
Have you stored rainy water either in tanks for watering	
Have you diversify your crops for example maize and millet	
Have you changed planting dates	
Do you own any livestock	

22.List the main constraints to adaptation measures

(a)Lack of capital(...) (b)lack of information (..) (c) shortage of labour to water (..) (d) Poor health(..) (e) Others…………………………………….

Appendix B: Normality test

```
. swilk h20h cropd date livst cropv edu hlb fmex nonf ha clifo credit percl trenp hotd
```

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
h20h	100	0.99940	0.050	-6.659	1.00000
cropd	100	0.99942	0.048	-6.745	1.00000
date	100	0.97929	1.710	1.190	0.11712
livst	100	0.96019	3.287	2.640	0.00415
cropv	100	0.99942	0.048	-6.745	1.00000
edu	100	0.99878	0.101	-5.095	1.00000
hlb	100	0.94702	4.374	3.274	0.00053
fmex	100	0.76097	19.736	6.616	0.00000
nonf	100	0.97168	2.339	1.885	0.02975
ha	100	0.91252	7.223	4.386	0.00001
clifo	100	0.99512	0.403	-2.016	0.97808
credit	100	0.98500	1.239	0.475	0.31739
percl	100	0.95103	4.043	3.099	0.00097
trenp	100	0.98160	1.519	0.927	0.17684
hotd	100	0.91728	6.829	4.262	0.00001

Appendix C: Correlation Matrices

```
. correlate h20h edu hlb fmex nonf ha clifo credit percl trenp hotd
(obs=100)
```

	h20h	edu	hlb	fmex	nonf	ha	clifo	credit	percl	trenp	hotd
h20h	1.0000										
edu	-0.0667	1.0000									
hlb	0.1272	-0.1466	1.0000								
fmex	0.2747	-0.1531	0.3930	1.0000							
nonf	0.0677	0.0594	0.4385	0.2887	1.0000						
ha	0.0901	-0.0592	0.3667	0.1674	0.3683	1.0000					
clifo	-0.0256	0.1351	0.0324	-0.0374	0.0339	0.0198	1.0000				
credit	0.4924	0.0860	0.1229	0.2033	-0.0016	0.1205	-0.0470	1.0000			
percl	0.2601	-0.0540	0.1360	-0.0912	0.0576	0.0389	-0.1854	0.0950	1.0000		
trenp	0.0789	0.0336	-0.0750	0.0048	-0.0044	0.0203	-0.0009	-0.0530	-0.0441	1.0000	
hotd	-0.0196	0.1342	0.1355	0.0786	0.1260	0.1535	-0.0404	0.1833	0.0700	0.0401	1.0000

```
. correlate cropd edu hlb fmex nonf ha clifo credit percl trenp hotd
(obs=100)
```

	cropd	edu	hlb	fmex	nonf	ha	clifo	credit	percl	trenp	hotd
cropd	1.0000										
edu	0.1511	1.0000									
hlb	0.2783	-0.1466	1.0000								
fmex	0.2345	-0.1531	0.3930	1.0000							
nonf	0.1743	0.0594	0.4385	0.2887	1.0000						
ha	0.1963	-0.0592	0.3667	0.1674	0.3683	1.0000					
clifo	0.0471	0.1351	0.0324	-0.0374	0.0339	0.0198	1.0000				
credit	0.2529	0.0860	0.1229	0.2033	-0.0016	0.1205	-0.0470	1.0000			
percl	0.0301	-0.0540	0.1360	-0.0912	0.0576	0.0389	-0.1854	0.0950	1.0000		
trenp	0.2813	0.0336	-0.0750	0.0048	-0.0044	0.0203	-0.0009	-0.0530	-0.0441	1.0000	
hotd	0.2778	0.1342	0.1355	0.0786	0.1260	0.1535	-0.0404	0.1833	0.0700	0.0401	1.0000

. correlate date edu hlb fmex nonf ha clifo credit percl trenp hotd
(obs=100)

	date	edu	hlb	fmex	nonf	ha	clifo	credit	percl	trenp	hotd
date	1.0000										
edu	0.0048	1.0000									
hlb	0.1908	-0.1466	1.0000								
fmex	0.0041	-0.1531	0.3930	1.0000							
nonf	0.0015	0.0594	0.4385	0.2887	1.0000						
ha	0.1209	-0.0592	0.3667	0.1674	0.3683	1.0000					
clifo	-0.1211	0.1351	0.0324	-0.0374	0.0339	0.0198	1.0000				
credit	0.2125	0.0860	0.1229	0.2033	-0.0016	0.1205	-0.0470	1.0000			
percl	0.4120	-0.0540	0.1360	-0.0912	0.0576	0.0389	-0.1854	0.0950	1.0000		
trenp	0.1904	0.0336	-0.0750	0.0048	-0.0044	0.0203	-0.0009	-0.0530	-0.0441	1.0000	
hotd	0.2994	0.1342	0.1355	0.0786	0.1260	0.1535	-0.0404	0.1833	0.0700	0.0401	1.0000

. correlate livst edu hlb fmex nonf ha clifo credit percl trenp hotd
(obs=100)

	livst	edu	hlb	fmex	nonf	ha	clifo	credit	percl	trenp	hotd
livst	1.0000										
edu	-0.0541	1.0000									
hlb	0.0017	-0.1466	1.0000								
fmex	-0.0606	-0.1531	0.3930	1.0000							
nonf	-0.0789	0.0594	0.4385	0.2887	1.0000						
ha	0.1222	-0.0592	0.3667	0.1674	0.3683	1.0000					
clifo	-0.0179	0.1351	0.0324	-0.0374	0.0339	0.0198	1.0000				
credit	0.0245	0.0860	0.1229	0.2033	-0.0016	0.1205	-0.0470	1.0000			
percl	0.5794	-0.0540	0.1360	-0.0912	0.0576	0.0389	-0.1854	0.0950	1.0000		
trenp	0.1394	0.0336	-0.0750	0.0048	-0.0044	0.0203	-0.0009	-0.0530	-0.0441	1.0000	
hotd	0.1149	0.1342	0.1355	0.0786	0.1260	0.1535	-0.0404	0.1833	0.0700	0.0401	1.0000

. correlate cropv edu hlb fmex nonf ha clifo credit percl trenp hotd
(obs=100)

	cropv	edu	hlb	fmex	nonf	ha	clifo	credit	percl	trenp	hotd
cropv	1.0000										
edu	-0.1192	1.0000									
hlb	0.1312	-0.1466	1.0000								
fmex	0.1091	-0.1531	0.3930	1.0000							
nonf	-0.0069	0.0594	0.4385	0.2887	1.0000						
ha	-0.0274	-0.0592	0.3667	0.1674	0.3683	1.0000					
clifo	0.0471	0.1351	0.0324	-0.0374	0.0339	0.0198	1.0000				
credit	0.1683	0.0860	0.1229	0.2033	-0.0016	0.1205	-0.0470	1.0000			
percl	-0.0200	-0.0540	0.1360	-0.0912	0.0576	0.0389	-0.1854	0.0950	1.0000		
trenp	0.1930	0.0336	-0.0750	0.0048	-0.0044	0.0203	-0.0009	-0.0530	-0.0441	1.0000	
hotd	0.2216	0.1342	0.1355	0.0786	0.1260	0.1535	-0.0404	0.1833	0.0700	0.0401	1.0000

Appendix D: Model specification and adequacy test

```
. estat gof, table group(10)
```

Logistic model for h20h, goodness-of-fit test

(Table collapsed on quantiles of estimated probabilities)

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.0496	2	0.3	8	9.7	10
2	0.2027	0	1.2	10	8.8	10
3	0.3007	3	2.5	7	7.5	10
4	0.3744	2	3.4	8	6.6	10
5	0.4552	4	4.1	6	5.9	10
6	0.6557	5	5.6	5	4.4	10
7	0.7717	6	7.1	4	2.9	10
8	0.8541	9	8.2	1	1.8	10
9	0.9216	10	8.8	0	1.2	10
10	0.9982	10	9.7	0	0.3	10

```
      number of observations =       100
            number of groups =        10
     Hosmer-Lemeshow chi2(8) =        13.66
                 Prob > chi2 =         0.0911
```

```
. estat gof, table group(10)
```

Logistic model for cropd, goodness-of-fit test

(Table collapsed on quantiles of estimated probabilities)

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.1331	0	0.8	10	9.2	10
2	0.2470	1	1.8	9	8.2	10
3	0.3378	6	3.1	4	6.9	10
4	0.4255	5	3.7	5	6.3	10
5	0.5723	4	4.8	6	5.2	10
6	0.6559	5	6.2	5	3.8	10
7	0.7466	6	7.0	4	3.0	10
8	0.8044	8	7.7	2	2.3	10
9	0.8919	8	8.3	2	1.7	10
10	0.9788	10	9.5	0	0.5	10

```
      number of observations =       100
            number of groups =        10
     Hosmer-Lemeshow chi2(8) =         7.94
                 Prob > chi2 =         0.4395
```

```
. estat gof, table group(10)
```

Logistic model for date, goodness-of-fit test

(Table collapsed on quantiles of estimated probabilities)

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.2502	1	1.5	9	8.5	10
2	0.4510	4	3.8	6	6.2	10
3	0.6776	6	5.7	4	4.3	10
4	0.7455	7	7.2	3	2.8	10
5	0.8425	9	8.0	1	2.0	10
6	0.8743	7	8.6	3	1.4	10
7	0.9052	9	8.9	1	1.1	10
8	0.9309	10	9.2	0	0.8	10
9	0.9587	10	9.5	0	0.5	10
10	0.9837	9	9.7	1	0.3	10

```
      number of observations =       100
            number of groups =        10
     Hosmer-Lemeshow chi2(8) =         6.12
                 Prob > chi2 =         0.6340
```

```
. estat gof, table group(10)
```

Logistic model for livst, goodness-of-fit test

(Table collapsed on quantiles of estimated probabilities)

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.1505	1	0.5	9	9.5	10
2	0.5005	2	3.1	8	6.9	10
3	0.8096	7	6.6	3	3.4	10
4	0.9158	10	8.8	0	1.2	10
5	0.9555	8	9.4	2	0.6	10
6	0.9829	10	9.7	0	0.3	10
7	0.9960	10	9.9	0	0.1	10
8	0.9990	10	10.0	0	0.0	10
9	0.9998	10	10.0	0	0.0	10
10	1.0000	10	10.0	0	0.0	10

```
      number of observations =       100
            number of groups =        10
     Hosmer-Lemeshow chi2(8) =         6.23
                 Prob > chi2 =         0.6210
```

. estat gof, table group(10)

Logistic model for cropv, goodness-of-fit test

(Table collapsed on quantiles of estimated probabilities)

Group	Prob	Obs_1	Exp_1	Obs_0	Exp_0	Total
1	0.2590	1	1.5	9	8.5	10
2	0.3481	4	3.2	6	6.8	10
3	0.4124	4	3.7	6	6.3	10
4	0.4822	2	4.5	8	5.5	10
5	0.5469	8	5.1	2	4.9	10
6	0.5947	6	5.7	4	4.3	10
7	0.6455	6	6.2	4	3.8	10
8	0.7094	5	6.8	5	3.2	10
9	0.8211	8	7.5	2	2.5	10
10	0.9243	9	8.7	1	1.3	10

number of observations = 100
number of groups = 10
Hosmer-Lemeshow chi2(8) = 8.10
Prob > chi2 = 0.4240

Appendix E: Regression Results

Logistic regression Number of obs = 100
LR chi2(11) = 46.14
Prob > chi2 = 0.0000
Log likelihood = -46.226239 Pseudo R2 = 0.3329

h20h	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_Iedu_1	.8040469	.5131934	-0.34	0.733	.2301393	2.80913
_Iedu_2	.5207749	.4135547	-0.82	0.411	.1098244	2.469455
hlb	.9133477	.1261299	-0.66	0.512	.6967683	1.197247
fmex	1.178439	.0839793	2.30	0.021	1.02482	1.355084
nonf	1.000019	.0002605	0.07	0.941	.9995087	1.00053
ha	1.013868	.0983031	0.14	0.887	.838398	1.226062
clifo	1.386788	.7526062	0.60	0.547	.4787023	4.017491
credit	18.9609	13.10871	4.26	0.000	4.890767	73.5091
percl	11.32857	10.2926	2.67	0.008	1.909032	67.22592
trenp	2.778105	1.705503	1.66	0.096	.8340435	9.253556
hotd	.2832063	.2149448	-1.66	0.096	.0639834	1.253541
_cons	.0362527	.048298	-2.49	0.013	.0026627	.4935827

Logistic regression | Number of obs = 100
LR chi2(11) = 35.41
Prob > chi2 = 0.0002
Log likelihood = -51.431154 | Pseudo R2 = 0.2561

cropd	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_Iedu_1	1.246254	.7514138	0.37	0.715	.3822831	4.062826
_Iedu_2	3.134197	2.222527	1.61	0.107	.7807655	12.58148
hlb	1.313534	.1830314	1.96	0.050	.9996145	1.726037
fmex	1.065363	.0603315	1.12	0.264	.9534418	1.190423
nonf	1.000013	.0002446	0.06	0.956	.9995342	1.000493
ha	1.048995	.1013924	0.49	0.621	.8679591	1.267792
clifo	1.16682	.6061616	0.30	0.766	.4215082	3.229996
credit	2.656556	1.484802	1.75	0.080	.8883123	7.944605
percl	.9372666	.61084	-0.10	0.921	.2612846	3.362114
trenp	6.281603	3.701439	3.12	0.002	1.979244	19.93617
hotd	3.869919	3.028173	1.73	0.084	.8349206	17.93736
_cons	.0072225	.0097975	-3.63	0.000	.0005059	.1031228

Logistic regression | Number of obs = 100
LR chi2(11) = 34.94
Prob > chi2 = 0.0003
Log likelihood = -41.823642 | Pseudo R2 = 0.2947

date	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_Iedu_1	1.215459	.8504449	0.28	0.780	.3084346	4.789804
_Iedu_2	1.189747	.9714449	0.21	0.831	.2401249	5.894845
hlb	1.308438	.2209261	1.59	0.111	.9397884	1.821697
fmex	.9719968	.0581052	-0.48	0.635	.8645313	1.092821
nonf	.9996352	.0002827	-1.29	0.197	.9990813	1.000189
ha	1.051822	.1227566	0.43	0.665	.8367581	1.322162
clifo	.6896002	.4205587	-0.61	0.542	.2086819	2.27882
credit	2.202116	1.481726	1.17	0.241	.5889749	8.233484
percl	9.463927	6.375375	3.34	0.001	2.527315	35.43916
trenp	4.180873	2.531203	2.36	0.018	1.276229	13.69636
hotd	4.992341	3.687335	2.18	0.029	1.173838	21.23246
_cons	.0259921	.0338572	-2.80	0.005	.0020233	.333897

Logistic regression	Number of obs	=	100
	LR chi2(11)	=	61.75
	Prob > chi2	=	0.0000
Log likelihood = -21.817389	Pseudo R2	=	0.5859

livst	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_Iedu_1	35.4861	49.17898	2.58	0.010	2.346427	536.6727
_Iedu_2	.3892577	.4337668	-0.85	0.397	.0438234	3.457547
hlb	.9238839	.177536	-0.41	0.680	.63394	1.346439
fmex	1.194824	.1255488	1.69	0.090	.972438	1.468067
nonf	.9985544	.0005492	-2.63	0.009	.9974787	.9996313
ha	1.539094	.2933877	2.26	0.024	1.059269	2.236271
clifo	5.674342	5.33128	1.85	0.065	.8998629	35.78118
credit	.1475412	.1693304	-1.67	0.095	.0155598	1.399014
percl	1240.734	2140.257	4.13	0.000	42.2048	36474.99
trenp	9.718509	9.553905	2.31	0.021	1.415191	66.73969
hotd	12.73467	16.54401	1.96	0.050	.9980804	162.4838
_cons	.0001855	.0004735	-3.37	0.001	1.25e-06	.0275888

Logistic regression	Number of obs	=	100
	LR chi2(11)	=	18.33
	Prob > chi2	=	0.0742
Log likelihood = -59.967696	Pseudo R2	=	0.1326

cropv	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_Iedu_1	.4563852	.2567035	-1.39	0.163	.1515497	1.374383
_Iedu_2	.3315554	.216213	-1.69	0.090	.0923576	1.190253
hlb	1.143878	.135265	1.14	0.256	.907244	1.442233
fmex	1.009857	.049937	0.20	0.843	.9165757	1.112632
nonf	.9999299	.0002308	-0.30	0.761	.9994776	1.000382
ha	.8979285	.0761924	-1.27	0.205	.7603514	1.060399
clifo	1.495125	.7164271	0.84	0.401	.5845248	3.824303
credit	2.253686	1.148197	1.59	0.111	.8302857	6.117293
percl	.7533298	.4330602	-0.49	0.622	.2441531	2.324385
trenp	3.125185	1.586508	2.24	0.025	1.155477	8.452598
hotd	4.507309	3.185156	2.13	0.033	1.128245	18.00658
_cons	.1926722	.201246	-1.58	0.115	.0248737	1.492445

Appendix E: Data Used

Edu	hlb	fmex	nonf	ha	clifo	credit	percl	trenp	hotd	h20h	cropd
1	2	4	1200	5	1	0	0	1	1	0	1
2	5	10	1000	7	1	1	1	0	1	1	0
0	3	5	0	8	1	0	1	1	1	1	1
2	2	5	1000	5	1	1	1	0	1	0	1
2	3	4	1200	2	1	0	0	1	1	0	1
2	5	8	2000	9	1	1	1	0	1	1	1
0	7	11	2400	10	1	0	1	1	1	1	1
0	4	20	2000	2	1	1	1	1	1	1	0
1	5	8	1200	2	1	0	0	0	0	0	0
1	4	5	1000	2	1	1	1	0	1	1	1
1	2	5	0	1	0	0	1	1	1	0	1
2	4	7	1200	3	1	0	0	1	1	0	0
0	4	3	0	2	0	1	1	0	1	1	1
0	8	30	2000	5	0	1	0	1	1	1	1
0	5	10	2400	6	0	1	1	1	1	1	1
2	3	7	1200	3	1	0	1	1	0	1	1
2	3	3	4000	2	1	0	0	1	1	0	1
1	7	9	2000	10	0	0	1	1	1	1	1
1	6	5	1200	4	0	0	1	1	1	0	1
0	6	2	2000	3	1	0	0	0	1	0	0
1	6	10	1000	4	1	1	1	1	0	1	0
0	3	5	1200	5	1	0	1	1	1	1	1
1	5	3	3000	6	1	1	1	1	1	1	1
2	1	4	1200	3	1	1	1	1	1	1	1
0	5	5	1200	6	1	0	0	1	0	0	1
1	6	6	0	2	1	0	1	1	0	0	1
1	3	3	1200	1	0	0	1	1	1	1	0
1	6	7	2000	5	1	0	1	0	1	0	0
0	2	2	0	1	1	1	1	1	1	1	0
1	4	8	2000	5	1	0	0	0	1	0	0
2	4	4	0	5	0	0	1	0	1	0	1
2	6	5	1200	4	1	1	1	1	1	1	1
1	4	3	1200	5	0	1	1	1	0	1	0
1	1	10	1200	2	1	0	0	1	0	0	0
0	2	5	1000	1	0	0	1	1	0	1	0
1	2	3	1000	2	1	0	1	0	0	1	0
0	7	12	0	4	1	0	1	1	1	1	1
1	5	6	2400	4	1	0	1	0	1	0	0
0	2	9	1000	5	1	0	1	1	0	1	0
0	3	3	0	4	1	0	1	0	0	0	0
0	2	5	0	3	1	0	0	1	0	0	0
0	4	3	1200	5	1	0	1	1	1	0	0
1	3	5	1000	8	0	0	1	0	0	1	0
1	2	4	1200	2	0	0	1	1	1	0	0

2	2	25	1200	4	1	1	0	0	1	1	1
2	8	15	3000	4	1	1	1	1	1	1	1
0	6	5	0	2	0	1	1	1	1	1	1
1	1	4	1200	1	1	1	1	0	1	1	0
0	7	18	2000	1	0	0	1	1	1	1	1
2	2	4	1200	1	1	0	1	1	1	0	0
1	6	10	3000	5	1	0	1	1	1	0	1
1	1	2	4000	7	0	0	1	1	1	1	1
1	6	2	1000	1	1	1	1	1	1	1	1
1	8	5	4000	12	1	0	1	1	1	0	0
0	2	3	0	2	0	0	1	0	1	0	0
0	3	10	1000	10	0	0	0	0	1	0	0
2	2	4	1200	10	0	1	1	1	1	1	1
2	2	2	0	2	0	0	1	1	1	0	0
1	4	6	0	3	1	0	1	1	1	0	0
0	6	14	2000	5	0	0	1	0	1	0	0
1	7	12	3000	10	1	1	1	1	1	1	1
2	6	5	1200	2	1	0	1	1	1	0	1
0	6	30	1000	6	0	1	1	1	1	1	1
1	4	5	2000	8	1	0	1	1	1	0	0
2	3	6	2000	5	1	0	0	1	1	0	1
2	2	2	1200	1	1	0	1	1	1	1	1
1	2	4	0	2	0	0	1	1	1	0	0
2	2	3	0	3	1	0	1	0	1	0	0
1	2	3	1200	2	0	0	0	1	1	1	1
2	9	10	3000	4	0	0	1	1	1	0	1
0	2	9	2000	5	1	0	1	1	1	0	0
1	1	7	1200	5	0	0	1	1	1	0	0
1	3	3	1400	5	0	0	1	0	1	0	0
2	2	9	3000	10	0	1	1	1	1	1	1
1	2	2	0	3	1	0	0	1	1	0	0
1	2	5	3500	2	0	0	1	1	0	0	0
1	4	4	2400	13	1	0	1	1	1	0	0
0	3	9	3000	6	1	1	1	1	1	1	1
2	2	11	4000	3	0	0	1	1	1	0	0
1	6	4	2000	5	0	1	1	0	1	1	0
0	5	13	3200	2	0	0	1	1	1	1	1
2	8	6	2000	5	0	1	1	1	1	0	1
1	2	6	0	5	0	1	0	1	1	0	0
1	2	2	1000	6	1	0	1	1	1	1	1
0	11	8	3200	12	0	1	1	0	1	1	1
1	8	17	3000	7	1	1	0	1	1	1	1
1	7	25	4000	5	1	0	1	0	1	1	1
1	6	6	3400	13	1	1	0	1	1	0	1
0	9	3	3000	3	1	0	1	0	1	0	0
1	2	3	0	5	1	1	1	1	1	1	1

2	**7**	**7**	**2400**	**3**	**1**	**1**	**1**	**0**	**1**	**1**	**0**
2	**3**	**5**	**0**	**4**	**0**	**1**	**1**	**1**	**1**	**1**	**1**
0	**2**	**3**	**1200**	**2**	**0**	**1**	**1**	**0**	**1**	**0**	**0**
1	**5**	**5**	**2000**	**6**	**1**	**0**	**1**	**1**	**1**	**0**	**1**
2	**2**	**3**	**0**	**2**	**1**	**0**	**0**	**1**	**1**	**1**	**0**
1	**7**	**6**	**4000**	**5**	**1**	**0**	**1**	**1**	**1**	**1**	**1**
1	**7**	**8**	**4000**	**5**	**0**	**0**	**1**	**0**	**0**	**1**	**0**
1	**10**	**15**	**2000**	**13**	**1**	**0**	**1**	**1**	**1**	**1**	**1**
0	**7**	**4**	**1000**	**7**	**0**	**0**	**1**	**1**	**1**	**0**	**0**
1	**6**	**10**	**3000**	**5**	**1**	**0**	**1**	**0**	**1**	**0**	**1**