ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

ECONOMIC VALUEATION OF AGRO BIODIVERSITY AND ITS DETRMINANT IN WEST GOJJAM ZONE, AMHARA REGION, ETHIOPIA: CHOICE EXPERIMENT APPROACH

BY:

Teshager Mazengia

June, 2019

ADDIS ABABA, ETHIOPIA

Economic Valueation of Agro-biodiversity and its Detrminant in West Gojjam Zone, Amhara Region, Ethiopia: Choice Experiment Approach

.

By:Teshager Mazengia

E-mail: teshagerm2016@gmail.com

A Thesis Submitted to

Department of Economics

Presented in Partial Fulfillment of Requirements for the Degree of Master of Science in Economics (Resource and Environmental Economics)

Addis ababa university

Addis ababa, Ethiopia

June, 2019

Addis Ababa University

School of Graduate Studies

I, the undersigned, declare that the thesis prepared by Teshager Mazengia entitled: **Economic Valueation of agrobiodiversity and its Detrminant in West Gojjam Zone, Amhara Region, Ethiopia: Choice Experiment Approach** submitted in partial fulfillment of the requirements for the degree of master of science in economics (Resource and Environmental Economics) compiles with the regulations of the university and meets accepted standards with respect to originality and quality

Signed by the Examining Committee:

Chairman________________________________ Signature_______________Date__________

External Examiner _______________________Signature_______________Date__________

Internal Examiner__________________________Signature_______________Date_________

Advisor _________________________________Signature_______________Date__________

Abstract

Environmental resources, such as agro biodiversity has many benefits to human beings. However, absence of markets and the activity of human beings increase the loss of agro-biodiversity. In this case, application of non-market valuation methods and identifying determinant factors of agrobiodiversity have paramount importance. Therefore, this study is conducted to quantify the total economic values and determinant factors of agro-biodiversity in West Gojjam zone of Amhara region. Random parameter logit estimate revealed that farmers WTA for landrace crops, organic farming, and crop species diversity are 549.58, 430, and 228.53 birrs per year per household. To see the effect of decision maker characterstics conditional logit with interaction terms was also evaluated and it shows that age, household size, and education level of farm household are significant factors affecting demand for agro-biodiversity attributes. In addition to valuation, determinant factors of agro-biodiversity were analyzed. The result of both poisson and Tobit model estimates of cereal and horticulture crop diversity, suggests that the sign and magnitudes of the effect of a farm, household, and agro-ecological characteristics accompanied by agriculture policies are different. For instance, age, gender, and household size have an insignificant effect on cereal crop diversity, while they have a significant effect on Horticulture Crop diversity. Moreover, number of plots is an important variable for increasing cereal crop diversity, while it has no significant effect on horticulture crop diversity. The study recommends that to conserve agro biodiversity effctively the government and agriculture organizations should motivate the production of organic farming through price premiums and quick certification of organic crops, expand gene banks to restore lost traditional varieties and motivate farmers to cultivate traditional crops, give training for farmers about agro-biodiversity, improv the efficiency of irrigation water use, and scientifically identify types of crops supported in intercropping.

Key words and PhraseS: Agro-biodiversity, Choice Experiment, Economic Valuation
JEL classification:D1, Q12, Q51, Q57

Aknowledgement

First of all I would like to thank Almighty God and his mother Saint Marry for give me strength and commitment for the compilation of this thesis and in whole of my life.

I am foerever indebted to my advisor **Wassie Birhanu (PhD)** for every thing he touhgt me. he provided advice on every step of this thesis and encouragement whenever I experienced self boubt in doing the thesis. with out his advice this thesis could not have been completed.

Next I would like to thank Debre Birhan University for sponsoring me to study at Addis Ababa university. I am greatfull to thank **Alemu Mekonenn (PhD)** for his advice on determining attributes of discrete choice experiment.

I would also like to thank **Gebretsadik Teshager** (lecturer at Dilla University) and **Samuel** (statsititian and working for Ethiopoian Develeopment Research Institute) for their invaluable advice on designing of choice experiment.

Finally I would like to thank all my friends and my best friend Ermiyas Tefera who helped me for the compilation of this thesis.

Table of Contents page

List of tables **page**

List of figures Page

List of Acronyms

ANRS = Amhara National Regional State

CLOGIT = Conditional Logit Model

CSA = Central Statistical Agency

CVM = Contingent Valuation Methods

DCE = Discrete Choice Experiment

FAO = Food and Agricultural Organization

FDRE = Federal Democratic Republic of Ethiopia

NAEP = National Assessment on Educational Progress

OECD = Organization for Economic Co-Operation and Development

RP = Revealed Preference

RUM = Random Utility Model

SNNPR = South Nations and Nationalities of Peoples Representative

SP= Stated Preference

WTA = Willingness to Accept

WTP = Willingness to Pay

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Biodiversity, as the basis of life, is the totality of terrestrial and other aquatic ecosystem, species and genetic diversity (FAO, 2018). Biodiversity grouped into three major classifications: - ecosystem, genetic and species diversity. Biodiversity has the role of ecosystem service, intrinsic value (Ricketts et al., 2006). Agro-biodiversity, which is one component of biodiversity, is the basis for food and livelihood security and development of food production, including bio-technology industries and composed of the diversity of genetic resources (e.g., varieties, breeds) and species used for food, fiber, and fuel (FAO, 1999).

Agricultural diversity is essential for both human beings and other living organisms. Diversified and sustainable agriculture played a significant role in smooth functioning of ecosystems and the economy. Hence, conserving and quantifying the value of agriculture diversity is fundamental. Since 90% of rural households in developing countries rely on biological resources for livelihood requirement, diverse verities and breeds underpin insurance against future threats and food security (Munzara, 2007)

Despite the roles and function of agriculture diversity, extinction of species is higher than its natural rate of extinction. Since the starting of the 20^{th} century, the world lost 90% agro-biodiversity of which 20% are stapled foods. In addition, (Slingenberg et al., 2009) indicates that world biodiversity decreased by 70% in 2000 and it will decrease by 63% in 2050. Human activities aggravate the extinction or loss of biodiversity by 100 to 1000 times the baseline rate (Teklu, 2016).

Loss of agro-biodiversity is the result of the loss of traditional of crops species, species extinction, and commercialization, which facilitates specialization crop production (Roe et al., 2018). The increase in demand for basic need results in overexploitation of resources and causes loss of agro-diversity. Over the last 49 years, agricultural expansion showed a significant increase, but this exerts socio-economic costs and disadvantages like agro-biodiversity and soil fertility loss, which reduces agricultural productivity and in turn, it contributes to food insecurity for 800 million to 1 billion peoples in the world (Thrupp, 2000).According to the NBSAP of Ethiopia report, agricultural intensification is the main causes of agrobiodiversity loss in the world. Replacement of traditional crop varieties by high yielding varieties, which is dependent on high levels of agricultural inputs are the main cause of genetic erosion of native varieties (FDRE, 2005). Genetic dissemination of uniform varieties of improved seed is a major cause of crop diversity loss (CSA, 2008).

Loss of agrobiodiversity by a faster rate than its natural rate indicates there are different factors, which causes loss of agrobiodiversity. Thus identifying specific factors which contribute tothe loss of agro-diversity requires detail analysis. To do this measuring or quantifying the values of agrobiodiversity is fundamental and it should be the first step (Pearce, 2001; OECD, 2004). As a result, this study intends to deal with economic valuation and determinant factors of crop agro- biodiversity, particularly cereal and horticultural crops.

1.2. Statement of the problem

Ethiopia as the home of agroecology and diversity, it is also the center for the diversity of crops (CSA, 2008). This biodiversity is the result of the country's variation in rainfall, temperature, diverse social and cultural conditions (McGurie, 2000). In developing countries including Ethiopia, because of lack of access to technologies, smallholder traditional farming conserved the majority of agrobiodiversity (Hammer, 2003). However, farmers application of high yielding, but uniform varities and chemical fertilizer on their farm distort farmers contribution for the conservation of agro-biodiversity (Brown et al., 1993). Though the rate of loss and extinction is not fully documented, the diversity of crop in Ethiopia is currently under constant threat because of the replacement of local varieties by improved seeds (Worede, 1991). This is because farmers do not consider their effect on biodiversity and producing types of crops they need. Difference between public and farmers values of agro-biodiversity creates biodiversity conservation gap (Wale, 2012; Hammer, 2003).

Quantifying both non-use and use values of agro-biodiversity in terms of monetary value that farmers attached is fundamental to effectively conserve agro-biodiversity. In addition, conservation of biodiversity without quantifying its economic or monetary value is not effective because farmers practice type of farming by only considering the direct benefit of farming. Thus estimating economic values of biodiversity is the first step to conserve biodiversity in general and agro-biodiversity in particular (Pearce, 2001). Economic values of resources can also be used for the comparison of alternative resources (Nunes and Bergh, 2001). Despite the importance of measuring economic values of agrobiodiversity, there were limited studies conducted on the subject. Moreover, the conservation of crop diversity is handled by households (farmers). Hence understanding the determining factors of crop diversity (cereal and horticulture) and relative importance of each attribute of crops are essential to effectively conserve crop diversity.

Despite lack of consensus on the effect of farm, household, market, and institutional factors on agro-biodiversity many researchers studied and evaluated determinants of agro-biodiversity. For instance, the study conducted by Birol (2004), Whitney et al. (2017), Abay et al. (2009), Rhima et al. (2013), Paudel et al. (2012) Reudiger (2013) revealed that household characteristics (gender, age, household size, education) have positive effect on agro-biodiversity. In consistent to this result Abebe (2013), Heezik et al. (2013), and Benin et al. (2004) conclude that household characteristics have no significant impact on agro biodiversity. In addition to household characteristics, researchers evaluated effect of farm characteristics (farm size, number of parcel of land, plot distance, access to irrigation water, soil types) on agro biodiversity. Rana; Grforth et al. (2007), Gauchan et al. (2005), Abay et al. (2009), Rhima et al. (2013) show farm characteristics have positive effect, while Abebe (2013) conclude that farm characteristics have no significant effect on agro biodiversity. Moreover, Guchan et al. (2005), Rhima et al. (2013), and Reudiger (2013) pointed out that market related factors have positive effect on agro biodiversity. Finally studies by Paudel et al. (2012), Benin et al. (2016), and Brown et al. (2008) revealed that agriculture technology adoption on farm has positive effect on agro biodiversity. Incosisitent to the result Rana et al. (2010), and Brush and Taylor (1992) found that agriculture technology adoption on farm has negative effect on agro biodiversity.

Only few empirical studies were conducted on valuation of agro biodiversity. For instance, (Birol, 2004) conducted a study on valuing agricultural biodiversity on a home garden in Hungary and found that households those lives with different market integration, infrastructure quality, and agro-ecological condition attaches different private values for different attributes of agrobiodiversity on home gardens. Kuruppu (2015) conducted a study on Farmer's valuation of agrobiodiversity on the home garden and he found that households atached highest value for livestock integration followed by organic production and landrace. In Ethiopia, to the best my knowledge, there is no study conducted on economic valuation of agro biodiversity.

Agro biodiversity is essential for all living organisms and human beings and becomes the concern in the world. However, public good nature accompanied by the absence of market price makes difficult to quantify economic values of agro biodiversity using market price. Absence of value is one factor for the loss of agro biodiversity. As a result, employing valuation methods, which includes both use and non-use value of agro biodiversity has great contribution for the conservation of agro-biodiversity. Despite the importance of quantifying economic values of agro biodiversity, there are few studies on valuation of agro-biodiversity and inconsistent results of studies conducted on determinants of agro biodiversity. This motivated the author of this thesis to conduct a study on valuation of agro biodiversity using choice experiment. Moreover, to the best of my knowledge there is no empirical study on economic valuation and determinants of agrobiodiversity in Bahir Dar Zuria and Bure Woreda. Hence, in an attempt to fill some of the knowledge gaps discussed above and add to the existing limited literature, this particular research is conducted on farm households private economic values and determinants of agrobiodiversity. To this end, this paper would answer the following questions:

- How much farm households are willing to pay for the conservation of different agrobiodiversity attributes?
- For which attributes of agro-biodiversity households attach highest monetary value?
- What and how socioeconomic, market, agricultural technology, and institutional factors affect different attributes of crop diversity in rural areas?
- Is the effect of agricultural technology, market, institutional, and household characteristics similar to different groups of crops?

1.3 Objectives of the study

1.3.1. General objective

The general objective of this study is analyzing economic values of agro-biodiversity and its determinant, particularly cereal and horticultural crops.

1.3.2. Specific objective

- To quantify the economic values of different attributes of agro-biodiversity
- To examine, specific attributes of agro-biodiversity households attach highest value.
- To examine, determinant factors of inter-species diversity of crops in rural areas.
- To assess whether agricultural technology, market, institutional, and household characteristics have similar effects on a different group of crops.

1.4. Significance of the study

It is known that biodiversity ensures the sustainability of lives. This study will be used as a basis for future studies related to valuation and determinat factors of agrobiodiversity. It will also be used for governmental and non-governmental organization to intervene and conserve biodiversity and to forward some policy options on the conservation of agro-biodiversity.

1.5. Scope and limitations of the study

Agricultural diversity in general and crop biodiversity, in particular, may vary from time to time and place to place. Furthermore, cost and time limits make difficult to obtain country-level determinants and farmers economic values of agricultural biodiversity using primary data . Thus, this study is restricted only to deal with economic valuation and determinant factors of agricultural biodiversity in Bahir Dar Zuria and Bure Woreda based on the data collected for 2010/11 cropping season. In addition, the study has the following limitations:

- The study used Margalef index of diversity, which is affected by sample size
- The study did not analyze crop specific determinants

1.6. Organization of the paper

This paper is organized into five chapters. The next chapter presents, chapter two, comprises theoretical and empirical litratures on economic valuation and determinant factors of agro-biodiversity. It also includes the theoretical underpinnings of the random utility model. The third chapter includes estimation frameworks. To measure economic values of agro-biodiversity non-market valuation method and to identify determinant factors Poisson and Tobit regression methodological frameworks are discussed. The fourth chapter covers estimation and discussion of the paper followed by the fifth chapter, which covers the conclusion and recommendation of the study.

CHAPTER TWO

2. REVIEW OF RELATED THEORETICAL AND EMPIRICAL LITERATURES

In this chapter both theoretical and empirical literatures on economic valuation of agro-biodiversity and its determinants are discussed.

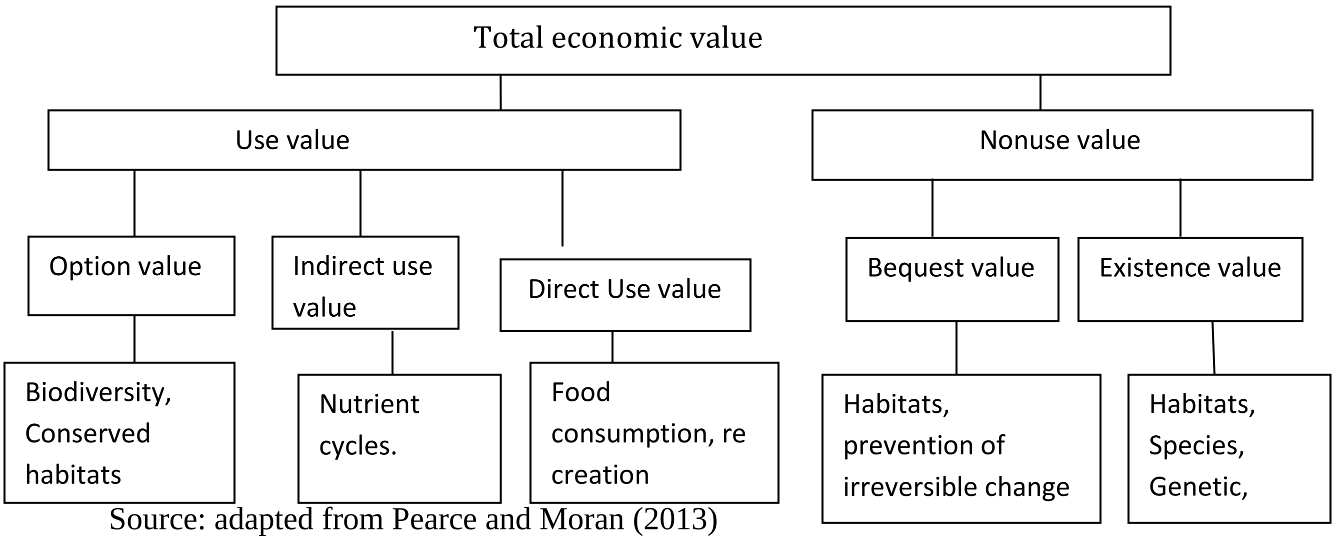
2.1. Review of theoretical literature

2.1.1. Economic valuation of natural and environmental resources

Valuation is an attempt to put monetary values for environmental goods or natural resource. Economic valuation of agro-biodiversity is not referring to stock of agro-biodiversity but a change in agro-biodiversity i.e. it is not determining the true value of agrobiodiversity rather valuing changes and comparing with other alternatives (Dixon &Pagiola, 1998). For some environmental goods either market price does not exist or captures only a small portion of its value. To consider these problems disaggregating any environmental impact into individual component of value is fundamental. One technique of doing this disaggregation is total economic value (Dixon & Pagiola, 1998).

(Freeman et al., 2014), pointed out that economic valuation of environmental services and goods are the sum total of discounted present values of environmental resources. Economic value is related to wellbeing and it is measured by willingness to pay. Hence, the more preferred the more WTP. However, most of the environmental goods have no obvious market price. The absence of market price for environmental goods leads us to use stated preference technique of valuation for environmental goods, which have no market prices. Stated preference approach enables us to cover demand curve (Elgar, 2006).

Total economic values of natural and environmental resources consist of use and non- use values. Use value is a value arising from the actual use of resources. Further use values can be classified as direct and indirect use values of resources. For instance, the direct values of agro-biodiversity are the actual consumption and sale of crops. Another component of total economic value is option value. It is the value of resources stemming from individuals willingness to pay for future use. Some authors classified option use value as use value. On the other hand, some others classify it as non-use value. Non-use value sometimes called passive use value arises from altruism. Non-use value can be classified as existence and bequest values. Bequest value of a resource is the benefit of natural and environmental resources accruing to any individual from the idea that others benefit from the resource in the future. While existence value is the amount that an individual is willing to pay for the existence of resourcesalthough he/she never seen the resource (Peace and Moran, 2013).



Source: adapted from Pearce and Moran (2013)

Figure 1: classification of total economic values of environmental goods

2.1.2. Economic valuation of agrobiodiversity

Agrobiodiversity has both direct and indirect use values. On-farm agro-biodiversity enhances productivity by conserving soil fertility and reducing crop disease, which we call direct use value of agro-diversity (Pascual & Perrings, 2007). Agricultural practice using artificial inputs with poor biodiversity makes farmers focus on a narrow range of agricultural technologies. Farmers dependence on narrow agricultural technology reduce the capacity of the system to absorb greater environmental or economic shocks, such as sudden and unexpected commodity price changes.

Creation of successful markets for conservation and sustainable use of biodiversity should be assessed in terms of both costs (efficiency) and biodiversity conserved (effectiveness).To achieve these objectives creation of a market for biodiversity in general and agro-biodiversity, in particular, should follow three stages: demonstration[1], capture (appropriation) [2]and benefitsharing[3] (OECD, 2004).

Effectiveness of conserving agro-biodiversity without quantifying its economic value is much lower than conservation of agro-biodivesrity after quantifying its value. Hence quantifying the values of agro-biodiversity is fundamental in conservation. The process of valuation has two steps: demonstration and quantification of value. Without quantification of values conservation of agro-biodiversity is not adequate. According to Pearce (2001) undertaking valuation of biodiversity has three main reasons: proper pricing of resources, facilitating cost-benefit analysis and green accounting.

Biodiversity, particularly, agrobiodiversity is seriously threatened all over the world (Pacicco et al., 2018). This makes conservation of biodiversity like agrobiodiversity is important. In many parts of Ethiopia, there is a large number of farming communities that increases crop genetic diversity through breeding and domestication of new crop species. However, the whole trend shows erosion of crop species is much greater than the generation of crop genetic diversity. United nation environment program (UNEP) reports that in the past there are around 7000 species of plants available for food, but because of globalization now only 150 crops are used. From the total supply of 150 crop varieties rice, maize, and wheat account 60% of the total food supply in the world (Pacicco et al., 2018).

2.1.3. Importance of valuation of natural and environmentalresources

[1] Is the process of identification and measurement of biodiversity values, this is important because the potential benefit from conserving biodiversity may not always be evident.

[2]The process of capturing some or all of the demonstrated and measured values pertaining to an environmental resource so as to provide incentives for its sustainable utilization. This is achieved through the design and implementation of regulatory mechanisms and markets that allow for values to be expressed and channeled from those who receive a benefit from the conservation of a biological resource to those who bear the cost.

[3]The valuation and appropriation of biodiversity values are not sufficient conditions for providing incentives for biodiversity conservation. The implementation of appropriation mechanisms must be undertaken in such a manner that the captured biodiversity benefits are distributed to those who bear the costs of conservation.

Valuation of natural and environmental resources provides knowledge about the relative importance of different values of biodiversity resources. In addition to the total values of resources, it provides the responsiveness of goods and services related to the resource being valued. Furthermore, economic valuation of environmental resource provides not only monetary value, but also preference ordering of alternative resources and conservation instruments, particularly in stated preference approaches of measuring values (OECD, 2001).

Measuring economic values of environmental resources are used for targeting the conservation in the time of scarce budget and identifying the damages for the loss of biodiversity. Now a days the loss and pressure of biodiversity are very large. Introducing protection of biodiversity without quantifying the monetary or economic values of biodiversity is much less and not effective as compared to conservation of agro-biodiversity by quantifying its value (OECD, 2001). Due to this quantifying the economic values of biodiversity are the first and fundamental steps to conserve biodiversity (Pearce, 2001). Quantifying economic values of resources are used for comparing the economic values of alternative resources (Nunes and Bergh, 2001). Even though biodiversity is not uniquely defined scientists generally agreed that the number of species per unit area is the starting point in measuring biodiversity (Whittaker. 1997).

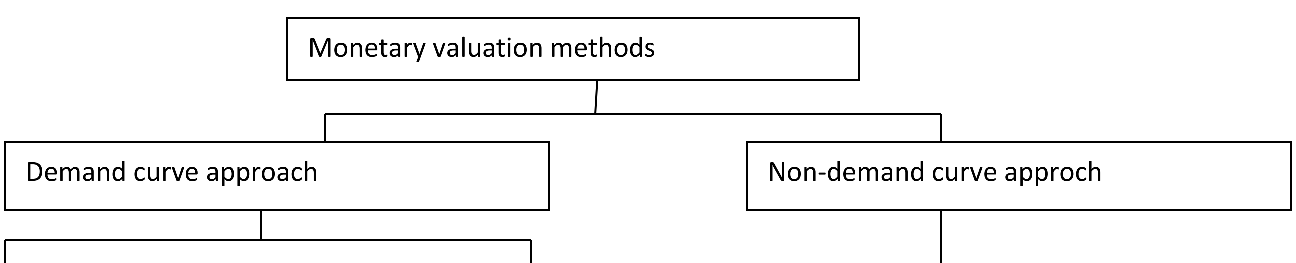
Environmental resource service flows can be classified based on different criterion. (Freeman, 2003) classified environmental resource flow in to four criterion. The first criteria of classifying service flow of the environment is a type of resource media i.e. whether environmental effects are stemming from a change in the quality of air, water, land or not. The second is based on economic channels at which wellbeing of the society is affected i.e. whether the effect of the environment on society's wellbeing is predicted on the basis of change in income or price. The third criterion is based on whether environmental factor affects the wellbeing of the society directly or not and the last is based on the value of the environmental resources that individuals attach.

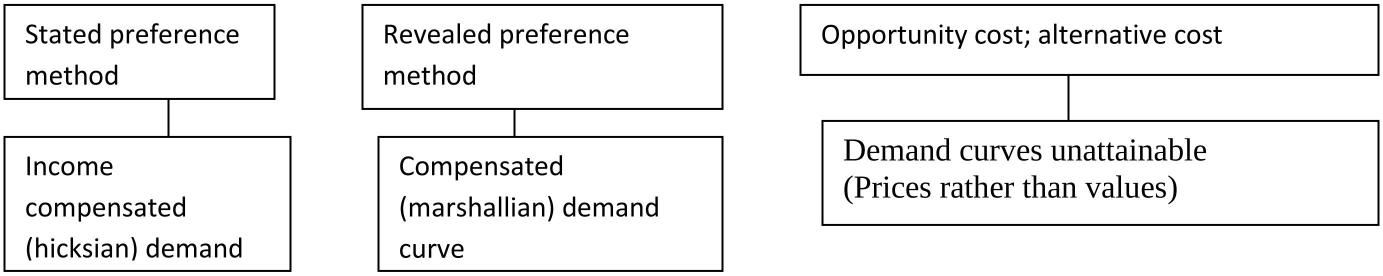
2.1.4. Methods of economic valuation of the environment

There are three commonly used environmental pricing techniques. The first technique relies on the use of the market price of goods and service as surrogate values of environmental resources. In addition, the quality of environmental good is treated as an input for the production of different outputs. Hence the change in environmental quality results changes in production costs and productivity, which in turn leads to a change in price and demand for goods produced by using environmental amenities as input. This is called dose-response techniques. The second pricing technique uses actual data like the cost of maintenance or preventing environmental degradation. The third one uses potential costs as a proxy for environmental value like shadow project appraisal (OECD, 2004).

Methods of measuring preference based outcomes broadly divided into two: revealed and stated preference methods. Revealed preference (RP) is the observation of preferences based on real market behavior applicable foronly the computation of use value for environmental resources (Freeman, 1993; OECD, 2004). RP method can be classified into direct and indirect methods. Among the direct methods, the competitive market price is mostly used method and from indirect methods travel cost and hedonic pricing are widely used models applicable for real goods based on the observable Marshallian demand curve. Welfare measure of RP is consumer surplus (Boardman et al., 2001).

Though RP has the advantage of maximizing external validity and low- cost of valuation, it has many critics. One of the problem of RP is the difficulty of obtaining sufficient variation for all variables of interest. The second problem of RP is multicollinearity among explanatory variables, which makes difficult to infer proper tradeoffs. the third problem is that RP requires that explanatory variables should be expressed in objective (Kroes & Sheldon, 1988). Aformentioned problems under RP makes use of stated preference approach attractive. As a result in this study stated preference approach is used. Detail of stated preference methods is discussed below.





Source; adopted from OECD (2004)

figure 2: methods of environmental valuation

2.1.5. Stated preference approach to valuation

SP is based on hypothetical method and consumers are asked to state their preferences for hypothetical scenarios having a set of attributes and different levels of these attributes. It has different advantages for valuation of natural and environmental resources as compared to revealed preference. First SP method of valuation is easy to control i.e. researchers define the conditions to be evaluated by the respondents. Second, SP preference approach is more flexible i.e. capable of dealing with wider verities of variables. Finally, it is cheaper to apply. Despite these advantages stated preference method has weakness in that it shows only relative utility instead of absolute utility. In addition, it depends on hypothetical data (Kroes & Sheldon, 1988; OECD, 2004).

2.1.5.1. Contingent valuation method

Following Davis (1963) contingent valuation method is most frequently used method to the valuation of environmental amenities based on Hecksian measure of welfare impacts. Contingent valuation method of environmental valuation is a type of valuation, which is involved in directly asking peoples about the value they place (attached) for environmental resources. The responses of peoples are contingent upon the conditions or criteria defined in a hypothetical market (Freeman et al., 2014).). CVM is one of SP methods of valuing environmental resources when respondents are asked to tell the maximum WTP or minimum WTA for environmental goods and bad respectively (Diamond and Hausmann, 1994).

Although CVM is frequently used methods of measuring environmental resource valuesit has criticisms on reliability and accuracy of estimates (Hanley et al, 2001). One of the problems of CVM isbias i.e. starting point, the vehicle of payment, hypothetical, strategic and mental account bias. Another problem is embedding, which means CVM depends on the extent where the value embedded in other goods. The divergence between WTP and WTA is another problem of contingent valuation method (Hanley et al, 1997). However, discrete choice experiment is not much affected by the above problems, which makes choice experiment study more suitable. The detail of the discrete choice experiment study is discussed below.

2.1.5.2. Discrete Choice Experiment

Discrete choice experiment denotes denotes a set of alternatives. A discrete choice implies respondents face choices among a set of alternatives meeting the requirement of a finite set, mutually exclusive and exhaustive (Train, 1993). The theoretical foundation of choice experiment valuation is introduced in Lancaster's (1966) attribute theory of consumer choice and (McFadden, 1974) employed empirical application of choice experiment using econometric analysis based on random utility theory. DCE is the simplest method than contingent ranking and contingent ordering methods of choice experiments; because of low cognitive complexity i.e. low degree of task complexity and experiment (Louviere etal.2000).

Choice experiment method is the generalization of contingent valuation methods in that instead of asking people between alternative specific and base level, CEM asks people to choose among described attributes. It is consistent with random utility and used for the elicitation of passive use value. Choice experiment has the advantage of measuring passive use value for the reason: it provides the detail description of attribute trade-offs that peoples are willing to make and error variance of choice experiment is equivalent to CVM and choice experiment has smaller variance as compared to CVM. Further CEM has advantages over CVM in that CEM is based on attributes, which allows individuals to value attributes and situational changes (Adamowic et al., 1997)

Choice experiment study deals explicitly with how society values related to individual agriculture component and a combination of components, but it do not concern the overall component (Hynes, et al, 2011). According to Hanemann (1999), to deal with an environmental valuation using CE, it requires linking Lancastrian microeconomic theory with consumers demand. The number of attributes is fixed without considering the level of consumer goods, which recognizes that attributes are fully known and objectively measurable. According to Bennett and Blamey (2001), inclusion of cost or monetary attribute, used as a proxy for income, is fundamental in the case of DCE to indirectly obtain WTP of respondents. The method is indirect in the sense that respondents are not directly asked to tell us their WTP

In the case of choice experiment, environmental attributes are varied in experimental design and respondents make repeated choices between different bundles of environmental goods, which vary in terms of attributes and the levels it takes (Hanley et al 1997). CEM is inspired by microeconomic approaches of Lancaster's (1966), which states individuals derive utility from the characteristics of goods rather than from goods directly. Respondents presented with different alternatives to trade costs between improvement and damage. Based on the way that variables or terms are interpreted probabilistic choice modeling is grouped into two: the decision rule and utility are random and deterministic respectively, which means individual behaviors are intrinsically probabilistic, indicating individual behaviors can change due to internal and external factors. The second category of decision rule is considered as deterministic and the utility is random, which implies the inability of researchers to precisely formulate an individual's behavior (Kjaer et al, 2005).

Quantifying the values of environmental resources using DCE passes a number of stages. According to Bennett and Blamey (2001), DCE should follow five steps: identification of attributes, identification of levels, experimental design, data collection, and data analysis. The details of all stages are discussed under the methodology part. However, before the identification of attributes the analyst should characterize the decision problems i.e. whether the analysis includes only use value or including option and non-use values.

2.1.6. Random utility and choice modeling

The assumptions that random utility model imposes are choice of individuals from different set of alternatives is described by utility function and they choose an alternative with the highest utility. Utility of individuals depends on two components: variables that the researcher oserves represented by independent variables and variables (attributes) at which the researcher do not observe represented by random variable. Random component of utility give rise to random utility model. Either multinomial or conditional logit model is suitable, if error terms are independently and identically distributed across alternatives with type I extreme value distribution (Horowitz, 1994).

Soufani (2012), pointed out that random utility theory models agent's preference on alternatives by drawing real-valued score of each alternative from parameterized distribution and rank individuals preference of different alternatives. To apply choice modeling the assumption is that researchers do not know individuals preference, attitudes, and income, but he/she know about the process that the agent makes choice (Hess et al, 2018). Manski (1977) formalized theoretical approaches of random utility theory and he identifies four reasons or source of randomness. These are information asymmetry, error of measurement, unobserved attribute, and heterogeneity in preferences.

To predict and analyze choice behavior among a discrete set of alternatives, a random utility model is widely used like multinomial logit and conditional logit models. Conditional logit model basis its assumption on the preference of individuals among available alternatives is explained with utility function. Random utility predicts the probability that the utility of a particular alternative exceeds all other alternatives. Choice sets are assumed to be known and fixed (Horowitz, 1991).

Choice experiment approach converts multi-attribute into single point profile called compensatory model. The well known compensatory model is the main effect additive utility model i.e. utility of an alternative is equal to the sum of utilities of its attribute (Kjaer, 2005). According to Regenwetter et al (2010) utility was identified as random ordinal variables without specific distributional property i.e. random utility model is a distribution-free model. RUM is considered as individual agents engaged in discrete choice tasks at which variation in choice behavior across independent repetition of the task creates randomness (Marschak, 1974).

2.2. Agro-biodiversity in the current time

Though there is no consensus about the compelementarity between biodiversity and agriculture, biodiversity and detailed knowledge about it allowed the system of farming to evolve. Majority of today's cultivated and consumed staple crops all over the world has its origin from Asia, Africa and Latin America (Raeburn, 1996). A traditional farming method that maximizes diversity includes small scale poly-cultural farming known as a home garden (fruits and vegetables) (Thrupp et al., 1996).

Another dimension of traditional agrobiodiversity is the use of landraces (Greenburg, 1994). Increase in production is due to the expansion of cropland and change in technology overtime. On average, 92.8% of crops had been lost from the period 1903 – 1983 (Fowler and Mooney, 1990). Though the relative abundance and diversity of different agricultural products are different, it includes crop diversity, below ground plant diversity, microbe diversity, and wild plant diversity.

As Hammer (2003) pointed out the Third World smallholder farmers cannot access to technologies, which is an artificial tool for the conservation of biodiversity in the case of traditional farming. Hence, smallholder farmers in developing countries maintained the majority of remaining agro-biodiversity. Despite these farmers do not take into account the effect of his/her action on agro-biodiversity. Rather they produce a type of crops based on their private needs. This creates a difference between farmers (individuals) and public (society) values of agricultural resources, social and private optimum level of conservation. The difference in private and social values of agrobiodiversity further creates conservation gaps of agrobiodiversity level between two economic actors (Wale, 2012).

2.2.1. Role of agrobiodiversity

Agricultural biodiversity is the basis for life and contributes three basic functions for human being. These are continuous transformation of inputs into outputs including the evolution of breeding for newly emerged verities, production through a biological process like pollination and predators (Cromwell, 1999). This diversity is a tool for alleviating poverty and enhancing development (Cromwell, 1999). Agro-biodiversity contributes to crop productivity, wealth generation, and nutritional values, food security and resilience to the farming system. It also contributes ecosystem service on the farm like retention of water, disease and pest management, the fertility of the soil and pollination. Agrobiodiversity has values for science and technology in the production of crops (Thrupp, 2000). (FAO, 2018) states Agriculture and biodiversity have bidirectional relationship i.e. agriculture includes the largest species on the earth and if administered sustainably and effectively it contributes well functioning of ecosystem like water quality, nutrient recycling, and erosion control.

Conservation and sustainable use of agro-biodiversity are essential for human being. It supports risk management for smallholder farmers and adaptations of agriculture for future environmental changes. Genetic diversity reduces climate and disease-related factors and increases resilience (Martins, 2015). Instability of agro-ecosystem service worsening insect pest problem increasingly related to the expansion of crop monoculture at the expense of natural vegetation, thereby decreasing local habitat diversity (Altieri and Letourneau, 1982).

2.2.2. Agrobiodiversity in Ethiopia

Ethiopia is the home of agrobiodiverity, particularly it is the home of different crops. Variations in rainfall, temperature, and soil type, diverse social and cultural conditions with market integration are the reason for the existence of varies of genetic diversity of crops in the country (McGuire, 2000). Increased intensification of agriculture characterized by lack of fallowing, severe drought or shortage of rainfall creates land degradation. Moreover, high growth of the country's population causes food insecurity (Shiferaw and Holden, 1997).

Ethiopia is the 8th world's center of crop diversity with primary or secondary domesticated crops (Engels and Hawkes, 1991). It has many domesticated crops like teff (*Eragrostisteff*) and enset (e*ventricosum)* (Edwards, 1991). Though the transformation of traditional agriculture to modern agriculture is necessary to feed the growing population in the country, it is contrary to the conservation of crop genetic diversity. Currently, many crops are treated and some are extinct (Worede, 1991). Over centuries traditional farming and traditional crops are the choice of farmers to satisfy their dynamic and changing needs, which is the foundation of farming in Ethiopia. Adoption of modern agriculture has sever impact on the environment in general and crop in particular (Worede et al 1999).

In the world traditional varities, which depends on subsistence farming, covers 60% of agricultural land and contributes 15 – 20% of global food demand. It also used as the primary input to breed modern varieties (Wood and Lennea, 1997). As Worede (2000) pointed out Ethiopian farmers are playing significant role for the conservation of crop diversity, even in severe situations i.e. drought and war, and rock-hewn mortars mostly used instruments to conserve seeds (Worede, 2000). However, the trend shows only high yielding variety of crops are concerned and traditional crop varieties (landraces) at which human beings depend for millennia are neglected (Asfaw, 1999). When it come to local crop variety of Ethiopia, most of the existing diversities are under constant threat of being irreversibly lost as a result of the replacement of local traditional varities by modern crops at an alarming rate (Worede, 1991). Moreover, the rate at which improved seeds are replacing the local varieties in Ethiopia has not been fully documented and the rates of displacement vary from crop to crop and from region to region (Worede et al., 1999).

The inhabitants of the environment are intricately affected by the use of pesticides. Even though pesticides are applied for the purpose of crop protection and to reduce loss from insects and pest attacks, under certain conditions crops can be affected by the use of pesticides. This is because, yield of some crops can be reduced and crops adjacent to the target crop can be affected form pesticide drift. Also crop rotations that are sensitive to chemicals can be inhibited or their growth can be hampered because of the residual effect of pesticide after the target crop growth is over (Pimentel, 1996). Isherwood (1999) stated that the use of chemical fertilizer affects soils, biodiversity, and human beings.

2.2.3. Causes for the loss of agro-biodiversity

Intensification and modernization; mechanization and monocultures; limited knowledge about sustainable use and conservation of agro biodiversity; lack and reduced access to genetic resources and economic changes are some among many causes for the loss of agro biodiversity (Martins, 2015). Loss of agro-biodiversity is caused by interrelated and manifold factors i.e. extension of modern and commercial farming, intensive use of high yielding inputs. The substitution of native breeds by high yielding variety is reinforced by donors promoting the import of exotic breeds, which threats native breed (Ellen, 2003). As Gore (1992) reported genetic erosion is the only serious problem for the loss of genetic diversity of agricultural product.

Commercialization of agriculture and regulatory framework, increased accessibility, changes in cropping patterns and land use practices, social inequality, population growth, and technological advancement are major factors contributing to the loss agro-biodiversity

(Upreti and Ghale, 2002). Population pressure, increasing patterns of energy consumptions and natural resource, perverse policies, failures to incorporate the monetary value of biodiversity into decision making, macroeconomic policy structures, and social change and development bias are the root causes of biodiversity loss (Hens and Boon, 2003).

Improved varieties, extension advice and fertilizer creates an incentive for farmers to grow exotic varieties which distorts farmers contribution for the conservation of biodiversity through growing traditional varieties of agriculture (Brown et al, 1993). Resource endowment, institution, policy and contextual condition of farmers affect the allocation of resources. Simultaneously industrial agriculture and green revolution particularly in Africa imposes causes degradation of natural resource like soil, water and biodiversity, which further decreases productivity ((Thrupp, 2000).

2.3. EMPIRICAL LITERATURE

Enhancing and conserving agricultural biodiversity has diverse benefits and most of countries in the world plans and sets policies to conserve agrobiodiversity. Like other countries, Ethiopia plans and implements different program to conserve agricultural biodiversity, but agricultural biodiversity is decreasing continuously due to several problems. Thus quantifying the values of different diversity of agriculture is essential to effectively conserve agrobiodiversity. In the following section empirical findings on determinants of agrobodiversity and its economic value are discussed.

2.3.1. Farmer's valuation of crop biodiversity

Birol E. (2004) conducted a study on farmer's valuation of agrobiodiversity in Hungarian small farms using choice experiment study. The author used four attributes: crop species diversity, landrace, organic farming, crop-livestock diversity and self-sufficiency as monetary units. The data were collected from three regions (Devavanya, Orsegvendi, and Szatmar-bBereg) and analyzed by using a random parameter logit model and a basic conditional logit model. The findings demonstrate that variations in private economic values of horticulture crop farming across regions are evident. Farmers attached highest willingness to accept values for agro-diversity (crop-livestock) mixed farming in Devavanya and Szatmar-bBereg. However, farmers in Orseg-vendi attaches' highest WTA values for crop species diversity. Using the same attributes and estimation models Kuruppu et al. (2015) found that farmers attached highest WTA value for crop-livestock mixed farming.

Paulrud and Latila (2010) applied choice experiment model for the analysis of how farmers in Swedish assess the values of the characteristics of energy crops. Two energy crops with six characteristics by including the size of the farm that farmers are willing to cultivate the energy crops are used. The result suggests that among included attributes visual impact on landscape and rotation period of energy crop are significant variables, those increasing utility of farmers. They also included farm, household characteristics as a predictor variable, and they found farm characteristics: age of the farmers, size of the farm and geographical area are significant variables.

(Sinafikeh, 2011), conducted a study to understand sustainable management of crop genetic biodiversity using choice experiment analyzing farmer's crop diversity attribute preferences. the author estimates the relative importance of attributes explaining perceived utility derived from four traits of sorghum and teff varieties. The estimation includes four basic attributes: selling price, productivity, environmental adaptability (drought, frost and poor soil) and yield stability. The result shows households attach the highest value for the attributes of environmental adaptability followed by yield stability and productivity attribute

The study on Agro-biodiversity of Mediterranean crops: farmers' preferences in support of a conservation program for olive landraces, which focuses on willingness to participate in the conservation by farmers in Apulia, Italy conducted by Sardaro et al. (2016) applies choice experiment study through the latent class model. They identified three groups of farmers. The first group is capitalist farms with high-profit level controlled by farm households and is unwilling to take part in the conservation. The second group is small and fragmented family farms managed by older peoples who preferred to take part in the conservation of olive oil crops.

2.3.2. Determinants of agrobiodiversity

Here the study discusses the relationship between household, farm, market and institutional characteristics and agrobiodiversity of crops. in addition, studies on the effect of agricultural technology on agro biodiversity are reviewed.

Family size has a positive effect on crop diversity, particularly fruits and vegetable crops (Birol 2004). Land ownership far from the homestead, family size, and distance to the market have a positive relationship with home garden or fruit and vegetable diversity (Whitney et al. 2017). Low-income households with low land holding have a high diversity of crops than high income with high landholding farmers Pandey (2013). The adoption of agricultural technology reduces the biological diversity of agricultural products in particular and aggregate diversity in general (Brush and Taylor, 1992). A number of plots of land, access to irrigation, membership in farmers group and agriculture technology has a positive significant effect on rice diversity (Rana;Garforth et al. 2007). They also conclude that altitude, chemical fertilizer, numbers of livestock that farmers have, number of plots of land have a positive significant effect on landrace diversity.

Gauchan et al. (2005) evaluate socioeconomic and agro-ecological determinants of conserving diversity on the farm: the case of rice variety using Poisson and Tobit model regression using 307 sample respondents from two farming regions. To compare spatial diversity of crops across the two regions they used Shannon Wiener index, which has a problem that an increase in species results ina nonlinear increase in its value and also Shannon Wiener index gives similar diversity values even tough in reality two communities have different diversity conditions and Berger –parker index. In addition, they did not include the effect of modern varieties and other agricultural technology inputs on on-farm diversity. They found that irrigation availability, market distance from the home of farm households havea positive effect on rice diversity. On the other hand, livestock assets contribute to less diversity.

Abebe (2013) conducted a study on the determinants of crop diversity and composition in Enset- coffee agroforestry home garden in southern Ethiopia. He used primary data collected from four kebeles of Sidama districts in the southern part of Ethiopia analyzed using stepwise multiple regression model. However, stepwise regression results: biased parameter estimation, inconsistency among model selection algorithms, and the problem of multiple hypothesis testing. Moreover, he did not include modern varieties in his analysis. Despite this, he found that household characteristics: age education status and gender of the household head have significant effects on crop diversity. Furthermore, the result shows farm size has no effect on crop species diversity.

Using censored regression and considering modern varieties as independent variable Benin et al. (2004) analyzed the determinants of cereal crop diversity on farms in the Ethiopian highlands. Their analysis shows that household characteristics such as sex and age of household head, education of the household member have no significant effect on cereal crop diversity. Oxen ownership, number of plots and farm sizes are found to be statistically significant and their effect is positive. Besides, they showed that greater livestock asset and household plot distance from homeis associated with lower cereal crop diversity. This is because in the case of fewer crops grown wealth is livestock is insurance against crop production failure.

Rehima et al. (2013) analyzed factors affecting farmers crop diversification in SNNPR, Ethiopia. They evaluate the data collected by the Ethiopian development research institute and international food policy research institute for the year 2008. They employed the second stage OLS regression model. Just like other researchers, they did not consider the effect of modern crop varieties on agro-biodiversity. They found that education hasa positive association with crop diversity. They argue that an increase in education contributes to human capital, which enhances household head to seek new knowledge, which in turn enables farmers for easy management of crop diversification. Moreover, a large number of plots that farm households own is associated with more crop diversity in that large number of the plot indicates greater variation in soil and agro-ecological conditions, which might be conducive to allocate multiple crops across larger plots. Finally, their result shows that market distance and extension workers contact has a positive significant effect.

Heezik et al (2013) evaluate the effect of garden size, household knowledge, and socioeconomic characteristics on plant diversity at farm households using 115 voluntary respondents from New Zealand. Shows gender and education levels of the household head do not affect the diversity of fruits and vegetables.However, inheritance from family positively affects the probability of having fruits and vegetable production.

Paudel et al. (2012) Analyzed the determinant factors of biodiversity of fruits and vegetable crops in western terai part of Nepal depending on 907 respondents by employing multivariate Poisson model and Shannon Wiener diversity index. With incorporating the effect of modern varieties in the model, the result of their analysis on independent regression of fruits and vegetables shows that technology index, which includes new varieties is associated with more diversity. Owningmore number of livestock's and family income are found to be positively associated with a diversity of crops. They argue that the positive association between livestock and diversity is because farm households with more livestock can easily access fodder and forage, those are used input for the production of fruits and vegetables. farther more they suggest that farm households with more income produce more diversified horticulture crops in that wealthier households demand nutritious foods and to fulfill this demand they cultivate a large number of crop species. Inaddition, they showed that education has a positive significant effect on vegetable diversity.

2.3.3. Adoption of agricultural technology and agro-biodiversity

Using separate multivariate poisson regression models of intra-species diversity of five major crops: maize, wheat, rice potato and mango, and interspecies diversity of vegetable, fruit, forage and fodder the work Paudel et al (2012) the result shows technology index which includes whether the household uses chemical fertilizer, improved seed, commercial farming, insecticide, and pesticide or not. It is found to be a positive and significant effect on intraspecies and interspecies diversity of all crop types. Paudel et al's result is contrary to Rana et al (2010) and similar to the work of Brown et al (2008). Availability of irrigation has a positive impact on rice, maize, and potato, which is the same as the results of the work of Rana, Garforth et al (2007), but contrary to the suggestion of Brush (1995).

Ras and Ghale (2002) used qualitative analysis and found that commercialization, technological adoption, and cropping patterns are the main causes of agro-biodiversity loss. Applying OLS and IV estimation the result of Noack et al (2017) shows that adoption of agricultural technology particularly improved seed reduces crop diversity both for the number of species and spatial diversity. Further, the result shows the effect of technology is different for different estimation models: 1% increase in the area of improved seed reduces the diversity of crops by 0.1% and 1.6% for OLS and IV respectively. Mekonnen and Mekuria (2018) found an empirical finding, which shows that there exists a negative relationship between improved seed and crop diversity.

Infrastructural development changes farming system from traditional to commercialization, which affects biodiversity negatively (Bosomes et al, 2014). The study conducted by Pandey (2013), show that Commercialization of fruit and vegetable production reduces diversity. On the contrary, Whitney et al (2017) found that commercialization has no effect on the biodiversity of horticulture (fruit and vegetable) crop diversity. Using separate multivariate Poisson regression models of intraspecies diversity of five major crops: maize, wheat, rice potato and mango, and interspecies diversity of vegetable, fruit, forage and fodder the work Paudel et al (2012) the result shows technology index which includes whether the household uses chemical fertilizer, improved seed, commercial farming, insecticide, and pesticide or not. It is found to be a positive and significant effect on intraspecies and interspecies diversity of all crop types. Using three stages least square estimation Brush et al. (1992) concludes that the area of farmland cultivated using improved seed has a negative significant effect on biological diversity (number of crops grown on the farm).

2.3.4. Empirical studies on the determinants of agrobiodiversity in Ethiopia

The study conducted by Ruediger (2013) on agrobiodiversity patterns in eastern Ethiopia using both count data and spatial variations (OLS, ordered LOGIT, and TOBIT models) of inter and infraspecies diversity of crops show that being female household head increases interspecies diversity of crops for OLS and OLOGIT crop count estimation. A number of children's, log-transformed wealth, farm size, market distance, and commercialization has a positive relationship with inter-species diversity of crops. However, the slope of farmland and commercialization crops have a negative effect. Commercialization of crops, the slope of farmland and natural logarithm of wealth has statistically significant effect on infra- species diversity of crops, but sign and magnitudes of their effects depend on the type of the model that the researcher applied.

Smale et al (2003) evaluate determinants of inter and infr-aspecies cereal crop diversity in both community and farm household level in Northern (Tigray and Amhara region) parts of Ethiopia using censored least absolute deviation estimation method. The result shows market distances to home and population density have a positive relationship with interspecies diversity of crops inthe Tigray region. However, they have no effect on the Amhara region. Household characteristics like education and number of oxen have a positive effect on crop diversity in both regions. Access to formal credit has a positive significant effect on crop diversity in Amhara region, but it has no effect in the Tigray region.

Socio-demographic characteristics of decision maker of farm household like age, gender, education, and family size have no effect on inte-rspecies diversity of crops. However, farmland has a positive relationship with inter-species diversity of crops, while livestock has a negative relationship with crop diversity. Inconsistent to the case of inter-species diversity, household characteristics (age, education, and female-headed households) and farm characteristics (slope, erosion, fertility, irrigation and farm size) have a statistically positive effect on intra-species diversity. However, the use of improved variety on farm has no effect on intra-species diversity of crops (Rehima, 2009).

Using Tobit model Mekonnen and Mekuria (2018) evaluated determinants of crop-livestock diversification. The finding shows a number of livestock, extension contact and access to the extension workers has a positive effect on crop diversity. While soil fertility status and land rent-out have a statistically negative relationship with crop diversity.Wale (2005) found that replacing high yielding varieties for traditional crops, results increase in productivity, but it treats the biodiversity of crops. They also revealed access to agricultural extension and resource endowment affects crop diversity positively.

According to Mussema et al (2015) using Hickman two-step estimation model identifies that last year income, farm size, number of plots, access to extension and distance to the market positively affects the propensity of crop diversification. On the other hand distance to the market has a positive impact on the intensity of crop diversification. However, previous income and extension service has no effect on the intensity of crop diversification. Farm size affects the intensity of crop diversification negatively.

Using censored regression analysis methods of the data collected from 300 samples with 249 complete data collection Abay et al. (2009) evaluates farm diversity and determinants of barley diversity in Tigray, the northern part of Ethiopia. They used the Margalef index of measuring crop diversity and found that age, gender (male headed), livestock ownership, family size, and farm size has a positive significant effect on inter varietal crops. On the other hand contact with extension, workers lower inter varietal crops. The fact that a male-headed household grows more crops that are diverse is associated with skills for frequent plowing and early planting of varieties. In addition, they suggest that large families have diverse preferences. To satisfy these diverse preferences household's produce diversified crops. Positive significant effect of livestock wealth is associated with a demand for fodder. Finally,the negative effect of contact with extension workers and positive effect of farm size on cereal crop diversity is as a result of agricultural policy, which overlooks the role of crop diversity, depends on cash income and soil heterogeneity respectively. Similar to other scholars they did not include modern varieties as the independent variable.

From theoretical and empirical litratures discussed above, it is reasonable to conclude that the importance of agro biodiversity is recognized by researchers and it becomes the concern of each country in the world since 19^{th} century. However, the loss of agro biodiversity is increasing at an increasing rate. Scholars suggested the loss of agro biodiversity is because of difference between the value that farm households and the society attach for agro biodiversity. In addition loss of agro-biodiversity is because of limited studies on economic valuation of the resources (both use and non-use value). Indicating empirical studies on values of agro-biodiversity have peramount importance to effectively conserve agro biodiversity. Despite this there is minimal effort on economic valuation of agro biodiversity. in addition to difference in values of resources among individuals. To fill this gap the current study evaluated farmers economic values of agro biodiversity using discrete choice experiment and determinants of agro biodiversity using Poisson and Tobit regression models.

2.4. Conceptual framework

A conceptual framework to analyze determinant factors of crop choice depends on the theory of farm household model. The model simultaneously takes into account interdependence of production and consumption. When farm households are price taker for agricultural crops at which they both consume and produce an optimal level of production is determined by independent of consumption choice and leisure (Singh et al., 1986). Given this sequential decision-making process a farm household maximizes utility over the consumption of goods they produce on their own farm (C_a), consumption of purchased goods (C_p) and leisure (L). Given this utility of farm,households was specified as:

$$U = U(C_a, C_P, l) \tag{3.1}$$

This utility function is constrained by:

Income

$$P_P C_a = P_a(Q_a - C_a) - P_l(L - F) - P_v V + \mathrm{E} \tag{3.2}$$

Time:

$$T = C_l + F \tag{3.3}$$

Production technology: $Q_a = Q(L, V, A, K)$ (3.4)

Where p_p = price of purchased goods, p_a = price of staple goods produced on farm, Q_a = households production of staple food, P_l = price of leisure (wage), L = total amount of labor employed of production of Qa, F = family labor, V = variable input, PV= price of variable input $E = \text{non labor or non} - \text{farm income}$

If markets are perfectly competitive production and consumption decision of farmers were made separately and they maximize net earnings determined by farm physical characteristics (Ω_{ff}). Moreover, the decision of households is also influenced by agro ecological decision. On the other hand, when both input and product markets are imperfect consumption and production decision are not separable. Specific characteristics of farm households (Ω_{HH}) and physical access to markets (Ω_{mm})) affects the amount of transaction costs prices, which governs household choice Benin et al. (2003). Finally, if farmers cannot change the total land area, consumption goods produced on farm were designed in to crop area through input-output relationships between goods and crops (Smale et al, 2001). Given the above information, the objective function (3.1) would specify as:

$$\max_{\alpha_{11},\alpha_{ij},\alpha_{mn\geq 0}} \; V\left(C_a, C_p, C_l; \Omega_{HH}\right)(3.4)$$

Where the choice variable α is share of i^{th} crop from the total crops that farm households produce, i = 1, 2…M, and variety j = 1, 2…n. the reduced form can be specified as:

$$\alpha * = \alpha * \left(Y, \Omega_{HH}, \Omega_{ff,}\Omega_{mm}\right) \qquad (3.5)$$

Then following van Dusen (2000) cited in Benin et al. (2003) econometrics estimable model of diversity takes the form:

$$D = D\left(\alpha * \left(Y, \Omega_{HH}, \Omega_{ff,}\Omega_{mm}\right)\right) \qquad (3.6)$$

Where D is diversity index, Ω_{HH} is household characterstics, Ω_{ff} farm characterstics, Ω_{mm} is market characterstics and Y is income.

CHAPTER THREE

3. THE METHODOLOGY OF THE STUDY

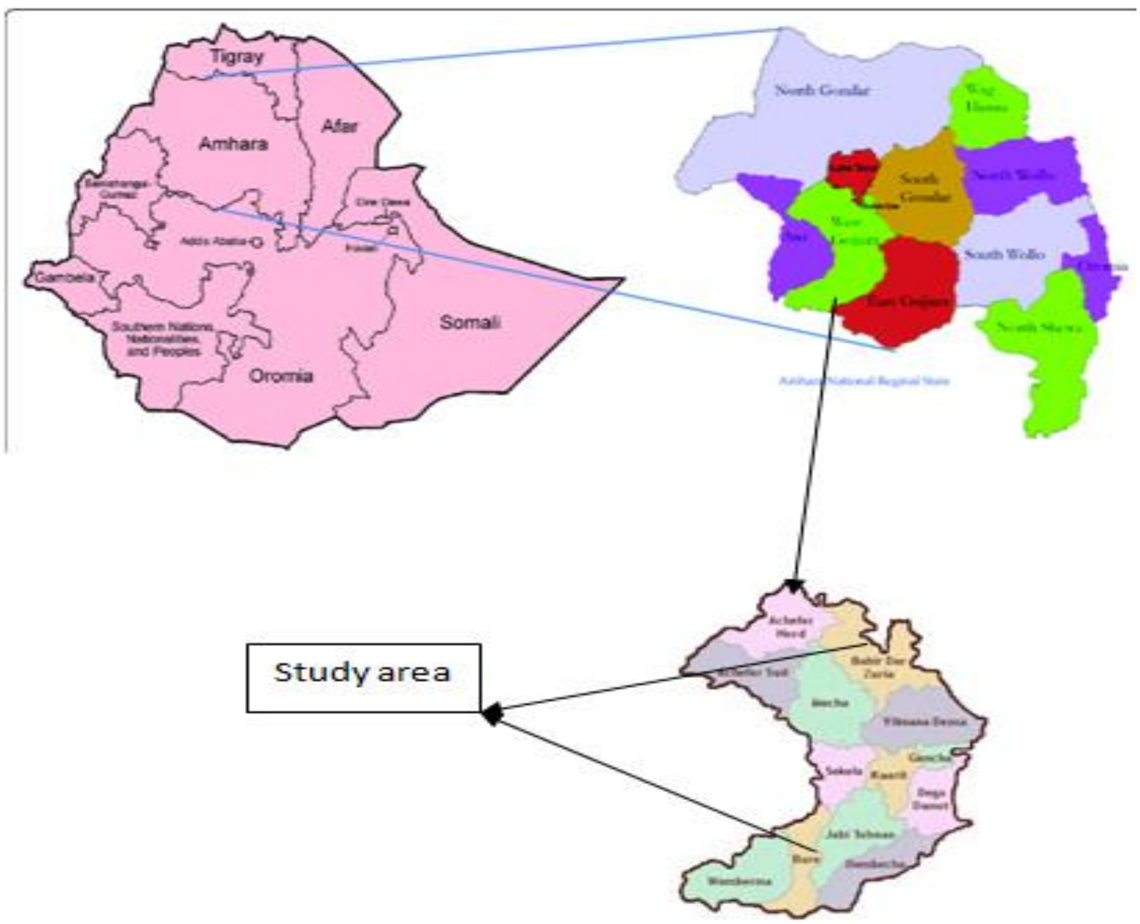
3.1. Geographical location of the study area

This study is conducted in Bahir Dar Zuria and Bure Woredas of West Gojjam zone in Amhara region. Bahir DarZuria Woreda is located to the south of Bahirdar via Tis Abay to Bahirdar gravel road and it is about 18 km far from Bahir Dar. It is approximately 1.283 km^2 and includes 36 Kebeles. The Woreda is bounded by Achefer, South Gonder, Lake Tana and Yilmana Densa Woreda in the West,east, North, and South respectively. The topography of the woreda is defined as, 32% is hilly, 13 % mountainous and 7% valley. Above sea level, the altitude of the woreda ranges from 1,750 to 2,300. In addition, all 36 kebeles have Woina- Dega climatic zones (MoWR, 2009). The greater part of the woreda is covered by Luvisols. According to population and census of Ethiopia (CSA, 2007), 182,730 peoples are live in Bahir DarZuria Woreda

Bure Woreda lies Southwest of Bahirdar along the high way from Bahir Dar to Addis Ababa. It is 175 km away from Bahir Dar. Most part of the Woredafalls under hot to warm climate and belongs to Kola and Woina Dega Zone.Though in the woreda diverse soil types exist, Nitosols[4] and cambisols cover greater parts. According to population and census of Ethiopia (CSA, 2007),100,570 with 50,984 male and 49,586 female persons are living in the Woreda. Similar to other rural areas of Ethiopia in both woredas agriculture with subsistence, low productivity, and low land holding, and backward production system is almost the only means of living. In addition to cereal and horticultural crops households in these Woreda produces chat and Gesho.

---

[4]Nitisols are deep, well-drained red tropical soils with diffuse horizon boundaries and a subsurface horizon with more than 30 % clay and moderate to strong angular blocky structure elements that easily fall apart into characteristic shiny, polyhedric ('nutty') elements. One of the best and most fertile soils of tropics.. Nitosols have moderate resilience and moderate to low sensitivity.



Source:https://www.google.com/search?q=map+of+amhara+region&oq=map+of+amhara+region&aqs=chrome..69i57j0l5.11704j0j4&sourceid=chrome&ie=UTF-8

Figure: 3.1. Location of the study area

3.2. Type and Sources of Data Collection

This study used both primary and secondary data. The secondary data was used as supplementary tools that were collected from published and unpublished books, magazines, and previous researcher findings, kebele and woreda administrative offices. The primary data was collectedusing interviewing. Both close-ended questions with a few options for responses and open-ended questions will be prepared to get detail information from the respondents regarding crop diversity practice. The rationale for the use of a close-ended questionnaire is because it makes it simpler for respondents to answer and for data analysis.

3.3. Nature of the data

Both qualitative and quantitative approaches of collecting data were incorporated. The qualitative data includes major economic and non-economic activities that the people participate in like preference, priority and opinions, knowledge acquisition, adoption and diffusion of technologies and know-how about the concepts of cropbiodiversity. Quantitative data's like the amount of output, inputs (number of labor required to cultivate crops, seeds, and other inputs) was collected.

3.4. Sampling technique and sample size determination.

This study employed hybrid sampling that first two weredas (Bure with 24 kebeles and Bahir Dar Zuria with 36 kebeles) from West Gojjam Zone were selected purposively. The rationale for the selection of these woredas is based on the long period experience of Horticulture (fruits and vegetable) and other crop production in the area. Then using systematic sampling the researcher selected four Kebeles fromBahir Dar Zuria and three kebelesfrom BureWereda respectively. From each Woreda the first kebele was selected using random sampling and the remaining 3 and 2 Kebelesfrom Bahir Dar Zuria and Bure respectively was selected at every eighth interval. The selected kebelesareAndassa, Wenjeta;Robit and Wegelsa from Bahir Dar Zuria and Wangadam, Gulem and Wundegi are from Bure.

Second from the total population of selected Kebels of each wereda (Andassa, Wenjeta, Robit and Wegelsa) with a total of households of 6546 and (Wangadam, Gulem and Wundegi) from Bure with a total households of 4323 a samples of 200 respondentswereselected by using Slovin's formula employed by Yemane (1967). The rationale for the use of this formula is that it is appropriate when the researcher knows nothing about the behavior of the population. When using Solvin's formula the researcher used 90% level of confidence and 10% precision.

$n = \frac{N}{1+Ne^2}$ where n = sample size, N = population and e = sampling precision

For Bahir Dar Zuria $n_1 = \frac{6546}{1+6546(0.01)^2}$ = 98.06 or by rounding = 100

For Bure $n_2 = \frac{4323}{1+3967(0.01)^2}$ = 97.54 or by rounding = 100

Numbers of respondents from each woreda with corresponding kebeles reported in (Appendix A).

3.5. Model specification.

3.5.1. Theoreticalunderpinnings of discrete choice model

3.5.1.1. Design of choice experiment

Unlike contingent valuation method, choice experiment method is used to estimate the values of both environmental goods and implicit values of its attribute or use and nonuse values (Hanley et al 1998a; Bateman et al, 2003). According to Morrison et al. (1996), CE is also preferred over other stated preference valuation techniques for the possibility of incorporating substitute goods and it is less susceptible to bias. The theoretical basis of the model is based on Lancaster's (1966) theory of consumer choice and the basis for econometric analysis is random utility theory introduced by (McFadden, 1974).

Random utility theory depends on prior assumptions (decision rule)..This assumption is a rational consumer[5], which outline the evaluation process of decision makers for alternatives and choice sets(Glenk et al., 2006). The concept of neoclassical economic theory is applicable by considering the assumption that individuals have perfect information and use all of it and they are willing to trade off among attributes (Louviere et al., 2000).On the other hand, researchers have no perfect information and theyfaceuncertainty[6], which necessitates the use of probabilistic models of the decision making process.

I. Definitions of attributes and assignment of attribute levels

Choice experiment tells us significant things for non-market values of environmental goods and attributes: it can be used for identification of significant attributes, which determines the values peoples attach for non-market goods, implied ranking of attributes among relevant

[5]Rational consumer implies decision makers are utility maximizing

[6]Uncertainty because of unobserved alternative attribute, uncertainty because of unobserved individual characteristics, uncertainty because of measurement errors and instrumental variables (Manski, 1977)

population, and the values of more than one attribute at once and the total economic values of resources or goods. Determination of attributes and levels for each attribute requires detail investigations of literature, consultation of experts, and pilot surveys. In this study, attributes and levels were determined by a detail review of literature and consulting experts.

In this study 6 agro biodiversity attributes were identified. These are crop species diversity, crop type, landrace, organic farming, expected yield, and the net benefit from crop production. Among six attributes crop species diversity, organic farming, and landrace are determined by NAEP expert and agricultural scientist and used by Birol (2004). The remaining attributes are identified depending on (CSA, 2017/18) reports on types of crops and the amount produced measured in quintal per hectare. The definitions of attributes is discussed below

Crop species diversity (CSD): Crop species diversity is used as the number of different crops that farm household produces. Forexample, farm household producing teff, wheat, onion, avocado, and chickpea considered as farm households having crop diversity of five. In this study, crop species diversity has four levels. The numbers of Levels are identified by NAEP experts and used by Birol (2004). The value for each level of crop species diversity was identified as 5, 10, 15, and 20 numbers of crops produced by farm households.

Organic farming (OF): is an agricultural system, which uses ecological pest and biological fertilizers derived from animal and plant wastes. According to Tamil Nadu Agricultural, university (TNAU, 2016) organic farming is cultivating the land and raising crops in such a way that it keeps the soil alive by using organic wastes (crop, animal, farm wastes, and aquatic wastes). Moreover,the United States Department of agriculture (UNDA) defines organic farming as a system, which avoids the use of synthetic inputs (such as fertilizer, pesticides, and other inorganic inputs). In this study, organic farming is used as a system of agriculture that farm households cultivate crops using only organic inputs (animal dung, plant wastes, and crop wastes). For the purpose of this study, organic farming takes two levels. These are whether farm households produce crops using organic farming or not.

Landrace (LR): - it lacks an accepted definition and different scholars define landrace in different ways. In this study, only the definition of landrace by Villa et al. (2005) is used. The author defines landrace as a bulk of genetic diversity in domesticated species located in traditional varieties maintained by farming systems. Landrace crops are severely threatened by genetic extinction because of replacement by modern genetically modified crops. Hence,the landrace attribute of crop production has two levels: whether a farm household produces landrace crops or not.

Crop type (CT): farmers produce different crops depending on the preference of farm household, agro-ecological condition including season. (CSA, 2017/18) groups grain crops into seven. These are cereal, pulses, oil-seed, vegetables, root crops, fruits, and stimulating crops (coffee and chat). However, using all crop groups in to choice experiment study is difficult for both the respondents and researchers to handle. Hence for the purpose of this study, the researcher groups, all seven types of crops into four. These are cereal, horticulture (fruits and vegetables), crops other than cereal and horticulture, and combined crops of all type.

Yield per hectares (YLD): this attribute is used to capture preference of households about the types of crops produced and methods of production that farm households used. For instance, Organic farming is less productive as compared to conventional farming, but the former conserve soil fertility and other microorganisms and the later do not. Moreover, the productivity of traditional crops is lower than modern varieties. Finally,the productivity of Cereal crop is lower than Horticulture and other crops. Hence, including expected yield attribute captures whether farm households are preferred biodiversity or productivity. Expected yield attribute has four levels determined depending on (CSA, 2017/18) report on the average productivity of crop groups (cereal, horticulture, others, and combined) with cereal the lowest and other types of crops the highest productivity.

Net benefit (NB): the productivity of different groups of crops is different i.e. Cereal crop productivity is lower than other crops (CSA, 2017/18). In addition, the Productivity of organic farming is lower than conventional farming. On the other hand, prices for organically produced crops are higher than conventional farming in markets where price primum for organically produced crops were formed. Moreover, the price of cereal crops is higher than other crops. Thus, the net benefit of different groups of crops using different types of farming (conventional or organic farming) is different. Hence, it captures the trade between attributes, net benefit attribute levels were determined depending on the types of crops that farm households produce and the methods they used. Accordingly, the net benefit attribute has four levels. These are 15000, 18000, 20000, and 25000 per year from the total crop production. Summary of variables and its levels used in the choice experiment is reported below in Table 3.1.

Table:3.1. Agrobiodiversity attributes used in a choice experiment

Agrobiodiversity attribute	symbols	Levels
crop species diversity	CSD	5 10 15 and 20
Crop type	CT	Cereal horticulture other combined
Landrace	LR	Landrace vs. improved seed
Organic farming	OF	Organic vs. conventional
Expected Yield	YLD	16 35 56 83
Net benefit	NB	15000 18000 20000 25000

II. Choice experiment design

As discussed above six agro biodiversity attributes were identified and four attributes have 4 levels and the remaining two attribute have2 levels. Using these attributes and levels very large unique combinations of crop diversity attributes could be constructed if we use full factorial design[7], but it might be difficult for both the researchers and respondents to handle. Thus, the study useda fractional factorial design at which the main effects were analyzed. Using fractional factorial design, which takes only into account main effects, results in loss of information. However,the main effect explains 80% of the variation of the case under investigation (Louviere et al. 2000). Based on orthogonalization[8]and balancing[9], 16 pairwise crop attribute combinations were formed. When the choice experiment design is both orthogonal and balances it represents 100% efficiency or D- efficiency. The more efficient the more information content in the choice experiment indicating attributes is not correlated and model estimates become consistent and efficient (Kuhfeld, 2006).

[7] 4^4*2^2(four factors or attributes with 4 levels and twofactors with levels) = 1024

[8]Orthogonalization is a situation where the variations of the attributes of the alternatives are uncorrelated in all choice sets.

[9]Each levels of each attributes have equal chance of occurrence or existence

According to Louviere et al (2000), the number of choice sets between 4 and 16 is generally considered as efficient. Thus, 16 pairwise combinations are randomly blocked into 2 blocks, with 8 choice sets of each block. Given these respondents are presented 8 choice sets each with two alternatives (alternative 1 and alternative 2) and the status quo option is included as the third option. Status quo option is included to ensure theoretical validity of welfare estimates and improve the efficiency of estimated parameters. for all attributes status quo takes zero value i.e. there is no improvement in farming system.

Table: 3.2. Sample choice set

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	5 crops	20 crops	0
Landrace	Yes	No	0
Crop type	combined	horticulture	0
Yield per hectare	35quintal	83 quintal	0
Organic farming	yes	no	0
The net benefit of crop production	25000Birr/year	18000 Birr/year	0
I prefer (please tick in the box)	☐	☐	☐

3.5.1.2. An empirical model of discrete choice experiment

Lancaster proposed that a consumer generates utility both from the good themselves and the attributes it provide. Let a farm family's choice of different attributes of crop diversity and utility depends on choice set, C which includes all possible alternatives. Farm family's utility function following Hensher et al. (2005) can be specified as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \qquad (3.11)$$

Where $U_{ij}$is the utility that individual iderive from alternative attribute j. $V_{ij}$is the attributes of crop diversity and $\varepsilon_{ij}$is random error term that indicates unknown factors about respondent i that cannot explained by attributes in alternative j.Given the above formulation, the probability that any respondent prefers alternative (j) in the choice set to any alternative option (k) of different groups of crops was expressed as:

$$P_{ij} = prob\big(U_{ij} - U_{ik}\big) > (\varepsilon_{ik} - \varepsilon_{ij}) \quad where\ j \neq k\ and\ k \in C \qquad (3.12)$$

3.5.1.3. Conditional logit model

The conditional logit model is used to analyze the choice of an individual among a set of alternatives. Conditional logit models are appropriate when a different class of models in which choice among alternatives is treated as a function of characteristics of environmental goods that we are interested in, rather than the characteristics of individuals making the choice.Another useful feature of a CLGT model is its ability to allow for differences in the available alternatives among individuals (Hoffman and Duncan, 1988). Conditional logit model was analyzed based on the prior assumption that attributes characteristics have a linear relationship in variables and parameters, and the error term follows extreme value type I distribution (Green, 1997; Heckman, 2006).The rationale to use conditional logit, model is because it takes into account correlation problems of attributes.

Following Heckman (2006) conditional logit model is derived from a random utility model. Assume that utility of farm household depends on choice set C with element (‘’x_{ij}’’) and household characteristics (Si), which comprises all options in crop attributes. Thus, farm households were assumed to have a utility function of the form:

$$U(S_i, X_{ij}) = V(S_i, X_{ij}) + \varepsilon(S_i, X_{ij}) \quad (3.14)$$

Where U is the utility of farm households i received from alternative j. X_{ij} represents values of attribute i in alternative j and it assumes different values for each alternative. Theprobability that farm household choose alternative j over another attribute k is:

$$P_{ij} = prob(U_{ij} - U_{ik}) > (\varepsilon_{ik} - \varepsilon_{ij}) \quad where\ j \neq k\ and\ k \in C \quad (3.12)$$

Finally, econometrics estimable model of the conditional logit model is specified as follows

$$P_{ij=} \frac{e^{V_{ij}}}{\sum_i^n e^{V_{ij}}} \quad 3.13$$

Then using the above formula conditional random utility was estimated using NLOGIT 5.0 econometrics software.For the purpose of this study, conditional logit model takes the form:

$$V_{ij} = ASC + \beta_1 * CSD + \beta_2 * LR + \beta_3 * OF + \beta_4 * CT + \beta_5 YLD + \beta_6 * NB + \varepsilon_i \ (3.14)$$

Where V_{ij} is indirect utility function for farm household i for alternative J =1, 2, 3. Where alternative specific constant (ASC) shows the average effect of any attributes not included in the model on utility.ASC takes the vaue 1 for either of alternatives chosen other wise zero for status quo. β_1-β_6 coefficients of crop attribute (crop species diversity, landrace, organic farming, crop type, expected yield and net benefit).For a given household (farm family), social and economic characteristics are constant across alternatives. Thus,the study used it only as interaction terms. After the estimation of parameters from cona ditional logit model, it is possible to obtain the welfare measure using the model:

$$CS = \ln \sum_i^n e^{Vi1} - \ln \frac{\sum_i^n e^{Vi0}}{\alpha} \qquad (3.15)$$

for linear utility index, following Hanely et al. (2001) marginal values of particular a attribute is reduced as

$$CS = -1\left(\frac{\beta attribute}{\beta monitaryattribute}\right) \qquad (3.16)$$

It is the marginal welfare measure of WTA or WTP, which measures the amount of income deducted/given from/to a farm household to make his/her utility to equal the level of utility before changes when improvement/environmental damages occur. Where α is Monetary attributes in the choice experiment (marginal utility of income), $V_{i1}$and V_{i0} are indirect utility after and before changes under consideration respectively and CS is compensating surplus. When estimating conditional Logit model the distribution of error term imposes independence of irrelevant alternative (IIA) assumptions[10]. This assumption would violate, which makes conditional logit results biased estimates (Bateman et al., 2003). Hence, the study used random parameter logit model and interaction terms of crop diversity attribute and socio-economic characteristics to compare the results with basic conditional logit model.

Random parameter logit model is given by

$$U_{ij} = V_{ij} + \varepsilon_{ij} = Z_j(\beta + \eta_i) + \varepsilon_{ij} \qquad (3.17)$$

---

[10]IIA assumption means the relative likelihood of two alternatives being chosen are independent of other alternatives.

Where U_{ij} is the level of utility that respondent i receives from attribute j, Indirect utility is assumed to be a function of the choice attributes Z (as well as of social and economic characteristics S, if included in the model) with parameters β, which due to preference heterogeneity may vary across respondents by a random component η_i . By specifying the distribution of the error terms e and η_i the probability of choosing j in each of the choice sets can be derived With accounting for unobserved heterogeneity

3.5.3. Model specification for determinants of agrobiodiversity

Determinantsforinterspecies diversity of cereals and horticultural crops were analyzed. Count number of crops and Margalef index of crops were used as diversity index. Countnumber of cereal and horticultural crop diversity was analyzed using Poisson regression model and Margalef index of crop diversity was analyzed by using Tobit regression model.both models were adopted from Verbeek (2004) and detail of them was discussed below.

3.5.3.1. Poisson model

Poisson regression is similar to regular multiple regressions except that the dependent (y) variable is an observed count that follows the Poisson distribution. Thus, the possible values of y are the non-negative integers: 0, 1, 2, 3…, poison regression is a suitable to model to quantify the relationship between count dependent variable and explanatory variables like the number of crops grown onhousehold's farm in each crop type, (Verbeek, 2004)). He also supposed that for such types of data the goal of Poisson regression is explaining the distribution of Yi given a set of explanatory variable X_i. Following his idea expected values of the number of crops that farm households, produce during production process given explanatory variables is specified as:

$$E\{y_i|Xi\} = e^{\{X_i\beta\}} \qquad 3.21$$

Since Y_i is non-negative, functional form that produces non- negative conditional expectation is required, which depends on the count variable following Poisson distribution. Thus, The Poisson regression model is the development of the Poisson distribution to a non-linear regression model of the effect of independent variables xi on a scalar dependent variable y. The density function for the Poisson regression is given as:

$F\{Yi|Xi\} = e^{-\mu i} \mu i^{yi} / y_i!$ *whrere* $E\{y_i|Xi\}_{=} \quad e^{\{X_i\beta\}}= \quad ,!= factorial$ 3.22

This means the mean of poison distribution is a function of explanatory variable x and the parameter estimates of β. The marginal effect of the Poisson model was interpreted as the proportionate change in the conditional mean if the repressor changes by one unit.

$$Bj=\frac{\frac{\partial(\frac{y}{x})}{\partial XJI}}{E(Y/X}$$ (3.23)

Though using count number of crop species as diversity measure is simplest, most practical, and objective measure of crop diversity it lacks theoretical elegance and it does not consider spatial diversity measures. As supplementary to count a number of cereal cropsMargalef diversity index was usedMagurran (2004). Detail of margalef index and its estimation techniques is discussed below.

3.5.3.2. Tobit regression model

Margalef diversity index is tried to compensate sampling effects by dividing the number of species S by the total number of individuals in the sample.

$D = \frac{S-1}{lnN}$ $where\ S =$Number of crops in the i^{th} crop type and LnN= sum of total number of crops produced by i^{th}household. For farm households who produces only one crop, margalef index take the value 0 and its value is positive for farmers producing more than one value.

In certain applications, a substantial part of the dependent variable will take the value zero, but positive for the rest of the population (sample). The Tobit model is used given that there is censoring from below (left censored).Tobit model is suited to deal with these types of variables. James Tobin (Tobin, 1958) suggested the original Tobit model. Hence,the left censoring Tobit model following Verbeek (2004) is specified as follows:

. $Di* = Xi\beta + \varepsilon i,\ i = 1,2,3,\ldots N$

$Di = Di*, \text{if } Di* > 0$ (3.21)

$$\mathrm{Di} = 0, \text{if } \mathrm{Di} * \leq 0$$

Where DI = Margalef index of crop diversity for i[th] household computed as Di = $\frac{\{S-1)}{LnNi}$. The values of margalef index for farm a household producing only one crop is zero.

where S = number of crops in the I[th] crop type and LnNi= sum of the total number of crops produced by i[th]household

Xi = is a vector of explanatory variables

β = vector of coefficients

ε_i = is the error term where $\varepsilon_{i\sim(0,}$ δ2)

Di* = is the latent variable which is not observed when it is less than or equal to zero but is observed if it is greater than zero

Hence the model describes two things

One: the probability that Di = 0 gives (Xi) as:

$$\mathrm{p}\,\{\mathrm{Di} = 0\} = \mathrm{P}\{\mathrm{Di} * \leq 0\} = \mathrm{p}\{\varepsilon\mathrm{i} \leq -\mathrm{Xi}'\beta\} \qquad 3.32$$

$$P\{Di = 0\} = P\{Di * \leq 0\} = P\{\varepsilon i \leq -Xi'\beta\}$$

$$P\{\frac{\varepsilon i}{\sigma} \leq -\left\{\frac{Xi'\beta}{\sigma}\right\} = \Phi\left\{-\frac{Xi'\beta}{\sigma}\right\} = 1 - \Phi\left\{\frac{X'\beta}{\sigma}\right\} \qquad (3.33)$$

Two: the distribution of Di given that it is positive. This is truncated normal distribution with expectation.

$$E\{^{Di}/_{Di} > 0\} = Xi\beta + \mathrm{E}\{^{\varepsilon\mathrm{i}}/_{\varepsilon\mathrm{i}} > -\mathrm{Xi}'\beta\} = \mathrm{Xi}'\beta + \sigma\frac{\phi(\mathrm{Xi}'\beta/\sigma\}}{\Phi\{^{\mathrm{Xi}'\beta}/_{\sigma}\}} \qquad (3.34)$$

3.6. description of Dependent and independent variables used in poisson and tobitmodel

3.6.1. Summary of Dependent variables

Variables	Diversity measure	Unit of measurment	Estimation methods used
Count cereal	Species diversity of cereal (S)	Number of cereal crops	poisson
Count horticulture	Species diversity of horticulture (S)	Number of horticulture crops	poisson
MICD	Richness indice	Margalef index(D) = (S- 1)/lnN	Tobit
MIHD	Richness indice	Margalef index(D) = (S -1)/lnN	Tobit

Note: micd is the value of Margalef index of cereal crop diversity that each farm household produces.
Mihd: is the value of Margalef index of horticultural crops that farm households produce.
N is total number of crops a farm household produced

3.6.2. Definitions and expected signs of explanatory variables used in the regression ofPoisson and Tobit models.

Gender: it is the gender of the household head. It takes the value 1 for female-headed households and zero for male-headed households. In the Ethiopian context, the types of crops and the area each crop covers is usually determined by the decision of household heads. in addition, the head of the household is either housewife or husband and husbands are usually responsible for the works related to farms at the field (far from home), while housewives are usually responsible for growing of crops near to home(backyard or home garden). Moreover, horticulture crops are usually cultivated at the backyard of the house of farm households and cereal crops cultivated at the field. Hence, it expected that cereal crop, diversity increase with male-headed households, and horticulture diversity increase with female-headed households.

Age is the age of farm household head. It isa continuous variable. At older age of farm household head the number of hours/days that he/she will stay at home increases. Thus, it is expected that the cereal and horticulture crop diversity have negative and positive relationships with the age of farm household respectively.

Education (Edu): it measures the maximum level of education that farm household head completed. For the purpose of this study, education is considered a categorical variable. It takes the value 1 for farm household head completed grade 1 -4, 2 for farm household head completed grade 5 – 8, 3 for farm households completed grade 9 -12, and 4 for farm household head completed college diploma and above. As the level of education that household head completes increases, he/ she willacquireknowledge about the role, causes for loss and consequence of biodiversity and cultivate diversified crops. On the other hand, as education level increases, farm household will produceuniform crops. Hence, it expected that education would have either a positive or negative effect on the diversity of both cereal and horticulture crop diversity.

Household size (hhsize):it is a member of the farm household usually live in the house. it is a continuous variable. As a member of household increases, farm households can easily access labor and produce diversified crops. On the other hand, as a member of household increase, they will produce highly productive, but uniform crops, which require more labor forces. As a result,a household member could have either positive or negative effects on both cereal and horticulture crops.

Awareness: it indicates whether a farm household head has knowledge on the role of agrobiodiversity and consequences for its loss. it takes the value 1 for farm household head having knowledge and 0 otherwise. The researcher expected that there could be a positive association with crop diversity of both cereal and horticulture.

Livestock: it is the total number of livestock (bulls, cows, oxen, male young, sheep, goats, horses, donkeys, and others). It is a continuous variable and changed into the same units by using tropical livestock unit[11]. Aanumber of livestock that a farm household own increases, it supplies input for the production of crops in the form of animal dung and manure. On the other hand, an increase in livestock may be considered by farm housed as insurance against crop failure and reduce the number of crops. Hence, it is expected that livestock has a positive association with cereal and horticulture crop diversity.

11

Oxen: it is the number of oxen used to plough farmland including cows that a farm household has. It is a continuous variable. Farm households having more oxen can plough farmlands frequently, and cultivate crops timely, so they could produce more diversified crops.

The proportion of irrigation land (Pi): Is a continuous variable measured as the ratio of irrigated farm size to total farm size and it took a value 0 for households who did not access irrigation water. A Farm household who can access irrigation water produces more than once per year. It is expected that as a proportion of irrigated has positive associations with both cereal and horticultural crops.

The type of the soil(soiltype): is an important variable, which determines the types and inturn number of crops that farm household produces. It takes a value 1 for farm households having farmlands with Nitosols and zero otherwise.The researcher expected that having farmlands with Nitosols increases both cereal and horticulture diversity.

Income is the amount of income that a farm a household receives in the form of remittance, aid, and a gift from family members who live in urban areas or out of the country. It is a continuous variable. Theoretically, as income in the form of remittance increases, farm households may feel wealthier and prefer more leisure and produces, in turn, produces low diversified crops. However, in Ethiopia farming is at the subsistence level, so as income increases farm households may use the income to purchase inputs for crop production. Hence, it is expected that an increase in income leads to an increase in the diversity of both cereal, and horticulture crops produced.

Distance to nearest market (mktdis): is the distance between the home of farm household and nearest market measured in kilometer. It is a continuous variable. Living far from the market to purchase or sell the types of crops and other consumption goods make the cost of traveling to the market increases. Thus, as farm households live far from the market produces more diversified crops particularly for horticulture crops, because farm households produce horticulture crops for sale.

Household plot distance (haploids):is a continuous variable, measured in a kilometer, representing the average distance between farm household home to farm plot. An increase in the average distance makes the production of horticulture crops difficult because the production of horticulture crop requires continuous employment of labor on the farm. Consequently, average plot distance is expected to have a positive association between cereal crops and a negative relationship with horticulture crops.

A number of plots (numplot): is another important variable determining crop diversity. It is a continuous variable representing in how many different places that a farm household owns farmland. If a farm household owns a large number of plots, he/she will access different agro-ecologies suitable for different types of crops. As a result, it was expected that farm households with more number of plots would produce more diversified crops.

Farm size: is a continuous variable, measured in number of Gemed's[12] of farmland. as farm size increases farm households can produce more diversified crops.

Extension workers (ES): is a dummy variable representing whether a farm household contacts with agricultural extension workers. It takes a value 1 for farm households meet with extension workers and zero otherwise. However, the activity of extension workers is determined by agricultural policy, in Ethiopia in terms of agro-biodiversity conservation extension workers overlooked their role. This is because of extension workers advice farmers on how to use high yielding modern varieties instead of traditional crops. Hence, it was expected that farmers contact with extension workers lower crop diversity.

Improved seed used on the farm (implied): is another important variable, which determines the diversity of crops. For a farm, household applied improved seed on their farm plot it takes a values 1 and zero otherwise. Improved seed affects the diversity of crops in two ways. First, the types of crops at which improved seed is applied increase the area share and lower the area share of other traditional local varieties. Second improved seed causes dissemination of local varieties. It was expected that improved seed application on farm reduces both cereal and horticultural crops.

technology index(index): is continuous categorical variable measured as an index using the number of agricultural technology inputs that farm households produce. for instance farm

[12] is traditional unit of measurement of farm size (4 gemeds of farm land = 1 hectare)

households use pesticide, chemical fertilizer, chemical herbicide on his/her farmland is considered as a farm household uses three agriculture technology inputes and the index takes the value 3. it is expected that as farm household uses more and more of agriculture technology products crop diversity decreses.

3.7. Diagnostic tests

3.7.1. after tobit model

Before reporting regression result of Tobit model diagnostic tests such as assumptions of normal and Homoskedasticityof error term were tested because these two assumptions are the main concern (Verbeek, 2004). Conditional moment test described by Pagan and Vella(1989) is used to test both assumptions. However, it does not show either one or both assumptions should be rejected. To avoid this problem an alternative test, theHausmantest, was used. To compute Haussmann test statistics symmetrically censored least square (SCLS) regression, which is consistent under Heteroskedasticity and non- normality was compared with the tobit regression model. In addition, Cameron and Trivedi's decomposition of information matrices test wasused.

3.7.2. after poisson

one of the important assumption under poisson regression model is over-dispersion. In this study over-dispersion assumption is tested by using Pearson and Deviance goodness of fit tests.

CHAPTER FOUR

RESULTS AND DISCUSSION

This study used primary data collected from 200 farm households. The data were collected from 2 woredas of west Gojjam in Amhara region. In this chapter, both econometrics and descriptive statistics about farmer's economicvaluation ofagro biodiversity at the household level and determinant factors of the crop (horticulture and cereal) species diversity were analyzed.

4.1. Descriptive statistics for both explanatory and dependent variables

4.1.1. Dependent variables

The current study used a count number of crops and Margalef index of crop species diversity as the dependent variable. For the whole sample farm households on average produces 2.87 cereal crops. While the Margalef index shows a mean value of 0.82 with maximum value of 1.72. In Bahir Dar Zuria farm households on average produce 2.98 cereal crops. While in Bure Woreda average cereal crop produced by farm household is 2.76.Margalef- index of crop diversity for different groups of crops are different in the two woredas. For instance, Margalef index for cereal crop diversity in this woreda shows mean values of 0.911 with a maximum value of 1.69. But in Bure Woreda the average value of Margalef index is 0.731 with a maximum of 1.72.

Fruit and vegetable diversity in both Woredas, the maximum and the minimum number of horticultural crops grown in each farm household's plot are the same. However, Margalef index shows horticultural crops are more diverse in BureWoreda as compared to Bahir Dar Zuriaworeda. On average 2.91 and 2.92 numbers of horticultural crops are grown in Bure and Bahir Dar Zuria Woreda repectively. Margalef index shows maximum value is1.78in Bure and 1.74 in Bahir Dar ZuriaWoreda with mean value of 0.88 in both Woredas.

Table: 4.1. Summary statistics of dependant variables

Variables	**obs**	**mean**	**Std.dev.**	**Min.**	**Max.**
Cereal	99	2.89		1	5
Margalef index of cereal crop	99	0.88	0.388	0	1.74
Fruit &vegetable	99	3.051	1.12	1	5
Margalef index of Horticulture crop	99	0.97	0.44	0	1.74
Cereal	101	2.931	1.14	1	5
Margalef index of cereal crop	101	0.904	0.474	0	1.92
Fruit &vegetable	101	2.921	1.163	1	5
Margalef index of Horticulture crop	101	0.87	0.46	0	1.61

From the total 200 respondents, 19(9.5%) farmers produced only 1 cereal crop and 69 (34.5%) produced 2 cereal crops. The remaining 44 (22%), 47(23.5%) and 21(10.5%) respondents produce 3, 4 and 5 cereal crops respectively. The majority, 80 respondents produces 3 (40%) horticultural crops followed by 45(22.5%) respondents producing 2 fruit and vegetable diversities. The remaining 28 (14%), 27(13.5%), and 20 (10%) respondents produce 4, 5, and 1 horticultural crop.

Table: 4.2. Frequency table of different groups of crops

	Cereal crop diversity					**Horticulture crop diversity**				
	1	2	3	4	5	1	2	3	4	5
frequency	19	69	44	47	21	20	45	80	28	27
percentage	9.5%	34.5%	22%	23.5%	10.5%	10%	22.5%	40%	14%	13.5%

4.1.2. Descriptive statistics for explanatory variables

i. Descriptive statistics of dummy explanatory variables

Respondents interviewed about their socioeconomic characteristics.As revealed belowin table 4.3.Among the total samples of 200 respondents 185 (92.5%) are male. Only 35 (17.5%) respondents have knowledge about the role, cause and consequence of agro-biodiversity, which indicates agricultural policy focusing on high yielding crops and supports farmers on how to use agricultural technology inputs instead of giving advice on conservation of biodiversity. Farmers also asked about the types of soil of their plots. The response shows 113 (56.5%) respondent have the type of farmland with Nitosols. Finally, respondents revealed that 171 (85.5%) are agricultural technology (improved seed) adopters.

Table: 4.3. Frequency table of dummy variables

Dummy variables	Frequency	%
Gender(male)	185	92.5
Awareness(yes)	35	17.5
Soli type(red)	113	56.5
Improved seed use(yes)	171	85.5
Contact with extension workers(yes)	94	47

Source: source own computation-using stata 14.2

ii. Summary statistics for continuous explanatory variables

The average age of respondent is 44.6 with a minimum age of respondent 28 and maximum age 56. Households live far from the average distance of 2.1 km with a minimum distance of 1 km and a maximum distance of 3.5 km. respondents have average farmland holding of 7.23 Gemed's lands with minimum land holding of 1 Gemed and maximum land holding of 12.

All livestock assets are changed in to a single unit using tropical livestock unit. In the study area,the average livestock that farm households own is 9.18 with maximum of 20 livestocks. Average household size is 5.52 with minimum and maximum 1 and 10 respectively. Households grow crops walking a maximum average distance of 3 km with a mean average of 1.25 km distance from home to plot field. Farm households adopt agricultural technology inputs. On average households adopt three agricultural technology with maximum adoption of four technology and minimum of nothing. Households on average own 2.64 oxen with a maximum of four oxen and some households do not own oxen. Geographically far households own both steep and flat plots of farmland. On average 0.213 size of the farm is flat with maximum proportionof0.5 farm size. Household grow crops in different fields (plots). On average farm households, own farmland at 3.21 different fields with maximum 9.Not all farm households accessed irrigation water. Among farm households accessed irrigation on average 0.213 gemed's of their farmland is cultivated by irrigation with a maximum of 0.5 of total farm size.

Table: 4.3. Summary statistics of explanatory variables

Variables	Mean(SE)	minimum	maximum
Age	44.55(6.56)	28	56
Market distance	2.1(0.75)	1	3.5
Farm size	7.23(3.12)	1	12
Livestock	9.18(12.17)	0	20
House hold size	5.52(2.4)	1	10
House hold plot distance	1.25(0.711)	0	3
Technology index	2.75(0.87)	0	4
Oxen	2.635(1.1)	0	4
Income	2131.6(1186.9)	0	5400
Average slope of farm land	0.23(0.1)	0	0.5
Irrigation land proportion	0.213(0.134)	0	0.5
Number of plot	3.21(1.51)	1	9

Note: SE is a standard error in parenthesis, Source: source own computation-using stata 14.2

4.2. Empirical analysis choice experimentresults

Using 100% D-efficiency experimental design 16 choice sets blocked into 2 blocks. To increase the variability of choice sets each block were randomized 2 times so that only 50 respondents were asked to complete the same choice sets. Since 200 respondents were interviewed using face-to-face interview and each respondent completed eight consecutive choice sets resulted ina total sample of 1600 observations. In addition, attribute levels are coded and entered into NLOGIT 5.0 econometrics software packages for estimation purpose.

The data were coded according to the levels of attributes. For organic farming attribute, organically produced crops were entered as 1 and those crops that were not produced organically were entered as -1. In addition, for landrace attribute, those crops that contained landrace were entered as 1 and those crops without landrace entered as -1. The levels used for crop species diversity and net benefit attributes were entered in a cardinal form. Consequently, the crop species diversity attributes took four levels (5, 10, 15 and 20 number of crops). Net benefit attribute has also four levels. These are 15000, 18000, 20000 and 25000ethiopian birr per year from the total crop production. Another attributes used in the estimation of the model are crop type and yield attributes. Crop type attributes took levels 1 for cereal crop, 2 for horticultural crops, 3 for other crops and 4 for combined crops. Finally yield[13]attribute took four levels. These are 16, 35, 56 and 83 quintals per hectare.

4.2.1. Conditional logit model estimation for the pooled (both Woredas)

4.2.1.1.Test of independent of alternative assumptions

The result of the conditional logit model is based on the assumption that an alternative to be chosen is independent of another alternative.This assumption is tested by using Mcfadden's test of independence of irrelevant alternative by excluding each alternative systematically and running separate regressions. The test was conducted on the hypothesis that Ho: restricted model is consistent and efficient, while the unrestricted model is consistent but inefficient. Under Ha: unrestricted model is consistent and efficient estimates.IIA assumption is tested and reported in Below Table 4.4 and 4.5 for both with and withouit ASC[14] respectively. In all cases,the critical value is less thanthe calculated chi-square value. Therefore, reject Hoso that IIA assumptions are violated for excluding both alternative 1 and 2 and with and without alternative specific constants. This implies conditional logit model

[13]Yield attribute is depending on the average crops produced per hectare per types of crops.

[14]Alternative specific constant is dropped to avoid singularity problems. Rolfe et al. (2000) suggests that since the ratios of different model parameters are consistent hausman test is valid though constant term is dropped.

ismisleading. This problem could be solved by either using a random parameter logit model or adding household and decision-maker characteristics into regression results as interaction terms. The two models were discussed below under 4.2.4.

Table: 4.4. IIA test for the pool of two districts with ASC

Excluded alternatives	Chisqrd	df	Pr(C>c)	IIA assumption decision
Alternative1	144.3246	7	0.0000	Rejected
Alternative 2	128.33	7	0.0000	rejected

Table4.5. IIA test for the pool of two districts without ASC

Excluded alternatives	Chisqrd	df	Pr(C>c)	IIA assumption decision
Alternative1	49.3528	6	0.0000	Rejected
Alternative 2	90.8178	6	0.0000	rejected

Source: own computation using Nlogit 5.

4.2.1.2. Conditional logit model

One of the assumption underlines choice experiment study is that observable utility function follows strictly additive form. As presented in Table 4.6of column 2 below all parameters of conditional logit estimate except the coefficients of crop type attribute are statistically significant at 1%. Crop type attribute is statistically significant at 10% level of significance. The result indicates that farmers have a positive preference for the proposed options.

All attributes have expected signs. The result indicates that more diversified crop production accompanied by traditional crop variety increasesthe utility of farm households. Inaddition,the utility of farm household increases with production of organic farming, the types of crops produced, and expected yield, particularly the coefficient of organic farming is the highest. Conventional farming is blamed for land degradation and soil erosion. In addition, it is criticized for affecting the health of human beings and other ecosystems. Organic farming with the use of organic inputs or nutrients is a type of farming proposed for a sustainable strategy producing healthy, restoring soil fertility and mitigating the environment. Moreover, farm households were asked about their preference for organic farming. Around 70% of the respondents preferred organic farming. Though they are prefer organic farming, farmhouseholds are not using organic agricultural inputs, because they believe that since the land is adopted chemical fertilizer, if we use organic farming, there may be crop failure and lower productivity (risk averse). Ijn line with this Scialabba (2003)suggests that in developing countries like Ethiopia where farm households have no economic means to purchase chemical inputs (chemical fertilizer, pesticide) adoption and expansion of organic farming is fundamental.

The result also indicates that the utility of farm households increases with an increase in the number of crops produced. This is because, farmers are better off if they have a large number of crop diversity in terms of culture, nutritious food, and the resistance of crops for climate variability. Moreover, farm households in the study area prefers to produce more diversified crops i.e. farmers are more willing to produce combined crops of cereals, horticultural crops and other crops instead of producing only cereal or horticultural crops. Finally, farm households preferand attach highest values for traditional crop varieties. However, the current agriculture system of expanding the supply of chemical fertilizer and improved seed in Ethiopia including the study area lowers the contribution of farmer's in situ conservation of biodiversity through the substitution of traditional crop varieties by modern, but uniform crops particularly for few crops like teff and maize.

ASC has negative sign and statistically significant at 1% significance, so attributes included in this model explains the variations of utility. the negative sign of ASC also indicates farmers are highly responsive to change in the choice set quality and they made decisions closer to both rational choice theory and the behaviors observed in reality(Kontoleon, 2003 cited in Birol,2004).

4.2.2. Comparison of preferences across woredas

Because of differences in market, agro-ecological and economic conditions across woredas, it is expected that farm households in different woredas are expected to face different trade-offs in the production of crops. Testing this difference may have important effects for the operation of cost-efficient and effective crop production and agricultural biodiversity conservation (Birol, 2004). To test whether or not a set of parameter estimation of the pooled conditional logit estimates are shared across the two distinct woredas, separate conditional logit models were estimated for each woreda and Swait Louviere log-likelihood ratio test was used, which has asymptoticx^2 chi-square distribution.

It is expressed as X^2=-2(LL_p – LL_i), where LL_p is log likelihood statistics for conditional logit estimates of the pool of the of the two woredas. While LL_i refers to log likelihood, values of conditional logit model estimation by districts. Conditional logit estimates of Bure and Bahir Dar Zuriya Woreda presented column 3 and 4 of table 4.6 below. Log-likelihood ratio test value[15] is larger than the critical value of chi-square distribution at 7 degrees of freedom and 5% level of significance. Hence, a parameter estimate of the pool is not shared across Woredas with similar effects. Furthermore, to make a pair wise comparison between the two woredas the same test was conducted. The result also shows the log likelihood ratio test is 94[16] again greater thanvalue of chi-square distributionat 5% level of significance. This justifies the preference of farm households in the two woredas are heterogenous.

In Bure Woreda, crop species diversity, organic farming and net benefit attributes of crops are positive and statistically significant. Indicating farm households have a large demand for a number of crops produced by using organic inputs, which may increase net benefit in markets where organically produced crops have a higher market price as compared to none organically produced crops. There is no significant demand for types of crops produced, landrace crop production and expected yields are evident in the woreda. in spite of the fact that in Bahir Dar Zuriaworeda, crop species diversity, landrace, expected yield and crop types are statistically significant attributes affecting demand for crops positively.

Table: 4.6. Conditional logit estimates of the pool and each woreda

Attributes	pool	Bure	Bahir Dar Zuria
	Coefficient (se)		
Alternative specific constant	-.826***	-1.2203**	.64791
	(0.28572)	(.55811)	(.57818)
Crop species diversity	.1963***	0.02474**	.08441***
	(0.00587)	(.01140)	(.01467)
Landrace	0.31684***	-0.08121	.082773***
	(0.05897)	(.10461)	(.12997)
Crop type	0.05652*	0.01476	0.024485***
	(0.03162)	(.06347)	(.06046)

[15]LR = -2(-1635.664-(-832.612+-785.54) = -2(1635.664+1618.152) = -2(-17.5) = 35 > chi2 (7) = 14.067.

[16] LR=-2(-832.612-(-785.54) = -2(-832.612+785.54)=-2(-47.072)= 94.144.

Expected yield	0.14411***	0.02109	0.21388***
	(0.03072)	(.05708)	(.05787)
Organic farming	0.28677***	0.34284***	.10393
	(0.05897)	(.10783)	(.10835)
Net benefit	0.54317D-03***	0.58395D-03***	.23670D-03
	(0.54137D-04)	(.2092D-04)	(.1843D-04)
Number of respondents	200	100	100
Number of observation	1600	800	800
Log likelihood function	-1635.66365	-832.61154	-785.5395
R-sqrd (R2Adj)	.0350(.0329)	0.0799(0.0712)	0.0729 (0.0689)
AIC(AIC/N)	3285.3(2.053)	1679.2(2.099)	1585.1(1.981)

Note: ***, **, * ==> Significance at 1%, 5%, and10% level. nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx. The standard error in parenthesisSource: own computation using NLOGIT 5.0 Econometrics software

4.2.3. WTA values for each crop attributes for the pool and by Woredafrom conditional logit estimates

Net benefit attribute, which is a proxy for monetary attribute, used to compute welfare change represented by WTA values. this is because net benefit is represents benefit rather than cost. hence WTA value is trade of or marginal rate of substitiution between monetary attribute and any other attributes under consideration. WTA value compensations for each attribute computed by dividing the coefficient of the attribute by monetary attribute reported below in table 4.7. In this paper, the monetary attribute is net benefit coefficients.

Table: 4.7. WTA values of each attribute (birr/year)

Attribute	Pool	Bure	Bahir Dar Zuria
Crop species diversity	361.4	42.4	356.61
Landrace	585.32	------	349.7
Organic farming	528	587.12	----
Crop type	104.1	-------	103.44
Expected yield	265.36	------	903.6

Source: own computation
Note: ----- indicates the demand for the attribute is statistically insignificant at 5% level of significance

In the study area, farm households attach highest values for traditional crop varieties followed by organic farming, crop species diversity,expected yield and types of crops producedrespectively. When we compare the two Woredas, Bahir Dar Zuria Woreda farm households attach highest private values for expected yields followed by crop species diversity, traditional crop varieties (landrace), and crop type attribute. While in Bure Woreda farm households attach highest private values for organic farming, which is proxy for soil microorganisms, followed by crop species diversity. The result suggests thatfarm households preference ordering about crop attributes is different across woredas and willingness to accept values of the pooled regression result do not share equally across woredas.

4.2.4. Accounting for preference heterogeneity

Analysis of conditional logit model depends on the assumption that farm households across different woredas have homogeneous preferences. However, in reality, farm households at different Woredas might have heterogeneous preferences. Taking into account this heterogeneity enables us to get consistent and unbiased estimates of individual preference (Green, 1971). Henceto take in to account theproblem of preference heterogeneity, random parameter logit estimation and conditional logit model with interaction terms were used. Both random parameter and conditional logit with interaction terms are discussed below.

4.2.4.1. Random parameter logit model estimates

All parameters specified as normally and independently distributed. The distribution simulation was based on 100 draws. The results of the random parameter logit model for the pool and by woredas presented below Table 4.8. To test whether there is a statistically significant difference between the random parameter Logit model and basic conditional logit model for both the pooled sample of the study area and Woreda level Swait Louviere log-likelihood ratio test was used. It is specified as; X^2=-2(LLr – LL_C) , where LL_r is log likelihood statistics for random parameter logit estimates and $LL_C$is log-likelihood statistics for conditional logit estimate.

The test statistics show that we reject the null hypothesis that the random parameter logit model for the pool and basic conditional logit models estimation coefficients are equal[17] . It

[17]For the pool LR = -2(-1635.664-(-1552.025)= -2(-1635.664 + 1552.025) = 162.28
For Bure woreda LR = -2(-832.612-(-787.76) = -2(-832.612 +787.76) = 89.7
For Bahir Dar Zuria LR =-2(-785.54-(-722.8) = -2(-785.54 + 722.8) = 125.48
CHI2 critical value at 14 degree of freedom and 5% level of significance is 23.685. Hence, for all Likelihood ratio test statistics is greater than chi2 critical value. Reject Ho.

implies using a random parameter logit model can improve model fit. In addition to this, random parameter logit estimates of the pool of the two Woredas and separate estimation result show that their is significant derived standard deviations indicating choice specific unconditional unobserved heterogeneity. Depending on this result, it is possible to conclude that the basic conditional logit model is not sufficient for the analysis of the data set collected and presented in this paper. As a result, WTA values computed from the basic conditional logit model is biased.

Random parameter logit estimate of the pooled shows all parameters are statistically significant andall parameter estimates have expected signs. ASC has negative coefficients indicating responsiveness of choice set quality. Separate random parameter estimates of the two Woredas also show there is unobserved preference heterogeneity.

Table: 4.8. Random parameter logit model

Attributes	Pool	Bure	Bahir Dar Zuria
	Coefficients(standard error)		
	Random parameters in utility functions		
Alternstive specific constant	-.58409*	-.98453	.79049
	(.31858)	(.64036)	(.66320)
Crop species diversity	.2141***	.03236**	.08611***
	(.00634)	(.01305)	(.01626)
Crop type	.08580**	-.02297	-.30741***
	(.04367)	(.07684)	(.08945)
Land race	.35816***	-.08453	-.090404***
	(.06366)	(.11733)	(.14232)
Expected yield	.15772***	.00749	.26952***
	(.03337)	(.06287)	(.06373)
Organic farming	.28063***	.41553***	.16786
	(.06974)	(.14459)	(.11904)
Net benefit	.6517D-03***	6967D-03***	.1986D-03
	(.1114D-04)	(.2322D-04)	(2122D-04)
	Derived standared deviations of parameter distribution		
NsASC	.97362***	1.17431***	1.37210***
	(.15197)	(.24902)	(.30445)
NsCSD	.00141	.01049	.00266
	(.00779)	(0.02087)	(.00898)
NsCT	.39368***	0.32318***	.54738***
	(.04262)	(0.06745)	(.08059)
NsLR	.01309	0.00717	.03039
	(.05813)	(0.10081)	(.08711)
NsYLD	.00965	0.02087	.00734

	(.02959)	(0.03962)	(.04434)
NsOF	.41110***	0.89449***	.07632
	(.07376)	(0.13629)	(.08961)
NsNB	.82631D-06	0.42570D-05	.14113D-04
	(.6730D-05)	(0.9770D-05)	.1123D-04
Number of respondents	200	100	100
Number of observation	1600	800	800
Log-likelihood function	1552.025	-787.8	-722.8
Chi squared [14 d.f.]	411.51	182.23	312.18
Significance level	0.0000	0.0000	0.0000
McFadden Pseudo R-squared	.12	0.104	.18

Note: ***, **, * ==> Significance at 1%, 5%, and10% level. nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.Standard error in parenthesis
Source: own computation using NLOGIT 5.0 Econometrics software

4.2.4.2. WTA values of random parameter logit estimates

Parameters of all attributes used in the model are statistically significant for both conditional and random parameter logit model. However, the values of coefficients (effect of attributes on demand for crops) for both models are different. Thus, it is important to compute WTA for each attribute after random parameter logit model and compare with WTA values for each attribute derived from the conditional logit model. WTA value of Random parameter logit model is reported below.

Table: 4.9. WTA values for each agro-biodiversity attributes for the pooled and by woreda derived from random parameter logit estimates.

Attribute	Pool	Bure	Bahir Dar Zuria
Crop species diversity	328.53	46.45	433.58
Landrace	549.58	------	455.21
Organic farming	430	596.43	----
Crop type	131.66	-------	1547.89
Expected yield	242	------	1357.1

source: own computation using NLOGIT 5.0 econometrics softawre

Since the difference between coefficients of conditional logit and random parameter logit model estimates are statistically significant and the fact that conditional logit model do not take in to account preference heterogeneity, WTA values for each attribute of the two models is different. Indicating that random parameter logit model fits well as compared to conditional logit model.Hence using basic conditional logitmodel without interaction termresults misleading and cost ineffective and inefficient policy options.

4.2.4.2.Conditional logit model accounting for preference heterogeneity

To analyze the effect of decision maker characterstics on demand for agro-biodiversity attribute conditional logit model with interaction termswas used. This is because the effect of social and economic characteristics on choice cannot be examined in isolation, but as an interaction term with choice attributes (Birol, 2004). If we include all household and decision, maker characteristics as interaction terms, the problem of multicollinearity may occur. To avoid this an auxiliary OLS regression was used and tested multicollinearity problem using VIF and only variables with the lowest VIF are included as interaction terms. Hence household size (HHSIZE), education (EDU), age (AGE) and income(Y) are included as interaction terms. For six agrobiodiversity attributes and four decision-maker characteristics 24 interaction terms were created. The result of a conditional logit model for the pooled of the two Woredas and separate estimates of each Woreda with interaction termsispresented below in Table 4.10 from column 2 – 4. Only interaction terms those are significant at 1%,5% and 10%level of precision with the two-tailed test are reported below.

Conditional logit estimates accounting preference heterogeneity reported in the second column of table 4.10 shows only household size, age of household head, and education are statistically significant. The demand for crop species diversity decreases with the number of household size. While crop species diversity increases with the age of household head. The demand for organic farming decreases with a number of household size and increases with the age of household head. In addition, the demand for organic farming increases with more education. This finding is consistent with the hypothesis that household heads with more education have more chance of acquiring knowledge the advantages of organic farming. Hence, households with more education prefer organic farming. The demand for crop type increases with the age of household head and decreases with household size.

Again, in BureWoreda, only age and household sizes are statistically significant. The demand for net benefit attribute is positive with moreeducation and household size. The crop type attribute is positive with increase in age and negative with more household size. Demand for organically produced goods increases with an increase in age and decrease with an increase in household size.

Table: 4.8. Conditional logit model accounting for preference heterogeneity for the pool and by woreda

Attributes	Pool	Bure	Bahir Dar Zuria
	Coeff(se)		
Alternstive specific constant	-2.90885*** (1.05696)	-4.97865*** (1.70669)	0.69925 (.58030)
Crop species diversity	0.04828* (0. .02595)	.04324 (.03898)	.09163 (.07290)
Land race	0.03500 (0.48922)	.12151 (.84069)	-.72905*** (.20831)
Crop type	-0.44629* (0.24994)	-.98293* (.56039)	-.24831*** (.06069)
Expected yield	0.41553* (0.24271)	.26824 (.44555)	.21446*** (.05810)
Organic farming	1.21419** (0.48947)	2.53800*** (.91762)	-.27776 (.60229)
Net benefit	0.49570D-04 (0. 4367D-04)	.00016** (.8085D-04)	.15512D-05 (.1850D-04)
Crop species diversity*household size	-0.00937** (0.00557)	----------	.00026 (.00370)
Crop species diversity*age	0.02435* (0.01345)	-----------	-.15032D-04 (.00148)
Organic farming* household size	-0.04134***-. (0.01369)	07695*** (.02912)	-.00607 (.03162)
Organic farming*age	0.01476*** (.00563)	.03271*** (.01167)	.01104 (.01262)
Organic farming*education	0.01617* (0.0088)	---------------	----------
Crop type*household size	-0.02839* (0.01369)	-.09635*** (.03532)	---------
Crop rtyep*age	0.01329** (0.00556)	.03343** (.01443)	-----------
Net benefit*education	----------	.32625D-05* (.1957D-05)	-----------

Net benefit*household size	----------	.90847D-05* (.4828D-05)	----------
Number of respondents	200	100	100
Number of observation	1600	800	800
Log likelihood function	-1629.83	-821.54	-779.654
R-sqrd (R2Adj)	.0384(.0339)	0.0308(0.0216)	0.08(0.07)
AIC(AIC/N)	3289.7(2.056)	1673.1(2.091)	1589.3(1.987)

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.The standard error in parenthesis
Source: own computation using NLOGIT 5.0 Econometrics software

4.2.5. Analysis of follow up (debriefing) questions

Respondentswere asked a follow up questions about the reason for choosing proposed options or status quo. Out of 200 respondents, 158 chose the new options (alternative 1 &2). Though there are no respondents, who chose only status quo for eight consecutive choice sets 42 respondents chose both status quo and new options depending on the combinations of levels for each attribute. Respondents who chose the status quo were asked why they chose the status quo option. The majority, 45.24%[18], explained that they do not believe that the new proposed option might be real. While 35.71% explained that the new proposed option requires higher investment cost and this is not affordable for us. The remaining 19.05% response showed that respondents are not willing to change their cropping pattern and production. They believe that they are satisfied with the current situation.

Respondents were also asked to explain the first priority that made them to choose newly proposed options. Among the total 158 respondents who didn't chose status quo, the majority, 47.47% of respondents were explained that they chose because of yield attribute followed by 33.54% of respondents chose a new proposition because of organic farming. While 18.99 respondents explained that they prefer because they opt for a number of crop species produced. The remaining respondents opteda new option because of local varieties (landrace) attribute.

Finally, respondents were asked about their first criterion for choosing either of the newlyproposed options. The majority, 31.65% attached the first priority for expected yield

[18] 46.75% is from respondents who opted for status quo, but not from the total sample.

followed by crop species diversity and organic farming attributes. the detail of farmers preference for each attribute is reported below.

	Debriefing questions	frequency	%
Reasons for choosing the status quo			
A	I don’t believe that the levels listed in each attribute will be real	19	45.24
B	Alternatives will require high investment in agriculture costs and I can’t afford it	15	35.71
C	I am not willing to change my production system and technology that I am using	8	19.05
	Total	42	100
Number one priority to choose alternatives other than the status quo			
A	Crop species diversity	30	18.99
D	Yield per hectare	75	47.47
E	Organic farming	35	33.54
	Total	158	100
the immediate criterion to choose either of the new proposed alternatives			
A	I always opted for the alternatives with higher crop diversity	45	28.48
B	I always opted for a total amount of crops produced	50	31.65
C	I always opted for organic production with natural fertilizers	25	15.82
D	I always opted and demanded traditional cultivars(Landrace)	20	12.66
E	I always opted for the type of crops produced	18	11.39
	Total	158	100

Source: own computation

4.3. Determinants of agro-biodiversity

4.3.1. Diagnostic tests

In certain applications, a substantial part of the dependent variable takes zero value, but positive for the rest of the population (sample). Tobit model is suited to deal with these types of variables. James Tobin (Tobin, 1958) suggested the original Tobit model. Before reporting regression result of Tobit model diagnostic tests were tested. Particularly assumptions normal and Homoskedasticity of error terms are the main concern (Verbeek, 2004). Conditional moment tests described by Pagan and Vella(1989) is used to test both assumptions. However, it does not show either one or both assumptions be rejected. To avoid this problem an alternative test, Hausmantest, is used. To compute Haussmann test statistics symmetrically censored least square (SCLS) regression, which is consistent under Heteroskedasticity and non- normality, is compared with the Tobit regression model. In addition, Cameron and Trivedi's decomposition of information matrices test is used.

The values of Margalef index of cereal and horticultural crops are greater than or equal to zero (for households producing only one crop). For Margalef index of cereal crop diversity, critical values of conditional moment test statistics for the hypotheses that HO: error term is normally distributed against Ha: error term is non- normally distributed computed by parametric bootstrapping method with number of replications of 150 shows critical values of 45.56 at 1% and 27.56 at 5% with calculated values of 14.41. This confirms that the error term is normally distributed. The Hausman test shows whether there is a significant difference in the coefficients of Tobit and SCLS regression. Ho: the difference in coefficients is not systematic. The value shows critical values of 1.00 confirming the Tobit model is consistent and efficient. Cameron and Trivedi's decomposition of information matrices test result shows p-value for Heteroskedasticity, skewness, and kurtosis is 20, 11.26, and 30.4%(See in appendix B2 and B3). All P-values are greater than 5%. So the result confirms that no Heteroskedasticity and error term is normally distributed (no kurtosis and no Skewness). A graph showing the distribution of the error term is presented in (Appendix B.8) .

For Margalef index of horticulture crop diversity, critical values of conditional moment test statistics for the hypotheses that HO: error term is normally distributed against Ha: error term is non- normally distributed computed by parametric bootstrapping method with number of replications of 200 shows critical values of 44.7 at 1% and 26.8 at 5% with calculated values of 25.55. This confirms that the error term is normally distributed. The Hausman test shows whether there is a significant difference in the coefficients of Tobit and SCLS regression. Ho: the difference in coefficients is not systematic. The value shows calculated values of 0.8029 confirming the Tobit model is consistent and efficient. Cameron and Trivedi's decomposition of information matrices test result shows p-value for Heteroskedasticity, skewness, and kurtosis is 46.67, 72.4, and 30.95% respectively (See also in Appendix B.5, B.7 and Appendix B.6 for hetrosckedasticity, im test and normality test). All P-values are greater than 5%. So the result confirms that no Heteroskedasticity and error term is normally distributed (no kurtosis and no Skewness) (See Appendix B.9).

normality test for both cereal and horticulture model estimates

		critical value			decision rule
model	bootstrap conditional moment value	1%	5%	10%	
micd	14.41	15.97	27.6	45.58	reject
mihd	25.55	16.39	26.8	44.7	reject
	Cameron & Trivedi's decomposition of im-test	Chi2	df	prob>c2	
micd	kurtosis	4.25	1	0.304	reject
	skewness	5.36	19	0.113	reject
mihd	kurtosis	3.85	1	0.05	reject
	skewness	24.5	19	0.18	reject

4.3.1. Tobit model estimation result

4.3.1.1. Tobit estimation result of cereal crop diversity

To analyze the determinant factors of cereal crop diversity Tobit model estimate and the marginal effect of each explanatory variables is reported in Table 4.9 below (See also Appendix B.1). From 19 explanatory variables included in the model, only nine variables are statistically significant. Among statistically significant variables awareness about loss and cause of biodiversity, number of oxen farm household owns, farm size, number of plots and market distance has positive effects. While household plot distance, improved seed application on the farm, farmers contact with extension workers and agricultural technology adoption other than improved seed has negative effects on cereal crop diversity. However farm household characteristics like age education status and gender of the household head, and family size has no effect on the diversity of cereal crops. This result is similar to the findings of Abebe et al. (2013), Benin et al. (2004), Heezik et al (2013). Inconsistently Rehima et al. (2013), Ruediger (2013) found that household characteristics have a significant effect on cereal crop diversity. statistically significant variables are discussed below.

Having knowledge about role and causes for the loss of agro-biodiversity increases spatial diversity of cereal crops in the study area. Spatial diversity of crops for farm households having knowledge is greater by 25.62% as compared with farm households without knowledge. Having knowledge increases the probability that a farm household produces more than one crop by 0.00342. Moreover, awareness about loss and role of agrobiodiversity increases crop diversity by 0.254 for farm households producing more than one crop and by

0.26 for the whole sample.The result is consistent with Birol(2004), Whitney et al. (2017), Abay et al. (2009), (Birol 2004).

Number of oxen that farm household owns increases crop diversity. Owning one more oxen increases spatial diversity of crops by 6.04%. On average having one more oxen increases the probability that farm households produce two and more cereal crops by 0.0006. While as farm households own one more oxen number of crops, they produce will increases by 0.06 units. Moreover having additional oxen will increase cereal crop diversity for farm households who currently produce more than one-cereal crops by 0.063 units. This is because if farm households have no oxen they will rent out it and the renter will cultivate the type of crops with more productive, but uniform crops. In addition to this, farmers with no oxen will supply labor for those farmers having more oxen to get oxen for one or two days to plough their plot of land. This reduces a number of days and hours that farmers devote on his/her plot. As a result, farmers are obliged to cultivate a few crops, which do not require ploughing more times. The result is consistent with Benin et al. (2004) and Smale et al (2003).

Spatial cereal crop diversity that farm households grow on their plothas a positive association with the types of soils at which farm plots characterized. Farm households having Nitosol soil farmland produces 9.82% more diversified cereal crops than farm households who do not have such a type of soil. Besides a discrete change from 0 to 1 (if farm household owns farmland with Nitosol soil property who previously do not have farm plots characterized by types of soils other than Nitosols. the probability of producing more than one cereal crop increases by 0.0011. Besides, for farm households currently produce more than one crop, this discrete change increases crop diversity by 0.981. In the same token, for the truncated sample discrete change in the dummy variable from 0 to 1 increases diversity by 0.934.This might be because Nitolosl is conducive for all types of crops as compared to other types of soils.

Distance from the nearest market is another significant variable, which increases crop species diversity. As the distance from the market increases by 1 km crop species diversity increases by 6.6%. Besides 1 km increase in the market,the distance increases the probability that farm households producing more than one unit of cereal crop by 0.001 and it also increases the crop species diversity for the whole sample by 0.066 and by 0.0653 for farm households producing two and more cereal crops.This reveals that on the one hand distance from the market increase transport cost and time cost of frequently going to the market to buy the types of crops they did not grow.On the other hand, the distance from the market increases the cost of producing and selling commercial or high yielding, but uniform crops. Hence to reduce these costs farm households produce diverse crops, particularly types of crops used for own consumption. the result is similar with the study conducted by Ruediger (2013), Smale et al (2003), Mussema et al (2015), Gauchan et al. (2005), (Birol 2004) and Rehima et al. (2013).

Average household plot distance from home lowers crop diversity. as average household plot distance increases by 1 km crop species diversity decrease by 15.5%, the probability of being uncensored by 0.0012, for truncated by 0.155, for censored samples by 0.154. This result indicates that as farm households live far from their plot, they face the difficulty of managing (protecting crops from animal damage) their farmlands effectively. Inaddition, it is costly to plough and cultivates the types of crops that require frequent labor supply on distant plots during the production season. For insane farmers far from their plot will want to cultivate barely instead of teff in that barely requires less frequent plough on average 2 times, which reduces walking time of households to arrive at their plot. The result is similar to the findings of Benin et al. (2004), while it is contrary to Mussema et al (2015).

A number of plots of land that farm household owns is another factor, which determines the diversity of cereal crops a household will produce. Owning an additional plot of land increases the probability of producing more than one cereal crops by 0.00213.Moreover, a unit increase in the number of plots that a household owns a diversity of crops for those currently producing two and more cereal crops will increase by 0.022 units. In Ethiopia, it is common that farmers grow similar crops per field because sometimes one crop will cause other crops affected by insects and other damages.on top of that, a large number of plots that farm households own is associated with more crop diversity in that large number of the plot indicates greater variation in soil and agro-ecological conditions, which might be conducive to allocate multiple crops across larger plotsInconsistence to this result. On the other hand, Benin et al. (2004), Rehima et al. (2013) founds a similar result.

Farm size has a statistically significant effect on the spatial diversity of cereal crops. A one-Gemed increase in farm size increases crop diversity by 3.08%. Moreover, a unit increase in farm size increases the probability that farm households produce more than one crop by 0.00021 respectively. In addition, the crop species diversity of censored samples increases by 0.22. In the same token, owning one additional Gemed's of farmland increases the diversity of crops that farm household's produce currently producing more than crops by 0.031. Contrary to this result Abebe (2013) found that farm size has no effect on crop species diversity. Whereas Benin et al. (2004), Ruediger (2013), (Rehima, 2009) founds a positive association with crop species diversity.

Application of improved seed on-farm lowers crop species diversity. Crop diversity for farm households applying improved seed on their farmland has 26.7% lower cereal crop diversity as compared to farm households using traditional verities. Applying improved seed on farmland reduces the probability of producing more than one crop by 0.002. On average, it also reduces the diversity of censored samples by 0.2664 and for the whole sample by 0.2672. The fact that improved seed application in particular and agricultural technology, in general, implies in the study area the types of crops supplied, an improved seed is very limited in a number of species. The result is contrary to Paudel et al (2012), Brown et al (2008), but similar to Ras and Ghale (2002), Noack et al (2017), Mekonnen and Mekuria (2018)

Finally, farmers Contact with extension workers also lower crop species diversity of cereal crops. The negative effect of contact with extension workers on cereal crop diversity is because of agricultural policy, which overlooks the role of crop diversity, depends on cash income, which in turn depends on the uniform but high yield crop varieties.

Table: 4.9. Tobit estimation result of spatial cereal diversity

Variables	**Margalef index cereal crop diversity estimation result and marginal effect**				
	coefficient	Pr(micd>0)	E(micd|micd>0)	E(micd*|micd>0)	p-value
Gender*	-0.0635	-.000634	-.0630236	-.063477	.149
Age	0.00579	.0000544	.005754	.0057933	0.123

Edu*	-0.0517	-.0006508	-.0512126	-.0516661	0.488
Hhsize	0.0008	7.66e-06	.0008105	.0008161	0.946
Awareness*	0.2562	.0034188	.2536852	.2559467	0.000***
Livestock	-0.0016	-.0000148	-.001571	-.0015817	0.340
Oxen	0.0604	.0005664	.0599447	.060354	0.024*
Pi	0.1274	.0011951	.1264827	.1273465	0.389
Slop	-0.3078	-.0028866	-.3055057	-.3075921	0.110
Soiltype*	0.0982	.0010611	.0973847	.0981331	0.095*
Income	-0.00001	-1.04e-07	-.000011	-.0000111	0.496
Mktdis	0.0658	.0006168	.0652848	.0657307	0.017**
Hhplotdis	-0.1550	-.0014533	-.1538086	-.1548591	0.000***
Numplot	0.0221	.0002076	.0219666	.0221166	0.088*
Farmsize	0.0308	.000289	.0305838	.0307927	0.000***
Impseed	-0.2673	-.0011186	-.2663778	-.2672175	0.000***
Es*	-0.2670	-.0040915	-.2640009	-.2666513	0.000***
Index	-0.0529	-.0004968	-.0525757	-.0529347	0.03**
Wid	-0.0010	-.0000102	-.0010743	-.0010816	0.981
Cons	0.595				
Log likelihood =	**-29.91458**	**N**		**200**	
LR chi2(19) =	**307.26**	**Prob> chi2 =**		**0.0000**	
Pseudo R2 = 0.8370					

Note: * p<0.1, ** p<0.05, *** p<0.01 shows level of significance at 10%., 5% and 1% respectively. (*) dy/dx is for discrete change of dummy variable from 0 to 1

Source: own computation

Tobit estimation result of horticulture crop diversity

tobit estimation result for margalef index of horticultural crops reported below. Contrary to the result of Margalef index of cereal crop diversity, Tobit estimation result for horticultural crops shows that farm household characteristics like gender and age of household head found to be statistically significant. Being male reduces horticultural crop diversity that farm household produces during the production season. This is because in Ethiopia male farmers have the responsibility of cultivating field crops as compared to female-headed households. This result is contrary to the result of Abay et al. (2009). he argues that male headed household produces more diversified crops because of difference in skills for frequent ploughing and early planting of crops.

Number of oxen that farm household owns increases horticulture crop diversity. Owning one more oxen increases spatial diversity of crops by 14.4%. On average having one more oxen increases the probability of being uncensored, for censored and for truncated by 0.00013, 0.144 and 0.1441 respectively. Spatial horticultural crop diversity of farm household's having red soil farmland is more diversified crops as compared to farm households without red soil farmland by 21.33%. Its marginal effect on the probability of being uncensored, for the censored and truncated is 0.0004, 0.2131 and 0.2133 respectively. Being female lowers horticultural crop diversity by 9.25%. Moreover, for all samplesit lowers horticulture crop diversity by 0.093 and for farm households with positive (>0) margalef index being female lowers spatial diversity of cereal crops by 0.0924 units. Age is another significant variable affecting horticulture crop diversity.

Income in the form of remittance, aid, and gift is another significant variable, which reduces fruit and vegetable crop species diversity. As the income of farm household increases by 1 birr crop species diversity decreases by 0.004%. Besides 1 birr, increase in income decreases the probability that farm households producing more than one unit of horticulture crop by $3.58e^{-08}$ and it also decreases the crop species diversity for the whole sample by 0.00388 and by 0.000388 for farm households producing two and more cereal crops. Average household plot distance from home lowers crop diversity. as average household plot distance increases by 1 km crop species diversity decrease by 15%, the probability of being uncensored by 0.00014, for truncated by 0.1503, for censored samples by 0.15.

Farm size has a statistically significant effect on the spatial diversity of horticulture crops. Increasing farm size by 1 Gemed (Timad) increases crop diversity by 1.17%.Application of improved seed on-farm lowers crop species diversity. Crop diversity for farm households applying improved seed on their farmland has 9.76% lower cereal crop diversity as compared to farm households using traditional verities. Applying improved seed on farmland reduces the probability of producing more than one crop by 0.00055. On average, it also reduces the diversity of censored samples by 0.976and for the whole sample by 0.976. Contact with extension workers also lower crop species diversity.

Table: 4.10. Tobit estimation result of spatial horticultural crops

variables	Margalef index of horticulture crop diversity estimation result and marginal effect				
	coefficient	Pr(mihd>0)	E(mihd|mihd>0)	E(mihd*|mihd>0)	p-value
Gender*	-.0925	-.0001008	-.0924111	-.0924925	0.021**
Age	.0099	9.10e-06	.0098584	.0098659	0.005***
Edu*	.0094	8.14e-06	.0094335	.0094403	0.890
Hhsize	.0197	.0000182	.0197011	.019716	0.075*
Awareness*	.0698	.0000677	.0697598	.0698151	0.116
Livestock	.00012	1.14e-07	.0001234	.0001235	0.934
Oxen	.1440	.000133	.1439605	.14407	0.000***
Pi	.2348	.0002167	.2346093	.2347877	0.082*
Slop	.2446	.0002257	.2443909	.2445767	0.159
Soiltype*	.2133	.0003897	.21305	.2133436	0.000***
Income	-.00004	-3.58e-08	-.0000388	-.0000388	0.010***
Mktdis	.0127	.0000118	.0127288	.0127385	0.607
Hhplotdis	-.1503	-.0001387	-.1501548	-.150269	0.000***
Numplot	-.0068	-6.24e-06	-.0067616	-.0067667	0.566
Farmsize	.0117	.0000108	.0116822	.0116911	0.046**
Impseed*	-.0976	-.000055	-.0975497	-.0975962	0.074*
Es*	-.1660	-.0002227	-.1658022	-.1659763	0.002***
Index	-.0466	-.000043	-.0465159	-.0465513	0.036**
Wid*	-.0509	-.0000486	-.0508372	-.050877	0.213
Cons	.2235				0.307
Log likelihood = -29.91458		N		200	
LR chi2(19) = 307.26		Prob> chi2 = 0.0000			
Pseudo R2 = 0.8370					

Note: * p<0.1, ** p<0.05, *** p<0.01 shows level of significance at 10%., 5% and 1% respectively. (*) dy/dx is for discrete change of dummy variable from 0 to 1

Source: own computation

4.3.2. Poisson regression results

4.3.2.1. Determinants of count cereal crop diversity

Reporting estimation results of Poisson regression requires the most important assumptions, equal- dispersion of the variance of error terms, to hold. The assumption of equal dispersion tested by using deviance and Pearson goodness of fit test. The result of Deviance goodness-of-fit test is 41.82 with a residual degree of freedom 180, Pearson goodness-of-fit is 41.83161 with a residual degree of freedom 180. The ratios of test statistics and degree of freedom for deviance and Pearson goodness of test is 0.2323 and 0.2324 respectively. This indicates the data set is under-dispersed. This result was supported by the log-likelihood ratio test of the negative binomial regression model and Poisson regression model. It is computed as twice of the difference between Poisson and negative binomial regression likelihood values.LR = 2[307.01043 -307.01043] = 0.000. Also the LR test of alpha = 0: chibar2 (01) = 0.00 with prob>=chibar2 = 1.000. This shows there is no difference between Poisson and negative binomial regression estimator, and So Poisson model can fit the data presented in this paper. Though under-dispersion is not a series problem, to deal with it the researcher used the robust standard error.

As indicated in the table below, asterisks have used to indicate the coefficients that are significant at 0.1, 0.05 and 0.001 level. Among 19 predictor variables, nine are statistically significant affecting the count number of crop diversity. Among significant variables awareness, household size, irrigation proportion, oxen and farm size at 1% have a positive effect. While technology index, contact with extension workers, exogenous income (remittance, aid, and gift) and improved seed have a negative significant effect on count cereal diversity.

Household size of farmers is an important factor affecting the count diversity of cereal crops. A household with higher members has higher number of cereal crops, such that different crops have different cultivation properties i.e. some crops require large labor forces, such as teff, maize, and wheat, while some other crops require few labor forces millet and barely having higher number of members are used to cultivate and harvest different crops. So large family members have the capacity to grow types of crops that require more labor force. The estimated coefficient of household size is significant at 5%. For exponential models, we can estimate the effect on the expected number of counts or the percentage effect. Therefore, the coefficients in this paper had interpreted by using two techniques (coefficients of Poisson regression and average marginal effect). The percentage effect had computed by exp (coefficient of the variable). If one household member was added, the count number of cerealcrops a household grows will increase by 2.8% or 0.079 units. This result is consistent with prior studies of.

A number of oxen a household own is another important factor, which affects cereal crop diversity. A household who do not own oxen has used, as a reference and the coefficient of oxen is significant at 1% level. As compared to farmers, owning zero oxen owning 1 more oxen increase crop diversity by 69% or 1.01. Count number of crops for farmers with 2, 3, and 4 oxen will be greater than farmers without owning oxen by 104.6% or 1.53, 101.2% and 96% or 1.14 respectively. This is because if farm households have no oxen they will rent out it and the renter will cultivate the type of crops with more productive, but uniform crops. In addition to this, farmers with no oxen will supply labor for those farmers having more oxen to get oxen for one or two days to plow their plot of land. This reduces a number of days and hours that farmers devote on his/her plot. As a result, farmers are obliged to cultivate a few crops, which do not require plowing more times. The result is similar to previous studies of Smale et al. (2003), Benin et al. (2004).

Awareness, having knowledge about the role and effect of loss of agrobiodiversity, increases count cereal diversity. A number of cereal crops that a farmer with knowledge about agrobiodiversity cultivates is more diverse than the number of crops a farmer without knowledge cultivates by 9.34% or 0.256 unit.

Irrigation proportion is another significant variable, which affects count cereal crop diversity positively. Farmers with a higher proportion of irrigation farmland have more diversified crops as compared to farmers with a low proportion of irrigation farmland by 32.6% or 0.81 units. Most of the time farmers accessed irrigation water cultivates (grows) crops either two or three times per years and seasonality affects the type of crops cultivated. Thus, a farmer who accesses irrigation water produces different crops for different seasons. This result is similar to Mekuria and Mekonnen (2018); Rana and Garforth et al.(2007), but contrary to the results suggested by Brush(1995).

Farm size has a positive significant effect at 5%. Owning 1 more gemed's of farm land increases the average number of count cereal diversity by 1.64% or 0.047 units. This result is consistent with smale et al. (2003); Rehima (2009). However, the result is contrary to Mussema et al (2015). While technology index, contact with extension workers, exogenous income and application of improved seed on the farm are associated with lower diversity of count cereal diversity. application of improved seed on farmland hasa strong effect on reducing a number of cereal crops produced thorough homogenization of crops and expansion of area coverage for the type of cereal crops in which improved seed is used. Farm household's contact with extension workers reduces count cereal crop diversity. This is because extension workers create awareness about how to use improved seeds and row planting instead of diversifying crops produced by farm households.

4.3.2.2. Determinants of count horticultural crop diversity

Similar to tests conducted in case of cereal crop diversity the assumption of equal dispersion has tested by using deviance and Pearson goodness of fit test. The value of the ratio of deviance and Pearson to the degree of freedom is 0.286 and 0.2701 respectively. As a rule of thumb if the ratio is less than 1 it indicates under-dispersion and likelihood ratio test of alpha = 0 is insignificant i.e. we accept the hypothesis that alpha = 0. Thus, Poisson regression might fit better in the case of underdispersion with robust standard error regression. Moreover, the log likelihood ratio tests of the negative binomial regression model and Poisson regression model shows the same result. It is computed as twice of the difference between Poisson and negative binomial regression likelihood values.LR = 2[307.01043 - 307.01043] = 0.000. Also the LR test of alpha = 0: chibar2 (01) = 0.00 with prob>=chibar2 = 1.000. This shows there is no difference between Poisson and negative binomial regression estimator, and So Poisson model can fit the data presented in this paper. Though under-dispersion is not a series problem, to deal with it the researcher used the robust standard error.

Poisson regression result of count horticultural crop is reported in the second column of table 4.10. Among 19 predictor variables, 9 are statistically significant factors affecting the count number of horticultural crop diversity. Age, household, number of oxen farm household own, proportion of irrigation, soil type, income, number of plot, application of high yielding(improved seed) and farm households contact with extension workers are statistically significant.

Statistical test of individual parameters confirms that older decision makers cultivate more crop species and vice versa. Household size has also a positive significant effect on horticultural species diversity. Farm size is another significant variable affecting horticulture species diversity positively. Number of oxen that farm household own also increases and there is a significant difference on the number of horticultural crops produced with farm household who do not own oxen and with farm households owning 1, 2, 3 and 4 oxen. Farm households with a larger proportion of irrigation farm cultivate diversified horticulture crops.

This is because usually, a farmer with irrigation produces fruits and vegetables, but only a few cereal crops. Farm households with red soil farmlands will produce more diversified crops as compared to farmers with other types of farmlands. Having more income reduces horticulture species diversity. Other significant variables reducing fruit and vegetable crop diversity are the application of improved seed and contact with extension workers.

Table 4.11. Diagnostics test statistics after Poisson regression

Test statistics	Count index of cereal		Count index of fruit	
	Poisson	Nbreg	Poisson	nbreg
Logpseudolikelihood	-329.34415	-------	-355.2160	-----
Log likelihood	----------	-329.344	--------	-355.216
Residual df	179		179	
Deviance	22.0941	--------	51.15	---------
(1/df)	(.1234)	-------	(.286)	---------
Pearson	18.078	--------	48.348	--------
(1/df)	(.101)	--------	(.2701)	-------
Wald chi2(20)	2488.02	------	531.70	--------
LR chi2(20)	----------	239.57	----------	99.39
Prob> chi2	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.2700	0.2667	0.1227	0.1227
LR test of alpha=0:chibar2(01)	-------	4.1e-06	-------	0.00
Prob>= chibar2 -	-------	0.499	-------	1.00

Table: 4.12. Poisson estimation result of both cereal and horticulture crop diversity

variables	Count cereal diversity			Horticulture crop diversity		
	coeff	AME	p-value	coeff	AME	p-value
Gender	-0.0191	-0.055	0.663	-0.0398	-0.12	0.254
Age	0.006	0.015	0.122	0.01	0.03	0.003***
Edu	0.02	0.056	0.787	0.0328	0.092	0.408
Hhsize	0.03	0.08	0.042**	0.03	0.09	0.002***
Awareness	0.09	0.256	0.0739*	0.005	0.014	0.906
Livestock	0.06	0.002	0.736	0.001	0.0013	0.702
Oxen						
1	0.525	1.01	0.000***	0.37	0.713	0.000***
2	0.716	1.53	0.000***	0.604	1.32	0.000***
3	0.699	1.479	0.000***	0.652	0.146	0.000***
4	0.673	1.404	0.000***	0.685	0.157	0.000***
Pi	0.282	0.810	0.042***	0.222	0.657	0.033**
Slop	-0.285	-0.817	0.103	0.151	0.446	0.411
Soiltype	0.0867	0.249	0.149	0.198	0.587	0.0004***
income	-0.003	-0.0001	0.040**	-0.000042	-0.0013	0.007***
Mktdis	-0.01	-0.026	0.683	-0.004	-0.011	0.866
Hhplotdis	-0.0477	-0.137	0.159	-0.06	-0.164	0.103
Numplot	-0.01	-0.03	0.442	-0.0136	-0.040	0.099*
Farmsize	0.0163	0.047	0.007***	0.005	0.014	0.315
Impseed	-0.283	-0.811	0.000***	-0.108	-0.319	0.005***
Es	-0.148	-0.426	0.013**	-0.131	-0.389	0.022**
Index						
1	-0.0242	-0.068	0.786	0.176	0.54	0.188
2	0.0479	0.140	0.419	0.0489	0.141	0.455
3	0.0389	0.113	0.509	0.0525	0.152	0.488
4	-0.142	-0.378	0.07*	0.011	0.031	0.884
cons	0.227		0.262	-0.06		0.795

Log pseudolikelihood =	-307.01043	-303.92027
Wald chi2(19) =	463.52	662.14
Prob> chi2 =	0.0000	0.0000
Pseudo R2 =	0.0895	0.1041
N	200	200

Note: * p<0.1, ** p<0.05, *** p<0.01 shows level of significance at 10%., 5% and 1% respectively

Source: own computation using stata 14.2

CHAPTER FIVE

5. CONCLUSION AND POLICY IMPLICATIONS

Agrobiodiversity is essential for the well functioning of ecosystems and sustainability of crop production. However, currently, agrobiodiversity loss increases at an alarming rate. Farm and household characteristics, agriculture policy, and agro-ecological conditions are the factors affecting agrobiodiversity. Identifying the specific causes of the loss of agrobiodiversity has paramount importance. To do so quantifying the economic values of agrobiodiversity attributes are fundamental and is the first step. Hence, the aim of this study was to evaluate the economic values and determinant factors of agro-biodiversity. To achieve these objectives of the study primary data were collected from farm households of two purposively selected woredas of Amhara national regional state. The economic valuation was analyzed by applyinga choice experiment study. While Poisson and Tobit's models were applied to identify the determinant factors of agro-biodiversity in the study area.

5.1. Conclusion

To identify for which agro biodiversity attributes farm households attach the highest value and how much, discrete choice experiment study using 100% D- efficient experimental design was employed. Choice experiment model was analyzed using NLOGIT 5.0 econometrics software. In the choice experiment study to check the persistence of unobserved preference heterogeneity, the similarity for parameter estimates of basic conditional logit and random parameter logit model was tested using Mcfadden’s IIA assumption. The test statistics show the IIA assumption is violated indicating there exist preference heterogeneity, which makesthe conditional logit model is biased and inconsistent to the data collected and presented in this study. As a result, RPL model estimates were used to compute WTA and compensating the surplus value of agrobiodiversity attributes.

parameter estimate of RPL model for the pooled samples using six agro biodiversity attributes (crop species diversity, landrace, organic farming, types of crops produced, expected yield per hectare, and net benefit as a monetary attribute) as explanatory variables affecting the utility of farm households was regressed. The result revealed that all attributes are statistically significant and have the expected signs. This means the utility of farm households increases with an increase in the number of crops produced, production of traditional crops with organic farming, and more diversified groups of crops with higher expected yield. The result further shows that farm households attach highest value for the production of traditional crops varieties followed by organic farming and crop species diversity with WTA value of 549.58, 430, and 228.53 birrs per year respectively.

In addition, to test whether RPL estimate distributed across woredas, separate RPL regression was conducted for each woreda. The result suggested that farm households in the two woredas have different preferences for different attributes (characteristics) of agrobiodiversity. For instance, in Bure Woreda only organic farming and crop species diversity attributes are statistically significant with WTA value of 596.43 and 46.45 birr/year respectively. While in Bahir Dar Zuria woreda farm households utility is significantly affected by types of crops produced, expected yield, production of landrace crops, and crop species diversity. In the Woreda, farm households attach the highest value for types of crops produced followed by expected yield, landrace, and crop species diversity with WTA value of 1547.89, 1357.1, 455.21, and 433.58 birr year.

To show the effect of decision maker characteristics on the choice of agrobiodiversity attribute and in turn, the utility of farm households, conditional logit model with interaction terms was regressed.To avoid multi-collinearity four decision-maker characteristics with lowest VIF were selected. These are household size, age, education, and income and interacted with six choice variant attributes. The result revealed that larger household size lowers the demand for crop species diversity and organic farming. On the other hand, the demand for crop species diversity increase with older age and organic farming increases with older age and a higher level of education.

In addition to farmer's economic valuation of agrobiodiversity, in this study determinants of agrobiodiversity particularly cereal and horticulture crop diversity were examined.Poisson regression for count data and Tobit model for Margalef index of cropdiversity were used. for instance, Tobit model estimate of cereal crop diversity shows household characteristics like gender, age, and household size have no significant effect on cereal crop diversity. On the other hand, awareness, number of oxen, soil type, market distance, number of plots, and farm size are a statistically significant effect. While average household plot distance, improved seed, contact with extension workers, and agriculture technology negatively affects cereal crop diversity. However, tobit model estimate of horticulture crop diversity shows farm household characteristics: gender has a negative significant effect, while age and household size have a positive significant effect on horticulture crop diversity.A number of the plot has an insignificant effect. Improved seed, contact with extension workers, and agriculture technology index negatively affect horticulture crop diversity. While a number of oxen, the proportion of irrigation, soil type, and farm size have a positive significant effect.

5.2. Policy implication

The findings of this study are important in designing policies on effectively conserving agriculture diversity by identifying farmer's preference about crops and its attributes and identifying determinant factors. Hence, based on the findings this study draws the following policy implication, which will be used for the conservation of agrobiodiversity:

- The results of a choice experiment study show that farmers utility increases with the production of crops using organic inputs. However, in Ethiopia, there is little emphasis on the preparation and use of organic inputs. This is because agriculture policy makers and extension workers believe that use of chemical input (improved seed and chemical fertilizer are highly productive and they advise farmers on how to use chemical inputs of agriculture production, but not in reality. Dwivedi & Charyulu (2010) pointed out that the net return of conventional farming is lower than organic farming. Thus, the role of the government, agricultural institutes, and biodiversity conservation institutes are critical in motivating farmers towards organic farming through setting and announcing premium prices for organic crops, quicker certification process, and creation of separate green channels of marketing organic crops.
- Crop species diversity is another policy variable, which increases the utility of farm households. It has also the benefit of reducing vulnerability and improving overall health, increasing productivity, stabilizing income, and enhancing well functioning of ecosystems. However, the current state of agriculture shows that intensification (specialization) of agriculture lowers crop diversity. so the government should increase the capacity of gene banks to restore lost crop varieties.

- The result of the determinants of agrobiodiversity shows that improved seed application on a farm reduces both cereal and horticulture crop diversity. Thus, the government should consider this loss and expand the capacity of crop breeding companies and gene banks to conserve traditional varieties of crops. In addition to this extension workers, overlooked the role of biodiversity, are mainly give training on methods of using agriculture technology and its adoption. However, they should train farmers on conservation traditional varieties.
- Awareness is another determining factor of cerealcrop diversity. Hence, the government, in addition to extension workers, should organize biodiversity experts and give training to farmers on the role, cause and consequences of agriculture biodiversity.
- The proportion of irrigation is found to be significant factors, which affects both cereal and diversity crop. Hence, the government and the concerning authority should improve the efficiency of irrigation water use on agriculture while optimal productivity in continuing through the programming of technological advancements like pressurized irrigation system at which releases of water is controlled so that crops receive the optimal water and sprinklers, which can able at distant places.
- Soil type is a significant variable affecting crop diversity of horticulture. Farmers choose the type of crops produced for the type of soil characteristics that their farm plots have traditionally. So the government and agriculture institutions in the region should scientifically identify the types of crops suitable for the type of crops.
- Farm size is also determining factor crop diversity, but it is difficult to increase farm households landholding. An alternative option is like improving the application of inter-cropping by scientifically identifying which crops can be cultivated simultaneously on a farm using inter-cropping and reducing pest disease and weeds at the same time increases productivity.
- In conclusion, since preference is different across regions or woredas farm households attach different values for different agro biodiversity attributes. In addition, the sign and magnitude effect of a farm, household, agro-ecological characteristics are different for different types of crops. Thus, the government should not use similar policies for the conservation of agricultural biodiversity.

Reference

Abay, F., Bjørnstad, A., &Smale, M. (2009).Measuring on farm diversity and determinants of barley diversity in Tigray, northern Ethiopia. Momona Ethiopian Journal of Science, 1(2).

Dwivedi, A., & Charyulu, K. (2010).Economics of Organic Farming Vis--Vis Conventional Farming in India.

Abebe, T. (2013).Determinants of crop diversity and composition in Enset-coffee agroforestry homegardens of Southern Ethiopia.

Altieri, M. A., & Letourneau, D. K. (1982). Vegetation management and biological control in agroecosystems. Crop protection, 1(4), 405-430.

Asfaw, Z. (1999). The barleys of Ethiopia.In Genes in the Field (pp. 83-113).CRC Press.

Benin, S., Smale, M., Pender, J., Gebremedhin, B., &Ehui, S. (2004). The economic determinants of cereal crop diversity on farms in the Ethiopian highlands. Agricultural Economics, 31(2-3), 197-208.

Bennett, J., & Blamey, R. (Eds.). (2001). The choice modelling approach to environmental valuation. Edward Elgar Publishing.

Birol, E. (2004). Valuing agricultural biodiversity on home gardens in Hungary: An application of stated and revealed preference methods (Doctoral dissertation, University of London)

Blamey, R. K., Bennett, J. W., Louviere, J. J., Morrison, M. D., & Rolfe, J. C. (2002). Attribute causality in environmental choice modeling. Environmental and Resource Economics, 23(2), 167-186.

Boardman, A. E., Greenberg, D. H., Vining, A. R., &Weisbrod, B. A. (2001).Cost Benefit Analysis, 2 edn, Printice Hall, Upper Saddle River, New Jersey

Brown, K., Pearce, D., Perrings, C., Swanson, T., & Mundial, B. (1993). Economics and the conservation of global biological diversity (No. 2).World Bank.

Brush, C. G. (1992).Research on women business owners: Past trends, a new perspective and future directions. *Entrepreneurship theory and practice*, *16*(4), 5-30.

Brush, S. B. (1995).In situ conservation of landraces in centers of crop diversity. Crop science, 35(2), 346-354.

Brush, S. B., Taylor, J. E., &Bellon, M. R. (1992).Technology adoption and biological diversity in Andean potato agriculture. Journal of Development Economics, 39(2), 365-387.

Brush, S. B., Taylor, J. E., &Bellon, M. R. (1992).Technology adoption and biological diversity in Andean potato agriculture. *Journal of Development Economics*, *39*(2), 365-387.

CSA 2008.Large and Medium Scale Commercial Farms Sample Survey2007/2008 (2000 E.C.). Results at Country and Regional Levels: Report on Area and Production of Crops, and Farm Management Practices. Statistical Bulletin 443. Addis Ababa, Ethiopia.

CSA. (2008). Summary and statistical report of the 2007 population and housing census: population size by age and sex.

Diamond, P. A., &Hausman, J. A. (1994). Contingent valuation: is some number better than no number?. Journal of economic perspectives, 8(4), 45-64.

Dixon, J., &Pagiola, S. (1998). Economic analysis and environmental assessment. Environmental assessment sourcebook update, 23, 1-21.

Edwards, S. B. (1991). Crops with wild relatives found in Ethiopia. Plant genetic resources of Ethiopia, 42-47.

Ellen G. (2003). Securing tomorrow's food. Promoting the sustainable use of farm animal genetic resources. Published by the League of Pastoral People, Ober-Ramstadt, p.6

Engels, J. M. M., & Hawkes, J. G. (1991).The Ethiopian gene centre and its genetic diversity. Plant genetic resources of Ethiopia, 23-41.

Food and Agricultural Organization (FAO, 2018).Biodiversity for sustainable agriculture.

Gauchan, D., Smale, M., Maxted, N., Cole, M., Sthapit, B. R., Jarvis, D., &Upadhyay, M. P. (2005). Socioeconomic and agroecological determinants of conserving diversity on-farm: the case of rice genetic resources in Nepal. Nepal Agriculture Research Journal, 6, 89-98.

Glenk, K., Barkmann, J., &Marggraf, R. (2006). Unveiling regional preferences for biological diversity in Central Sulawesi: a choice experiment approach. In A Matter of Mutual Survival, Social Organization of Forest Management in Central Sulawesi, Indonesia (Vol. 10).

Gliessman SR. (1998).Agro-ecology: ecological processes in sustainable agriculture, Michigan Aann Arbor press.

Gore, A. (1992). Earth in the balance-ecology and the human spirit

Hammer, K. (2003). A paradigm shift in the discipline of plant genetic resources. Genetic Resources and Crop Evolution, 50(1), 3-10.

Hanley, N., &Shogren, J. (2002). Economics and nature conservation: awkward choices. Daniel W. Bromley and JouniPaavola, eds, 120-130.

Hanley, N., Mourato, S., & Wright, R. E. (2001). Choice modelling approaches: a superior alternative for environmental valuatioin?. Journal of economic surveys, 15(3), 435-462.

Hoffman D. S.and Duncan J. G. (1988). Multinomial and Conditional Logit Discrete-Choice Models in Demography. Population Association of America, Vol. 25, No. 3 (Aug.,1988), pp. 415-427.

Horowitz, J. L. (1991). Modeling the choice of choice set in discrete-choice random-utility models. Environment and Planning a, 23(9), 1237-1246.

Howard, P. (2003). The major importance of 'minor 'resources: Women and plant biodiversity. London, UK: International Institute for Environment and Development (IIED).

International Food Policy Research Institute (IFPRI), (2008). Economic importance of agriculture for sustainable development and poverty reduction: The case study of Ethiopia. Global forum on agriculture, 29 – 30 November 2008. Paris

Isherwood, K. F. (1999). Fertilizer Use and the Environment.5th AFA International Annual Conference, 9-11 February 1999, Cairo, Egypt

Kjær, T. (2005), A review of the discrete choice experiment-with emphasis on its application in health care. Denmark: SyddanskUniversitet

Kontoleon, A., Pascual, U., &Smale, M. (2009). Introduction: agrobiodiversity for economic development: what do we know? Agrobiodiversity conservation and economic development. Agrobiodiversity, Environment and Economic Development. UK: Routledge Explorations, 1-24.

Kroes, E. P., & Sheldon, R. J. (1988).Stated preference methods: an introduction. Journal of transporteconomics and policy, 11-25.

Kuhfeld, W. F. (2006). Construction of efficient designs for discrete-choice-experiments. *The handbook of marketing research, Uses, misuses, and future advances, Sage Publ., Thousand Oaks, Calif*, 312-363.

Kuruppu, I. V., Edirisighe, J. C., Herath, H. M. L. K., Jayasinghe-Mudalige, U. K., Wijesuriya, W., Udugama, J. M. M., & Fernando, A. P. S. (2015). Farmers' valuation of agro-biodiversity in home gardens: case study in the Kurunegala district. Journal of Environmental Professionals Sri Lanka, 4(1).

Lancaster, K. J. (1966). A new approach to consumer theory. Journal of political economy, 74(2), 132-157.

Louviere, J. J., Hensher, D. A., &Swait, J. D. (2000). Stated choice methods: analysis and applications.Cambridge university press.

Magurran, A. E. (2013). *Measuring biological diversity*.John Wiley & Sons.

Marschak, J. (1974). Binary-choice constraints and random utility indicators (1960).In Economic Information, Decision, and Prediction (pp. 218-239).Springer, Dordrecht.

Martins C. (2015).Agro biodiversity – the key to food security, climate adaptation and resilience. GIZ publishing, GERMANY

McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior.105-135 in P. Zaremiibka (ed.), Frontiers in Econometrics. New York: Wiley.

McGuire, S. (2000). Farmers' management of sorghum diversity in eastern Ethiopia. *Encouraging Diversity: the conservation and development of plant genetic resources*, *London: Intermediate Technology Publications*, 43-48.

Mekuria, W., &Mekonnen, K. (2018). Determinants of crop–livestock diversification in the mixed farming systems: evidence from central highlands of Ethiopia. Agriculture & Food Security, 7(1), 60.

Morrison, M., Blamey, R. K., Bennett, J. W., & Louviere, J. (1996). A comparison of stated preference techniques for estimating environmental values (No. 408-2016-25523).

Munzara, A. (2007, October). Agro-biodiversity and Food Security.In UN/Trondheim Conference on Biodiversity and Ecosystems. October (Vol. 28).

Mussema, R., Kassa, B., Alemu, D., &Shahidur, R. (2015). Determinants of crop diversification in Ethiopia: Evidence from Oromia region. *Ethiopian Journal of Agricultural Sciences*, *25*(2), 65-76.

Noack, F., Larsen, A., &Quaas, M. (2017).Technology Adoption and Crop Diversity.

Nunes, P. A., & van den Bergh, J. C. (2001). Economic valuation of biodiversity: sense or nonsense?. Ecological economics, 39(2), 203-222.

OECD (Organisation for Economic Co-operation and Development)(2005). Handbook of Market Creation for Biodiversity: Issues in Implementation. Organisation for Economic Co-operation and Development. OECD, Paris.

Organisation for Economic Co-operation and Development. (2001). Valuation of Biodiversity Benefits: Selected Studies. OECD Publishing.

Pacicco L, Bodesmo M, Torricelli R, Negri V (2018) A methodological approach to identify agro-biodiversity hotspots for priorityin situ conservation of plant genetic resources. PLoS ONE 13(6): e0197709. https://doi.org/10.1371/journal.pone.0197709.

Pagan, A., &Vella, F. (1989). Diagnostic tests for models based on individual data: a survey. Journal of Applied Econometrics, *4*(S1), S29-S59.

Pascual, U., &Perrings, C. (2007).Developing incentives and economic mechanisms for in situ biodiversity conservation in agricultural landscapes. Agriculture, Ecosystems & Environment, 121(3), 256-268.

Paudel, B., Rana, R. B., Sthapit, B. R., Maharjan, S. K., Shrestha, A., Shrestha, P., ... &Adhikari, A. (2012). Determinants of agriculture biodiversity in Western Terai landscape complex of Nepal.

Paulrud, S., &Laitila, T. (2010). Farmers' attitudes about growing energy crops: a choice experiment approach. Biomass and Bioenergy, 34(12), 1770-1779.

Pearce, D. (2001). Valuing biological diversity: issues and overview (pp. 27-44). OECD: Valuation of Biodiversity Benefits; Selected Studies. Paris, OECD.

Pearce, D., & Moran, D. (2013). The economic value of biodiversity.Routledge.

Pimentel, D. (1996). Green revolution agriculture and chemical hazards. Science of the total environment, 188, S86-S98.

R. Greenburg (1994). 'Phenomena, comment and notes', Smithsotnian 25(8), , pp. 24-7.

Raeburn, P. (1996). The last harvest: the genetic gamble that threatens to destroy American agriculture. U of Nebraska Press.

Rana, R. B., Garforth, C., Sthapit, B., & Jarvis, D. (2007). Influence of socio-economic and cultural factors in rice varietal diversity management on-farm in Nepal. Agriculture and Human Values, 24(4), 461-472.

Rehima M. Belay K., Dawit A and Rashid S.(2003).Factors affecting farmers' crops diversification: Evidence from SNNPR, Ethiopia

Ricketts T., Brooks T., Hoffmann M., Stuar S. Balmford, A., Purvis A., Reyers B., (2006). Ecosystems and Human Well-being: Current State and Trends.

Roe D, Seddon N. and Elliott J. (2018). Biodiversity loss is a development issue: A rapid review of evidence.

Ruediger A. (2013). Diversity beyond Risk Management.: Patterns of Agro-biodiversity in Eastern Ethiopia.

Sardaro, R., Girone, S., Acciani, C., Bozzo, F., Petrontino, A., &Fucilli, V. (2016). Agro-biodiversity of Mediterranean crops: farmers' preferences in support of a conservation programme for olive landraces. Biological Conservation, 201, 210-219.

Scialabba, N., Grandi, C., & Henatsch, C. (2003).Organic agriculture and genetic resources for food and agriculture.

Shiferaw, B., & Holden, S. T. (1997). A farm household analysis of resource use and conservation decisions of smallholders: an application to highland farmers in Ethiopia. Agricultural University of Norway, Department of Economics and Social Sciences.

Smale, M., Bellon, M. R., Aguirre, J. A., Rosas, I. M., Mendoza, J., Solano, A. M., ...&Berthaud, J. (2003). The economic costs and benefits of a participatory project to conserve maize landraces on farms in Oaxaca, Mexico⋆. *Agricultural Economics*, *29*(3), 265-275.

Tamil Nadu Agricultural university (TNAU, 2016). organic farming: organic farming practice. TANU AGRITECH portal available online:http://agritech.tnau.ac.in/org_farm/orgfarm_introduction.html

Teklu G. (2016): Causes for Biodiversity Loss in Ethiopia: A Review from Conservation Perspective. Journal of natural sciences research.6(11).

Thrupp, L. A. (2000). Linking agricultural biodiversity and food security: the valuable role of agrobiodiversity for sustainable agriculture. International affairs, 76(2), 283-297.

Thrupp, L. A., Hecht, S., Browder, J. O., Lynch, O. J., Megateli, N., & O'Brien, W. (1996). The diversity and dynamics of shifting cultivation: Myths, realities, and policy implications (p. 1). Washington, DC: World Resources Institute.

Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica: journal of the Econometric Society*, 24-36.

Train Kenneth, E. (2003). Discrete choice methods with simulation. Cambridge: Cambridge UniversityPress.

Upreti, B. R., &Upreti, Y. G. (2002). Factors leading to agro-biodiversity loss in developing countries: the case of Nepal. Biodiversity & Conservation, 11(9), 1607-1621.

vanHeezik, Yolanda, et al. "Garden size, householder knowledge, and socio-economic status influence plant and bird diversity at the scale of individual gardens." Ecosystems16.8 (2013): 1442-1454.

Villa, T. C. C., Maxted, N., Scholten, M., & Ford-Lloyd, B. (2005). Defining and identifying crop landraces. *Plant Genetic Resources*, *3*(3), 373-384.

Wale Z. E. (2005). The Economics of On− Farm Conservation of Crop Diversity in Ethiopia

Wale, E. (2012).Addressing the information problem in agriculture via agro biodiversity: Streamlining the issues, challenges and policy questions. African Journal of Agricultural Research, 7(30), 4187-4197.

Whittaker, R. H. (1977). Evolution of species diversity in land communities. Evol. Biol., 10, 1-67.

Wood, D., &Lenne, J. M. (1997). The conservation of agro biodiversity on-farm: questioning the emerging paradigm. Biodiversity & Conservation, 6(1), 109-129.

Worede, M. (1991).An Ethiopian perspective on conservation and utilization of plant genetic resources. Plant genetic resources of Ethiopia. Cambridge University Press, Cambridge, 3-19.

Worede, M., Tesemma, T., &Feyissa, R. (1999).Keeping diversity alive: an Ethiopian perspective.In Genes in the Field (pp. 148-166).CRC Press.

Appendices

Appendix A. sample size determination and its distribution across kebeles

$n = \frac{N}{1+Ne^2}$ where n = sample size, N = population and e = sampling precision

For Bahir Dar Zuria $n_1 = \frac{6546}{1+6546(0.01)^2}$ = 98.06 or by rounding = 100

For Bure $n_2 = \frac{4323}{1+3967(0.01)^2}$ = 97.54 or by rounding = 100

Total sample size $n = n_1 + n_2 \Longrightarrow n_{=}$ 100 + 100 = 200. Then to determine the number of respondents from each kebele the study will use proportional sampling using the formula of $\frac{HHi}{HH}$*n, where HHi= household size of kebele i, HH= total household size of the selected kebeles per wereda. Following this

for Bahir Dar Zuria	Bure
Andassa= $\frac{1693}{6546}$*100 = 26	Wangadam= $\frac{1654}{3967}$*98= 41
wenjeta = $\frac{1716}{6546}$*100= 26	Shekwa= $\frac{1062}{3967}$*98= 26
Robit = $\frac{2237}{6546}$*100= 34	Wudegi= $\frac{1251}{3967}$*98= 31
Wagelsa = $\frac{900}{6546}$*100= 14	

Appendix B: regression results and digostic tests for tobit model

Appendix B.1: tobit estimation result of margalef(spatial) cereal crop diversity

```
Tobit regression                                Number of obs     =        200
                                                LR chi2(19)       =     307.26
                                                Prob > chi2       =     0.0000
Log likelihood = -29.914584                     Pseudo R2         =     0.8370
```

micd	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gender	-.0635224	.0437976	-1.45	0.149	-.1499419	.022897
age	.0057972	.0037372	1.55	0.123	-.0015769	.0131712
edu	-.0517136	.0744797	-0.69	0.488	-.1986737	.0952465
hhsize	.0008166	.0121226	0.07	0.946	-.0231033	.0247365
awarness	.2562068	.0485195	5.28	0.000	.1604702	.3519434
livestock	-.0015828	.0016533	-0.96	0.340	-.0048449	.0016794
oxen	.0603943	.0265451	2.28	0.024	.0080166	.112772
pi	.1274314	.1476781	0.86	0.389	-.1639606	.4188234
slop	-.3077971	.1914033	-1.61	0.110	-.685466	.0698717
soiltype	.0982099	.0585234	1.68	0.095	-.017266	.2136858
income	-.0000111	.0000163	-0.68	0.496	-.0000433	.000021
mktdis	.0657745	.0272368	2.41	0.017	.012032	.119517
hhplotdis	-.1549623	.0339634	-4.56	0.000	-.2219774	-.0879472
numplot	.0221314	.0128964	1.72	0.088	-.0033152	.047578
farmsize	.0308132	.006386	4.83	0.000	.0182126	.0434138
impseed	-.267295	.0595812	-4.49	0.000	-.3848581	-.1497319
es	-.2669674	.0587267	-4.55	0.000	-.3828445	-.1510903
index	-.05297	.0242312	-2.19	0.030	-.1007819	-.0051581
wid	-.0010824	.0447669	-0.02	0.981	-.0894145	.0872498
_cons	.5947672	.2382166	2.50	0.013	.1247283	1.064806
/sigma	.2470338	.0138402			.2197249	.2743426

```
           30  left-censored observations at micd <= 0
          170     uncensored observations
            0 right-censored observations
```

appendix B. 2: conditional moment normality error term test for margalef index of cereal crop diversity estimation

Conditional moment test against the null of normal errors

	critical values		
CM	%10	%5	%1
14.412	15.96684	27.357338	45.57505

APPENDIX B.3: Hetroskedasticity test using Hausman specification test for cereal diversity

```
                 b = consistent under Ho and Ha; obtained from scls
  B = inconsistent under Ha, efficient under Ho; obtained from tobit

Test:  Ho:  difference in coefficients not systematic

             chi2(18) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =        6.57
            Prob>chi2 =      0.9933
```

Appendix B.4: Tobit estimation result of margalef(spatial)horticulturecrop diversity

```
Tobit regression                                  Number of obs   =        200
                                                  LR chi2(19)     =     342.17
                                                  Prob > chi2     =     0.0000
Log likelihood = -4.2619725                       Pseudo R2       =     0.9757
```

mihd	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
gender	-.0924981	.0397457	-2.33	0.021	-.1709226	-.0140736
age	.0098664	.0034379	2.87	0.005	.0030829	.0166499
edu	.0094407	.0679454	0.14	0.890	-.1246262	.1435076
hhsize	.019717	.0110039	1.79	0.075	-.0019954	.0414295
awarness	.0698188	.0442555	1.58	0.116	-.0175043	.1571419
livestock	.0001235	.0014993	0.08	0.934	-.0028349	.0030819
oxen	.1440773	.0241752	5.96	0.000	.0963758	.1917787
pi	.2347996	.1342939	1.75	0.082	-.0301833	.4997825
slop	.2445891	.1729633	1.41	0.159	-.0966946	.5858727
soiltype	.2133665	.053447	3.99	0.000	.1079073	.3188258
income	-.0000388	.0000149	-2.61	0.010	-.0000681	-9.51e-06
mktdis	.0127392	.0247073	0.52	0.607	-.0360122	.0614905
hhplotdis	-.1502766	.0308775	-4.87	0.000	-.2112028	-.0893504
numplot	-.0067671	.0117712	-0.57	0.566	-.0299936	.0164594
farmsize	.0116917	.0058139	2.01	0.046	.00022	.0231634
impseed	-.0975992	.0544024	-1.79	0.074	-.2049436	.0097453
es	-.165989	.0536078	-3.10	0.002	-.2717656	-.0602125
index	-.0465536	.022015	-2.11	0.036	-.0899927	-.0031146
wid	-.0508796	.0407554	-1.25	0.213	-.1312965	.0295372
_cons	.2235011	.2180346	1.03	0.307	-.2067155	.6537177
/sigma	.2258805	.0122346			.2017398	.2500213

```
   23  left-censored observations at mihd <= 0
  177     uncensored observations
    0 right-censored observations
```

appendix B. 5: conditional moment normality of error term test for margalef index of horticulturediversity estimation

Conditional moment test against the null of normal errors

	critical values		
CM	%10	%5	%1
25.549	16.38851	26.797276	44.697424

APPENDIX B.6: Hetroskedasticity test using Hausman specification test for horticulture diversity

```
                            b = consistent under Ho and
>  Ha; obtained from scls
            B = inconsistent under Ha, efficient under
> Ho; obtained from tobit

    Test:  Ho:  difference in coefficients not systemat
> ic

                chi2(18) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                         =        8.27
               Prob>chi2 =      0.9743
```

APPENDIX B.7: Hetroskedasticity test using Cameron and TRivedi's decomposition of IM-TEST for horticulture diversity

```
. estat imtest

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	199.08	197	0.4452
Skewness	24.51	19	0.1771
Kurtosis	3.85	1	0.0496
Total	227.45	217	0.2996

Appendix B.8: distribution of erro terms of cereal crop estimation

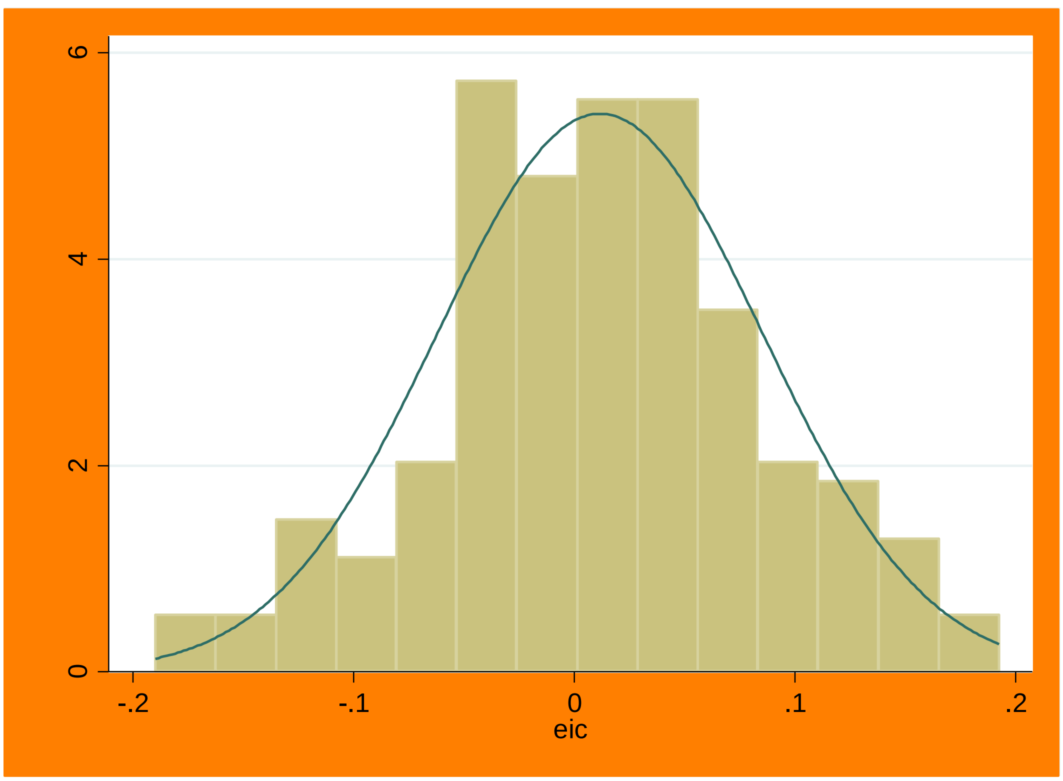
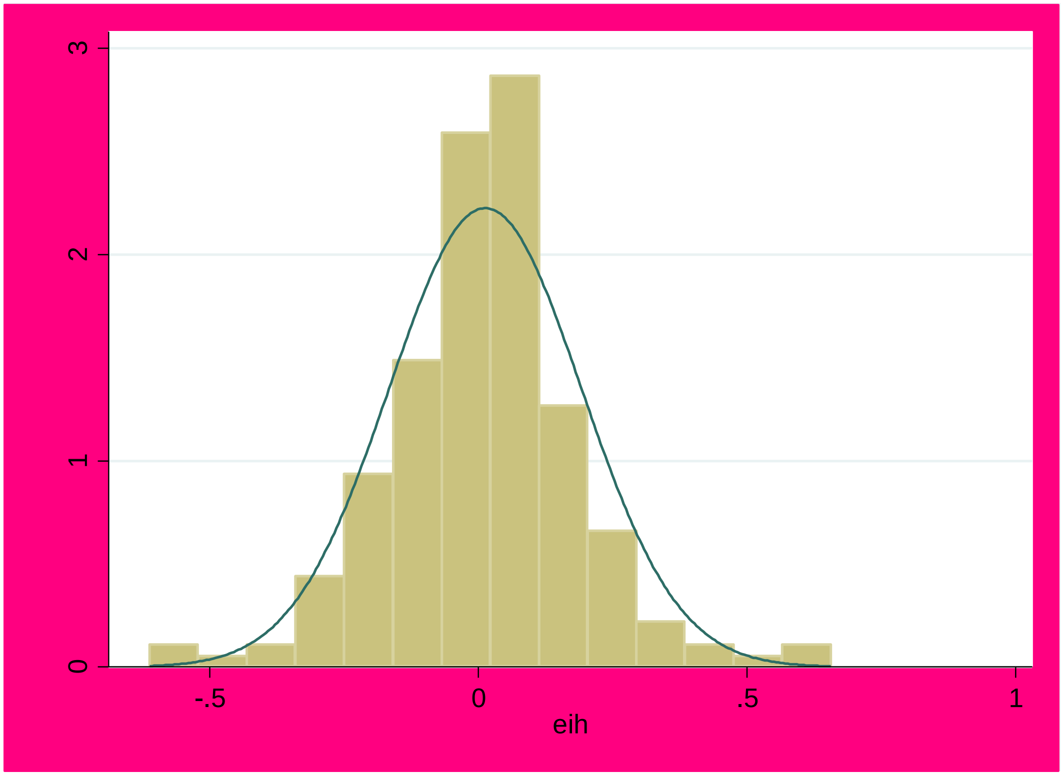


Figure: 3. Distribution of error term for margalef index of cereal crop diversity

Appendix B.9: distribution of erro terms of cereal crop estimation



Appendix C: POISSON REGRESSION and goodness of fit test

Appendix C.1. Poisson estimation result of cereal crop diversity

```
Poisson regression                                Number of obs   =        200
                                                  Wald chi2(19)   =     463.52
                                                  Prob > chi2     =     0.0000
Log pseudolikelihood = -307.01043                 Pseudo R2       =     0.0895
```

Cereal	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
gender	-.0741845	.0419571	-1.77	0.077	-.156419	.0080499
age	.0037597	.0037618	1.00	0.318	-.0036133	.0111326
edu	-.021036	.0699141	-0.30	0.764	-.1580652	.1159932
hhsize	.0203835	.0141483	1.44	0.150	-.0073467	.0481136
awarness	.1271982	.0530311	2.40	0.016	.0232592	.2311372
livestock	.0003613	.0017011	0.21	0.832	-.0029727	.0036953
oxen	.0206926	.0277893	0.74	0.456	-.0337734	.0751587
pi	.3093752	.1363216	2.27	0.023	.0421898	.5765607
slop	-.2790482	.1781704	-1.57	0.117	-.6282557	.0701594
soiltype	.1308668	.0679621	1.93	0.054	-.0023365	.26407
income	-.0000263	.0000154	-1.71	0.088	-.0000564	3.91e-06
mktdis	.0090235	.0221434	0.41	0.684	-.0343767	.0524238
hhplotdis	-.073221	.0331454	-2.21	0.027	-.1381847	-.0082572
numplot	-.0002117	.011989	-0.02	0.986	-.0237096	.0232862
farmsize	.0190607	.0062158	3.07	0.002	.006878	.0312433
impseed	-.2237044	.052467	-4.26	0.000	-.3265378	-.120871
es	-.1437423	.0556523	-2.58	0.010	-.2528188	-.0346659
index	-.0415084	.0253402	-1.64	0.101	-.0911743	.0081574
wid	-.0358472	.041691	-0.86	0.390	-.1175601	.0458656
_cons	.9341608	.2613709	3.57	0.000	.4218833	1.446438

appendix C.2: DEVIANCE and pearson goodness of fit test for count cereal diversity estimation

```
. estat gof

         Deviance goodness-of-fit =      41.82
         Prob > chi2(180)         =     1.0000

         Pearson goodness-of-fit  =   41.83161
         Prob > chi2(180)         =     1.0000
```

Appendix C.3: Poisson estimation result of horticulture crop diversity

```
Poisson regression                              Number of obs     =        200
                                                Wald chi2(19)     =     662.14
                                                Prob > chi2       =     0.0000
Log pseudolikelihood = -303.92027               Pseudo R2         =     0.1041
```

horticulture	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
gender	-.0605244	.0332171	-1.82	0.068	-.1256288	.00458
age	.0094736	.0030928	3.06	0.002	.0034118	.0155354
edu	.0143419	.0358996	0.40	0.690	-.0560201	.0847039
hhsize	.0241869	.0093566	2.59	0.010	.0058484	.0425254
awarness	-.0067678	.0367548	-0.18	0.854	-.0788058	.0652702
livestock	-.0000422	.00111	-0.04	0.970	-.0022177	.0021333
oxen	.0851444	.0208291	4.09	0.000	.0443201	.1259687
pi	.2585203	.104299	2.48	0.013	.054098	.4629427
slop	.1795386	.184459	0.97	0.330	-.1819944	.5410716
soiltype	.2308913	.0699562	3.30	0.001	.0937797	.3680029
income	-.0000395	.0000162	-2.44	0.015	-.0000713	-7.82e-06
mktdis	.0083898	.0211023	0.40	0.691	-.0329699	.0497496
hhplotdis	-.0733631	.0326897	-2.24	0.025	-.1374337	-.0092925
numplot	-.0096811	.0082582	-1.17	0.241	-.0258668	.0065046
farmsize	.008135	.005064	1.61	0.108	-.0017902	.0180601
impseed	-.096856	.0386242	-2.51	0.012	-.172558	-.0211539
es	-.1106635	.0560604	-1.97	0.048	-.2205398	-.0007872
index	-.0297326	.0210432	-1.41	0.158	-.0709765	.0115114
wid	-.0023529	.0418425	-0.06	0.955	-.0843627	.0796569
_cons	.3959069	.2458766	1.61	0.107	-.0860024	.8778162

appendix C.4: DEVIANCE and pearson goodness of fit test for count horticulture diversity estimation

```
. estat gof

         Deviance goodness-of-fit =  28.87483
         Prob > chi2(180)         =    1.0000

         Pearson goodness-of-fit  =  30.92042
         Prob > chi2(180)         =    1.0000
```

Addis Ababa University

College of business and economics

Department of economics

Appendix D. Survey questionnaire

Crop biodiversity

Dear respondents my name is Teshager Mazengia and I am final year MSc. student at Addis Ababa University. Currently I am conducting research on **'' farmers economic valuation of agro biodiversity and its determinant factors in West Gojjam Zone of Amhara National Regional State''**. You are randomly selected to provide accurate and reliable information on your preference on types of crop production, observation, and attitudes about agricultural activities. Your information will be important for policy makers on agriculture. Participating and answering the question is voluntary and skip the question you feel unhappy. The survey is anonymous, your name is not included in the survey, and your personal identity is kept in secret. It will take 30 minutes to complete all questions.

Thank you for your cooperation In advance

Teshager

Id __________ name of Keble's you are living __________

Name of woredas you are living ____________________

Part I: Socioeconomic characteristics of household head

1. Gender A. male B. female
2. age ____________
3. Marital status A. married/monogamous B. single/never married C. widow/widower D. divorced E. other (specify) _________________.
4. Maximum level of formal education attained _________________.

5. How many family members do you have including you? _____________.
6. From the total household members how many members are male? __________.
7. How many years have you work on farming as a household head? _________________.
8. Are you a member a/-leader in informal institutions? A. yes B. no
9. If yes for Q. 8 in which of the following informal institution you are participating?

A. Equib B. Edir C. Debo D. Kenja(oxen pairing arrangement) E. other

10. Are you member/leaders in formal institutions? A. yes B. no
11. If yes for Q. 10 in which of the following informal institution you are participating?

A. Kebele manager B. farmers cooperative C. other(specify)______________

12. did you attained in any training about the role, and consequences for the loss of agro biodiversity

A. Yes B. no

Part II: Farm related questions

13. Do you have your own farming land? A. yes B. no
14. If yes for Q. 13, which of the following land holding types do you have?

A. Own name Registered farmers land C. family farm land

B. Both D. other (specify) ______ .

15. How many gemed's of land your households have? ___________ (note: 1 hectare = 4 gemed)
16. Did you have rented in farmlands for the last cropping season? A. yes B. no
17. If yes for Q. 16 how many gemed's of farmland do you rented in? ____________.
18. What types of farming do you practice?

A. conventional(chemical fertilizer, herbicide, pesticide)

B. organic(with only compost and other traditional ingredients) C. both

19. If currently you are not using organic farming, do you have the intension to convert from conventional to organic farming? A. yes B. no
20. If yes for Q 19 after how many years, your household will convert in to organic farming. _____.
21. Do you meet Woreda's agricultural extension workers? A. yes B. no

22. If yes for Q.21, how many times per cropping season, do you meet agricultural extension workers? _______________.
23. Do you have irrigated land? A. yes B. no
24. If yes for Q 21 how many gemed's of irrigation farmlands do your households have? _________.
25. Which of the following methods of irrigation do you use?

A. surface irrigation B. sprinkler irrigation C. other (specify) ____________________

26. Which of the following source of irrigation waters your households use?

A. On farm ground water B. on farm surface water (dams and ponds) C. On farm surface water (lakes and rivers) D. other (specify) ______________.

27. Do you use agricultural technologies in your crop farming? A. yes B. no
28. If yes for Q. 27 which of the following agricultural technologies your households use on farming plot (more than one answer is possible)?
    A. improved seed B. Chemical fertilizer C. herbicides D. Pesticides E. other________.
29. In case of chemical inputs used please tell me the amount of each input used on your farming plot

Input type	Amount used
Improved seed (kg/gemed)	
Chemical fertilizer(kg/gemed)	
Herbicide(litter/gemed)	
Pesticide(litters/gemed)	
Other (specify) ________	

30. How many minutes on average do you walk to arrive at your farming plot from home? ________.
31. On average, how many meters your home far from the nearest market? ____________.

32. What types of plots, sizes, production, and sales for each crop type do you had for the last cropping season?

Crop type	slope	Area cultivated	Total production (in quintal)	Consumption from total production (in quintal)	Kept for seed (in kg.)	Total sale per year (in birr)	Other (specify)
Cereal							
Pulses							
Fruits and vegetables							
Roots and oil seeds							
Other							

33. Could you tell me the number of different crops your household produced for the last cropping season with in each crop types

Crop type	Number of crops	Crop variety		Lost crops	Lost variety
		Crop type	Crop variety		
Cereal		[1] [2] [3] [4] [5]			
Pulses		[1] [2] [3] [4] [5]			
Fruit and vegetables		[1] [2] [3] [4] [5]			
Roots and oil seeds					
Other					

Part III: Economic status of households

34. Please tell me the amount your household's get from the following sources.

A. Selling trees (amount in birr/year) ________ C. livestock sale (amount in birr/year) _______.

B. Total Crop produced (amount in birr/year) _________. D. off-farm income (amount in birr). _________.

E. other source (specify).___________ (Amount in birr) ______________

34. How many livestock does your household own?

A. cattle for farming (oxen and cows) ____ B. sheep and goat ____

C. hours and donkey ______ D. other (specify) __________.

35. Do your household earns off- farm income? A. yes B. no

36. If yes, which of the following are your households source of off-farm income (multiple choice are possible)

A. government employment B. employment in NGOs C. self employed (trade) D. other (specify) _________

37. do you get income from family members or relatives who live in urban areas or outside of the country in the form of remittance, aid and gift? A. Yes B. No

38. if yes for Q. 37 how much do you get per annum? ____________________ .

PART II: Choice experiment scenario

Ethiopian biodiversity institute and Ethiopian institute of agriculture identified agro biodiversity loss are increasing from time to time and, if the loss continues in this manner, it is difficult to get sufficient food in terms of quantity and nutritional quality, which causes hunger and sickness. Following this undertaking a survey that might have impacts on the Government's agricultural, crop diversity and food security policy is mandatory. To do this effectively your preferences about different types of crops is fundamental. Thus to conserve agro biodiversity depending on your preferences (first conserving crop groups preferred first by you) the authority wants your best preference for different combinations of crops. There is no right or wrong answers and your answers will be used in strictest confidence. Therefore, with the help of several crop producers and agricultural scientists the researcher have identified six crop characteristics and generated several crop types using differing levels of these characteristics. Crop characteristics and their levels were explained below:

1. **Crop species diversity on farm**: is the total number of grain crop species that grown on farm measures this. For example a household having one tomato variety, one bean varieties, one maize variety, and one onion variety has in total 4 different crops. The researcher will present you with 4 levels of crop diversity: 5, 10, 15, and 20.

2. **Organic production:** - indicates Household's, whom produces crops entirely with organic production methods like using natural fertilizer i.e. compost or farmers producing crops without chemical fertilizer, pesticides, and herbicides. I am referring when I use the term "organic production to this practices consider your imaginary crop production and decide whether or not you prefer type's of crop farming production entirely with organic methods.

3. **Landrace:** - it is defined as traditional and locally adapted crop variety, which the result of combined selection by farmers when propagating the variety that is most desirable characteristics. Such as crop variety that produces more fruits and resistant to climate. the researcher will ask you whether you prefer to have a crop in which a landrace is grown or not. This attributes has binary levels yes/no.

4. **Crop type:** - This attribute includes the types of crops produced by farmers in west Gojjam zone including your kebele. Depending on CSA classification, the researcher groups all crops produced by farmers in to four groups. These are cereals, horticulture, other crops, and combined of all. Consider your imaginary crop production you will be asked to choose your favorite crop types you prefer to produce.

5. **Expected yield**:- Expected yield of crop production is different for different combinations of the above specified crop characteristics (attribute). For instance the amount of crops produced (quintal/hectare) with organic farming will be lower than conventional farming, and horticulture production will yield higher as compared with other crop types. Depending on the types of crops and whether crops are produced with organic farming or not the researcher identifies four levels of expected yield attribute. Imagine if you produce only cereals, your yield will be 16 quintals/hectare. On the other hand, if you produce only horticulture crops yield will be 56 quintals/hectare, if you produce only other crops (pulses,

oil seeds, roots and tubers, permanent crops), the average yield will be 83 quintals/hectare, and if you produce combined of all crops on average you will get 35quintals/hectare.

6. **Net benefitof crop production**, which is an indicator for the contribution of crop farming to rural farm income, is the monetary values of crops net of production costs at the current year price. Net benefit is different depending on whether the farmer uses organic farming (other study shows net benefit from organic farming is greater than conventional farming) and depending on the types of products produced. Hence, the researcher identified four levels of net benefit attributes. These are 15000, 18000, 20000, and 25000. The researcher has put the generated crop characteristics in pairs on a series of cards, and he would like you to indicate out of the pair, which combinations of crop attributes you prefer in each card. Now, please imagine you will cultivate hypothetical crop farming. The following 8 questions will each present you different combinations of the above explained crop attributes (four with 4 levels in 10000m^2 and two with 2 levels) with two different alternatives: alternative 1 and alternative 2.

The researcher would like you to think about each scenario as if you were making a decision between them in the real world. Then will ask you to tell us which scenario 1 or 2 that you most prefer. You can state that you do not prefer either scenario by choosing 'Neither' (I would not have crop farming similar to this choice). If you choose neither as your preferred option then we would still like you to indicate whether scenario 1 and 2 would be the most preferable to you (i.e., the least bad) if crop farming is mandatory.Now I am asking you to choose your preferred alternatives in each of the following eight consecutive choice sets.

Choice set - 1

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	5	20	0
Landrace	1	2	0
Crop type	4	2	0
Yield per hectare	2	4	0
Organic farming	1	2	0
Net benefit of crop production	25000	18000	0
I prefer (please tick in the box)	☐	☐	☐

Choice set - 2

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	10	15	0
Landrace	2	1	0
Crop type	3	2	0
Yield per hectare	3	2	0
Organic farming	1	2	0
Net benefit of crop production	15000	20000	0
I prefer (please tick in the box)	☐	☐	☐

Choice set - 3

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	15	5	0
Landrace	1	2	0
Crop type	4	3	0
Yield per hectare	4	1	0
Organic farming	2	1	0
Net benefit of crop production	18000	20000	0
I prefer (please tick in the box)	☐	☐	☐

Choice set - 4

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	20	15	0
Landrace	1	2	0
Crop type	2	1	0
Yield per hectare	3	1	0
Organic farming	1	2	0
Net benefit of crop production	25000	20000	0
I prefer (please tick in the box)	☐	☐	☐

Choice set - 5

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	10	20	0
Landrace	2	1	0
Crop type	4	3	0
Yield per hectare	3	1	0
Organic farming	2	1	0
Net benefit of crop production	20000	18000	0
I prefer (please tick in the box)	☐	☐	☐

Choice set - 6

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	15	5	0
Landrace	2	1	0
Crop type	4	1	0
Yield per hectare	4	2	0
Organic farming	1	2	0
Net benefit of crop production	15000	18000	0
I prefer (please tick in the box)	☐	☐	☐

Choice set - 7

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	10	5	0
Landrace	1	2	0
Crop type	2	1	0
Yield per hectare	1	3	0
Organic farming	1	2	0
Net benefit of crop production	20000	18000	0
I prefer (please tick in the box)	☐	☐	☐

Choice set - 8

Attributes	Alternative 1	Alternative 2	Status quo
crop species diversity	20	5	0
Landrace	1	2	0
Crop type	1	3	0
Yield per hectare	3	4	0
Organic farming	1	2	0
Net benefit of crop production	15000	25000	0
I prefer (please tick in the box)	☐	☐	☐

PART IV: Follow up (debriefing) questions

4.1. Which one of the following best explains why you chose status quo?

A. I don't believe that the levels listed in each attribute will be real
B. Alternatives will require high investment on agriculture costs and I can't afford it
C. I am not willing to change my production system and technology that I am using
D. Other (specify

4.2. What was your number one priority to choose alternatives other than the status quo?

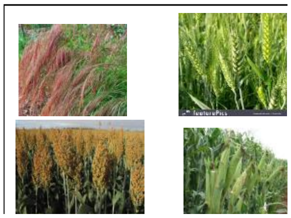
A. Crop species diversity B. Landrace C. crop type D. yield per hectare E. organic farming F. net benefit of crop production

4.3. What was your immediate criterion to choose either of the new proposed alternatives?

A. I always opted for the alternatives with higher crop diversity
B. I always opted for total crops produced
C. I always opted for organic production with natural fertilizers
D. I always opted and demanded traditional cultivars(Landrace)
E. I always opted for the type of crops produced

Sample Choice Set Card

Choice Set one

Attributes	Alternative 1	alternative	Status quo
Crop species diversity	5	20	Current state
Landrace	Landrace seed 	 No landrace	Current state
Crop type	Cereal products 	Horticulture 	Current state
Expected yield	35	83	Current state
Organic farming	Production of compost 	produ. with chemical input 	Current state
Net benefit	25000	18000	Current state
I prefer (please tick in the box)			