Farmers Economic Valuation of Agro-biodiversity in West Gojjam Zone, Amhara Region, Ethiopia: Choice Experiment Approach[1]

Teshager Mazengia Asratie[2]* and Wassie Berhanu[3]

Abstract

The public goods nature of the resource and the absence of market prices is one of the major challenges of agro-biodiversity conservation. Therefore, the use of non-market valuation methods, which takes into account both use and non-use values of resources is very crucial. This study was designed to quantify farm household's economic values of agro-biodiversity in a selected region in the northern Ethiopian highlands. We used the choice experiment method to evaluate farm households' willingness to pay for different agro-biodiversity attributes. The study used six agro-biodiversity attributes and 16 choice sets randomly blocked into two blocks. Sample of 200 respondents each presented with 8 choice sets resulting a total of 1600 observations. The random parameter logit estimates revealed that farmers willingness to pay for landrace, organic farming, and crop species diversity were 549.58, 430 and 228.53 birr per year per household respectively. The study recommends that, to conserve agro-biodiversity effectively, the government and agricultural development agencies should motivate the production of organic farming through price premiums and quick certification of organic crops, expanding gene banks to restore lost traditional varieties, and motivate farmers to adopt the practice of modern organic farming methods.

Key words: Agro-biodiversity, Choice Experiment, Economic Valuation

JEL Codes: D1, Q12, Q51, Q57

---

[1] Manuscript received: 2 July 2021

Accepted: 28 August 2021

[2] Department of economics, Debre Berhan University, Ethiopia

*Authors to whom correspondence should be addressed;

Email: teshagerm2016@gmail.com

[3] Department of economics, Addis Ababa University, Ethiopia

1. Introduction

This paper is centrally concerned with economic valuation of agro-biodiversity based on a case study from the northern Ethiopian highlands. Agro-biodiversity is a vital subset of biodiversity which is associated with agricultural ecosystems (Brookfield and Stocking, 1999; FAO, 2007). It generally refers to a totality of various animals, plants and micro-organisms at genetic, species and ecosystem levels, which are indispensable for direct or indirect use for sustainable livelihoods and food security. Agro-biodiversity is generally the outcome of the interaction among the environment, genetic resources and the management practices of culturally diverse peoples of different livelihood systems (farming, pastoralism, etc.) that dynamically adopt various technologies over a course of time periods (FAO 2007; FAO, 2018). The importance of diversified and sustainable agriculture for the maintenance of ecosystem and viable livelihoods in the context of poor agrarian countries in Africa cannot be overemphasized. Since a great majority of rural households in these countries rely on biological resources for their livelihoods requirements (Munzara, 2007), quantifying the value of agro-biodiversity is found to be very crucial. Ethiopia is a country of diverse agro-ecological systems, and is often considered as a center for diversity of crops, which is generally a result of considerable variations in rainfalls, temperature, and diverse social and cultural conditions of the country (McGurie, 2000). Although the nature and rate of biodiversity loss and species extinction is not fully documented, agro-biodiversity in Ethiopia has been under constant threat of degradation because of the replacement of local varieties by improved seeds and concomitant limitations of farmers' contribution to the conservation of agro-biodiversity (Worede, 1991, Brown et al., 1993; FDRE, 2005).

There is a general understanding that agro-biodiversity conservation is crucial to food security of smallholder operators in agrarian countries that are exposed to adverse outcomes of global climate change (Narloch et al., 2011). While recognizing the threatening pressure of changing climatic conditions in terms of species extinction, it is quite notable that adaptation initiatives should consider the value of biodiversity conservation for food security of smallholder poor agricultural operators in less developed countries (see Narloch et al., 2011). The small farmers in less developed countries are often considered as custodians of key agro-biodiversity natural capital of the world. Nevertheless, Kontoleon et al. (2009) underline that the threat to world agro-biodiversity in the present era of growing tendency for specialized agriculture. This is then particularly considered to signify the failure of free market to compensate the custodians (small farmers) for their investment in the conservation of diverse portfolios of global agro-biodiversity natural capital resources. An important feature of traditional agriculture is the risk-averse response behavior of poor peasant operators. In the typical case of financial market failure in rural areas of less developed countries, a key strategy of traditional farmers is to grow diverse portfolios of crop species on their farms along with non-crop biodiversity management as a form of natural insurance with a goal to decrease the variance of yields and increase mean level of income (Baumgärtner & Quaas 2010). Besides this private benefit of natural insurance function, the management of traditional crop varieties is also considered to have a significant value of generating public benefits of CO_2 storage and regulating climate-induced unpredictable future agricultural problems of increased pests and plant diseases (Wale, 2012).

The estimation of both the use values and non-use values, i.e. estimating the total economic value in monetary terms, of agro-biodiversity is an important prerequisite for conservation planning (Pearce, 2001). Provided that farmers only consider the direct benefit of farming and due to the public goods nature of agro-biodiversity resources, application of an appropriate valuation method that help capture the total economic value of the resource is required in order to express it in monetary terms. Therefore, with a view to add to the existing limited literature, this paper uses the choice experiment method in order to assess household economic valuation of agro-biodiversity resources based on a household level survey in the Ethiopian highlands. We hope it will help contribute to bridging some knowledge gaps, and will also motivate a similar and insightful further research in the area. The rest of the paper is organized as follows. The next section discusses the methodological approach of the Choice Experiment method, the adopted empirical model and sources of data. Section 3 is devoted to presentation and discussion of empirical findings. Concluding remarks and recommendations are given at the end.

2. Methods

2.1 Description of attributes and assignment of its levels

In this study, based on Central Statistical Agency of Ethiopia (CSA, 2017/18) and National Assessment of Educational Progress as well as agricultural scientist's classification, 6 agro-biodiversity attributes were identified and used. The first attribute is crop species diversity defined as the number of different crop species that farm household's produce and it has four levels (5, 10, 15, and 20 different crop species produced). The four level of crop species diversity attribute is identified based on CSA (2007/8) classification in that in the study area the most frequently cultivated cereals are five crops (wheat, maize, teff, barely, and sorghum) and for combined (cereal, horticulture, and other crops) maximum of 20 crops were produced and the other are taken purposively by considering practically cultivated crops of all types in the study area. The second attribute is crop type which is identified by capturing all the seven crop types (cereal, pulses, oil-seeds, vegetables, root crops, fruits, and stimulants or coffee and chat), and classifying in to four groups/levels based on Central Statistical Agency (CSA, 2017/18) classifications. These are cereal crop, horticulture (fruits and vegetables), crops other than cereal and horticulture crops, and combined crops of all types. Organic farming is the third attribute used in this study. According to Sivaraj (2016), organic farming is a practice of cultivating land and raising crops in such a way that it keeps the soil alive by using organic inputs (animal dung, plant wastes, and crop residues). In this study, organic farming takes two levels. These are whether farm households produce crops using the practice of organic farming or not.

The fourth attribute identified as determinants of farm household's utility of farming is landrace defined by Villa et al., (2005) as a bulk of genetic diversity in domesticated species located in traditional varieties maintained by farming systems. It is 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. The fifth attribute is yield per hectares, which is used to capture preference of households about the types of crops produced and methods of production adopted. For instance, organic farming is less productive as compared to conventional farming, but the former conserve soil fertility and other microorganisms and the latter does not. Moreover, the productivity of traditional crops is lower than modern varieties. Finally, the productivity of a cereal crop is lower than that of horticulture and other crops. Hence, including expected yield attribute will help to capture the case of whether farm households prefer biodiversity to 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 including root crops exhibiting the highest productivity. This study used CSA (2017/18) report of average crop productivity by type. For instance, the average productivity of cereal crop is 15.7 approximately 16 quintal per hectare, for horticulture (vegetable= 39.6 and fruit = 73.7) the average productivity is 56 quintals, for other crops the average productivity is 83 quintals. The last attribute used in this study is net benefit, which is a monetary attribute. The price of cereal crops is different from that of horticulture. On the other hand, prices for organically produced crops are higher than conventional farming in markets where price premium for organically produced crops were formed (CSA, 2017/18). In addition, the productivity of organic farming is lower than conventional farming. 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 agro-biodiversity attributes and the monetary attribute. Accordingly, the net benefit attribute has four levels. These are 15000, 18000, 20000, and 25000 per cropping season from the total crop production. Because of constraints in getting data for the average price of crops by type and the cost of production for each group of crops, the levels for net benefit attribute are determined by using 2018's average price of major crops in each crop groups (cereal, horticulture, other and combined of all groups) and taking 75% of revenue as cost of production. Summary of variables and levels used in the choice experiment exercise are reported below in Table 1.

Table: 1: Summary of agro-biodiversity attributes used in the choice experiment study

Agro-biodiversity attribute	Symbols	Levels
Crop species diversity	CSD	5 10 15 and 20
Crop type	CT	Cereal, horticulture, other, and combined of all types
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

2.2 Choice Experiment Design

By taking into account only main effects, we used 6 agro-biodiversity attributes, and the levels of each attribute is combined using fractional factorial design, which takes into account only main effects. This is because full factorial design is difficult to handle. Moreover, Louviere et al. (2000) argues that though factorial design only considers main effects it explains 80% of total variation. To make the design 100% efficient orthogonalization[4] and balancing[5] were used; and 16 pairwise attribute combinations were randomly assigned to 2 blocks, with 8 choice sets of each block. Thus, the respondents were presented 8 choice sets with 2 alternatives, and the status quo as the third options. Incorporating the third option ensures theoretical validity of estimates of farm household's welfare. For all attributes the status quo takes zero value i.e., no improvement in the farming system. A sample of choice set is shown in Table 2.

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

[5] Each level of each attributes has equal chance of occurrence or existence

Table 2: Sample choice set presented to respondents

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	35 quintals	83 quintals	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)	☐	☐	☐

2.3 The study area and source of data

In this study cross sectional data collected from farm households for 2018 cropping season. The 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 and three kebeles from Bahir Dar Zuria and Bure Wereda respectively. The first kebele was selected using random sampling and the remaining 3 and 2 from Bahir Dar Zuria and Bure respectively have chosen at every eighth interval. The selected kebeles are Andassa, Wenjeta, Robit and Wegelsa from Bahir Dar Zuria and Wangadam, Gulem and Wundegi are from Bure. 2nd from the total population of selected Kebeles of each wereda (Andassa, Wenjeta, Robit and Wegelsa) with a total of households of 5646 from Bahir Dar Zuryia and Wangadam, Gulem and Wundegi from Bure with a total household of 4323 a sample of 200[6] respondents were determined by using sample size determination formula developed by Carvalho (1984) cited in Zelalem (2005) and each respondent from each kebele was selected by using simple random sampling technique. Population ranges and sample size for each respective range are presented on Table 3 below.

[6] We used medium size sample determination

Table 3: Population target and required number of samples based on Carvalho (1984)

Determination Population Size	Low	Medium	High
51-90	5	13	20
91-150	8	20	32
151-280	13	32	50
281-500	20	50	80
501-1200	32	80	125
1201-3200	50	125	200
3201-10000	80	200	315
10000-35000	125	315	500
35001-150000	200	500	800

Then to determine the number of respondents from each kebele the study used 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. Following this the number of respondents from each kebele was determined as follows reported on Table 4.

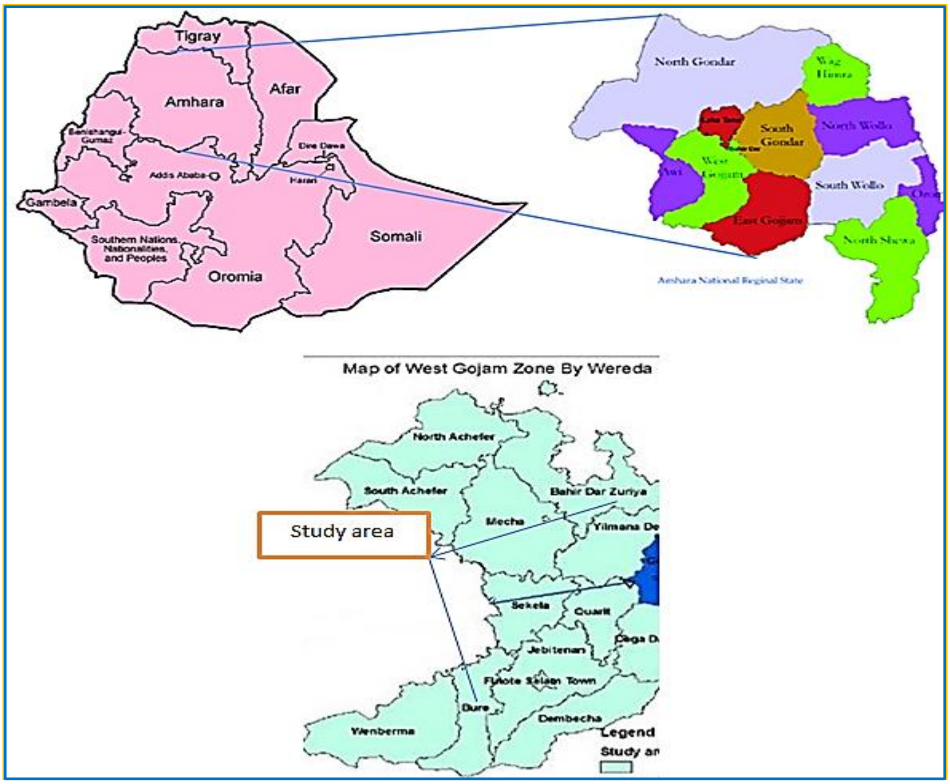
Table 4: Number of respondents from each kebele

Bahir Dar Zuria	Bure
Andassa = $\frac{1468}{9,969}$*200 = 29	Wangadam = $\frac{1770}{9,969}$*200 = 36
Wenjeta = $\frac{1481}{9,969}$*200 = 30	Shekwa = $\frac{1182}{9,969}$*200 = 24
Robit = $\frac{1917}{9,969}$*200 = 38	Wudegi = $\frac{1371}{9,969}$*200 = 27
Wagelsa = $\frac{780}{9,969}$*200 = 16	

Bure is the first district selected for this study. According to Bure district agricultural office report (BDAOR, 2015) the district is located $10^{o}17'$ to $10^{o}45'$N latitude and $37^{o}00'$ to $37^{o}10'$ E longitude with an average altitude of 1,500 to 2400 meter above sea level. The district has a total population of 175, 000 and 25,000 households having an average family size of 7 members per household. The population density is estimated to be 127.5 person/km^2. The second district is Bahir Dar Zuria and it has a total population of 182,730 (93,642 are men and the remaining 89,088 are female. It is located 1700 to 2300 meter above sea level altitude with average area coverage of 151,119 hectare. The district receives mean annual rainfall ranging from 820 to1250 mm. surveys in the district shows that 21% of the total district's area is cultivable and 36% are covered by water. The remaining 43% are used for pasture, forest coverage, and degraded land.

Though both districts have similar farming systems, in which farm households heavily rely on seasonal rainfall and traditional method of farming, each district has different types of soils. For instance, Bure district has three basic soil types. Namely, Humic Nitosols cover 63% of the district, and this is followed by Eutric Cambisols and Eutric Vertisols covering 20 and 17% respectively. Areas in wet Dega agro-ecology of the district receive torrential rainfall and it has relatively undulating topography, which is easily erodible. While in Bahir Dar Zuriya district, all 36 kebeles have Woina-Dega climatic zones (MoWR, 2009), the greater part of the district is covered by Luvisols. This in turn shows difference in agro-ecological conditions between the two districts and this difference makes differences in the types of crops cultivated and differential farm households' level of preferences. Moreover, unlike to the previous decades, the current agricultural development goals proposed by the government have resulted massive use of chemical fertilizers and crop protection chemicals, which is often considered to have damaging effect on the conservation of agro-biodiversity.

Figure 1: Map of the study area



2.4 Empirical Model of Discrete Choice Experiment

Here, a consumer is assumed to generate utility from both the consumption of goods themselves and pleasures derived from their attributes. Using a similar approach to Rose et. al., (2005), the model can be specified as follows:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad \textbf{(1)}$$

Where U_{ij} is the utility that individual i derive from alternative j, which is alternative one, alternative two, and the status quo and V_{ij} is the attributes of crop diversity, and ε_{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 is expressed as:

$$P_{ij} = prob(U_{ij} - U_{ik}) > (\varepsilon_{ik} - \varepsilon_{ij}) \quad \text{where } j \neq k \text{ and } k \in C \qquad \textbf{(2)}$$

Following Haan (2006), the conditional logit model is derived from a random utility model, which assumes that farm household's utility 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:

$$U(S_i, X_{ij}) = V(S_i, X_{ij}) + \varepsilon(S_i, X_{ij}) \qquad \textbf{(3)}$$

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

$$P_{ij} = prob(U_{ij} - U_{ik}) > (\varepsilon_{ik} - \varepsilon_{ij}) \quad \text{where } j \neq k \text{ and } k \in C \qquad \textbf{(4)}$$

Finally, the estimable model statistical specification of the conditional logit model is specified as follows:

$$P_{ij=} \frac{e^{V_{ij}}}{\sum_i^n e^{V_{ij}}} \qquad \textbf{(5)}$$

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

$$V_{ij} = ASC + \beta_1 * CSD + \beta_2 * LR + \beta_3 * OF + \beta_4 * CT + \beta_5 YLD + \beta_6 * NB + \varepsilon_i \qquad \textbf{(6)}$$

Where V_{ij} is indirect utility function for farm household i for alternative J =1, 2, 3. The alternative specific constant (ASC) shows the average effect of any attributes not included in the utility model. The ASC takes the value 1 for either of alternatives chosen otherwise zero for the status quo. The parameter β_1 to β_6 represents coefficients of crop attributes (crop species diversity, landrace, organic farming, crop type, expected yield and net benefit). For a given household, social and economic characteristics are constant across alternatives. Thus, the study used social and economic characteristics only as interaction terms. From conditional logit model specification, the welfare that farm household generates from agro-biodiversity attribute is modeled as:

$$CS = \ln \sum_{i}^{n} e^{Vi1} - \ln\frac{\sum_{i}^{n} e^{Vi0}}{\alpha} \quad \textbf{(7)}$$

According to Hanely et al. (2001), it is possible to reduce the model of marginal values of a particular attribute if the utility index is linear. Following this, the marginal values of an attribute is reduced as:

$$CS= -1\left(\frac{\beta attribute}{\beta monitaryattribute}\right) \quad \textbf{(8)}$$

It is the marginal welfare measure of willingness to accept (WTA) or willingness to pay (WTP), which measures the amount of income deducted/given from/to a farm household to make his/her utility to be equal to the level of utility before changes when improvement/environmental damages occur, respectively.

In Equation 7, α is monetary attributes in the choice experiment (marginal utility of income), V_{i1} and V_{i0} is indirect utility after and before changes under consideration, respectively, and CS is compensating surplus. When estimating conditional Logit model, the distribution of the error term imposes independence of irrelevant alternative (IIA) assumptions[7]. If this assumption is violated, the conditional logit results are considered to be biased estimates (Bateman et. al., 2005). Hence, to rectify this with an alternative model specification, this study

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

has adopted the random parameter logit model, with interaction terms of crop diversity attribute and socio-economic characteristics, to compare the results with that of the basic conditional logit model. The random parameter logit model is given by

$$U_{ij} = V_{ij} + \varepsilon_{ij} = Z_j(\beta + \eta_i) + \varepsilon_{ij} \quad \textbf{(9)}$$

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 represented by 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 by accounting for unobserved heterogeneity.

3. Results and Discussion

In this section conditional logit and random parameter logit model estimates are discussed. However, conditional logit model is based on the assumption of homogenous preference across districts and farm households. This assumption is tested by Mcfadden's test of independence of irrelevant alternative, which was done by excluding each alternative and running separate regressions. The test statistics is reported in Table 5 and 6 below with and without alternative specific constant, and which confirms the violation of the assumption i.e. in the study area there is preference heterogeneity across districts. This assures that the conditional logit estimates can be misleading. As a result, we employed estimation techniques which take in to account preference heterogeneity that enables us to get consistent and unbiased estimates of individual preference (Green & Rao, 1971). These are conditional logit model with interaction terms and random parameter Logit models. Estimation results of these models are discussed below.

Table 5: 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

Source: own computation using Nlogit 5.

Table: 6. 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.

3.1 Random Parametric Logit Model Estimates

The random parameter logit estimates for the pool and by district are reported in Table 7 the pooled sample estimated result shows that crop species diversity, crop type, net benefit, organic farming, expected yield and land-race attributes have positively significant effect on the utility of farm households'. The alternative specific constant (ASC) has negatively significant effect, indicating that farm household's responsiveness of choice set quality, and the attributes used in the estimation, explains variation in the utility of farm household's. Relative to other attributes, the land-race attribute has the highest effect on utility, which evidenced farm household's preference for traditional crop varieties instead of uniform but modern crop varieties. Farm household's utility is also a positive function of organic farming. This result is in line with Scialabba (2003) that indicates organic farming as a guarantee for the protection of land degradation, soil erosion and health of human being, particularly in a country or community where farm households are unable to buy chemical inputs. Despite this fact, the current system of expanding supply of chemical fertilizer and improved seed varieties appear to discourage farm household's contributions to agro-biodiversity. Moreover, farm household's utility increases with an increase in the number of different crops produced, because it is important to ensure better nutrition, resistance of crops to influences of climate variability, and keep cultural values.

The above discussion is based on the pooled sample of two different districts (Bahir Dar Zuriya and Bure). However, in these two districts there may be differences in farm land characteristics (including the type and quality of soil), socio-economic considerations, and market conditions. If this is the case, it will require different production process and conservation mechanisms (Birol, 2004). In this study, to check whether a pooled random parameter estimate are equally shared across the two districts or not, the log-likelihood ratio test introduced by Swait Louviere is employed. The test statistics[8] shows us the pooled estimate of random parameter logit model does not distribute across districts equally. Moreover, in the model there are statistically significant derived standard deviations, which is an indicator for the existence of choice specific unconditional unobserved heterogeneity. As a result, the effect of agro-biodiversity attributes on farm households' utility is discussed by running separate regressions for each of the districts.

For instance, in Bure district estimation results reported in column 3 of Table 7 show that crop species diversity, organic farming and net benefit attributes of agro-biodiversity have positive significant effect on farm household's utility. The Bahir Dar Zuria district estimates reported in column 4 of Table 7, on the other hand, show that crop species diversity, landrace, expected yield and crop types are statistically significant attributes affecting demand for agro-biodiversity positively. These indicate that the effect of agro-biodiversity attribute on utility of farm household depends on agro-ecological, economic and market characteristics of the study area under consideration.

[8] 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 ratios test statistics is greater than chi2 critical value. Reject Ho.

Table 7: Random parameter logit model estimates of the pool and by district

Attributes	Pool	Bure	Bahir Dar Zuria
	Coefficients (standard error)		
	Random parameters in utility functions		
Alternative specific constant	-.58409* (.31858)	-.98453 (.64036)	.79049 (.66320)
Crop species diversity	.2141*** (.00634)	.03236** (.01305)	.08611*** (.01626)
Crop type	.08580** (.04367)	-.02297 (.07684)	-.30741*** (.08945)
Land rac	.35816*** (.06366)	-.08453 (.11733)	-.090404*** (.14232)
Expected yield	.15772*** (.03337)	.00749 (.06287)	.26952*** (.06373)
Organic farming	.28063*** (.06974)	.41553*** (.14459)	.16786 (.11904
Net benefit	.6517D-03*** (.1114D-04)	6967D-03*** (.2322D-04)	.1986D-03 (2122D-04)
Derived standard deviations of parameter distribution			
NsASC	.97362*** (.15197)	1.17431*** (.24902)	1.37210*** (.30445)
NsCSD	.00141 (.00779)	.01049 (0.02087)	.00266 (.00898)
NsCT	.39368*** (.04262)	0.32318*** (0.06745)	.54738*** (.08059)
NsLR	.01309 (.05813)	0.00717 (0.10081)	.03039 (.08711)
NsYLD	.00965 (.02959)	0.02087 (0.03962)	.007344434)
NsOF	.41110*** (.07376)	0.89449*** (0.13629)	.07632 (.08961)
NsNB	.82631D-06 (.6730D-05)	0.42570D-05 (0.9770D-05)	.14113D-04 .1123D-04
Number of respondents	200	100	100
Number of observations	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%, and 10% level. Standard error in parenthesis
Source: own computation using NLOGIT 5.0 Econometrics software

3.1.1 The WTP values of random parameter logit estimates

Hanely et al., (2001) proposed that under standard consumer theory marginal rate of substitution between agro-biodiversity attributes can be computed by calculating the ratio of the partial derivatives of indirect utility function with respect to each attribute. Following this, under linearly additive indirect utility function the welfare, WTP value of each, attribute is obtained as the ratio of attribute's coefficient to the coefficient of monetary attribute. Hence, the marginal willingness to pay values of random parameter logit estimates for the pool and by district is reported in Table 8 below. In our case the monetary attribute is net benefit attribute of agro-biodiversity. For the total sample of the study (pooled estimation), the maximum willingness to pay is attached to landrace agro-biodiversity attribute followed by organic farming. To get one more landrace crop, farm households are willing to pay 549.58 Ethiopian birr per year. Moreover, to shift from conventional to organic farming they are willing to pay 430 Ethiopian birr. On the other hand, crop type attribute has the least effect on farm household's utility with marginal willingness to pay value of 131.66 Ethiopian birr. Since the random parameter logit estimation results of the pooled sample are not the same for separate regression estimation results of each district, the marginal willingness to accept value for each district is also computed separately. Hence, farm households in Bure district attached highest willingness to pay to the organic farming attribute with marginal WTP value of 596.43 followed by crop species diversity attribute of a willingness to pay amount of 46.45 Ethiopian birr. However, in Bahir Dar Zuria District the maximum willingness to pay is attached to the type of crops produced followed by expected yield with marginal WTP value of 1547.89 and 1357.1 ETB per year.

Table 8: WTP values for each agro-biodiversity attributes for the pooled and by district 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 software

3.2 Conditional Logit Model Accounting for Preference Heterogeneity

In addition to agro-biodiversity attributes, decision maker characteristics could also affect utility that farm households can get from agro-biodiversity. To identify this effect, conditional logit model with interaction terms was estimated. Here introduction of the interaction terms is found to be important because of the often-underlined notion that social and economic characteristics on choice cannot be examined in isolation from the attributes of products of choices (Birol, 2004). But including all decision maker characteristics may create the problem of multicollinearity. To minimize the problem of multicolinearity we used auxiliary OLS regression, and decision maker characteristics with the lowest VIF were taken an interaction term. The decision maker characteristics used in the interaction terms are household size (HHSIZE), education level (EDU), age of farm household head (AGE), and income (Y). With six agro-biodiversity attributes and four decision-maker characteristics 24 interaction terms are created. The estimation result of the model for the pooled sample and separate regressions for each district are reported in Table 9. Only interaction terms with significance level of 1%, 5% and 10% precision with the two-tailed test are reported.

In the pooled sample estimates reported in column 2 of Table 9 shows that only household size, age of household head, and education are found to be statistically significant. The demand for crop species diversity and organic farming are negatively affected by household size, but positively affected by 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 about the advantages of organic farming. The demand for crop type increases with the age of household head, but decreases with household size.

Table 9: Conditional logit estimates accounting preference heterogeneity for the pool and district

Attributes	Pool	Bure	Bahir Dar Zuria
		Coeff(se)	
Alternative 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 type* 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 observations	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 and standard error in parenthesis
Source: own computation using NLOGIT 5.0 Econometrics software

In addition to estimation result of pooled sample conditional logit model with interaction terms, separate estimations for each district were also conducted. In Bure district household size and farm household head's age have positive significant effect on organic farming attribute, and in turn the utility of farm households. On the other hand, household size and age of the farm household head's age has negative and positive significant effect on crop type attribute, respectively. However, there is no interaction term, which has significant effect on agro-biodiversity attributes in Bahir Dar Zuria district.

4. Conclusion and Recommendation

This study employed discrete choice experiment study using 100% D-efficient experimental design in order to examine farm household valuation of agro-biodiversity, especially by identifying the biodiversity attributes to which they attach the highest value. The NLOGIT 5.0 econometrics software was used to run and analyze the choice experiment model. The test statistics of IIA assumption is violated indicating the presence of preference heterogeneity, which indicates the biasedness and inconsistency of the conditional logit model. As a result, Random Parameter Logit model (RPL) estimates were used to compute WTP value of agro-biodiversity attributes. The Parametric estimates of the RPL model for the pooled samples revealed that all attributes are statistically significant and have expected signs. It is found that the utility of farm household increases with an increase in the number of crops produced, with production of traditional crops using organic farming, and with more diversified groups of crops of higher expected yield. The result further shows that farm households attach the highest value to the production of traditional crop varieties, followed by organic farming and crop species diversity with WTP value of 549.58, 430, and 228.53 birrs per year, respectively.

In addition, to test whether RPL estimate distributed across districts, separate RPL regressions were conducted for each district. The result suggests that farm households in the two districts have different preferences for different attributes (characteristics) of agro-biodiversity. For instance, in Bure district only organic farming and crop species diversity attributes are statistically significant with WTP value of 596.43 and 46.45 birr/year, respectively. In Bahir Dar Zuria district, on the other hand, farm households' utility is significantly affected by types of crops produced, expected yield, production of landrace crops, and crop species diversity. In this district, farm households attach the highest value for types of crops produced followed by expected yield, landrace, and crop species diversity with WTP value of 1547.89, 1357.1, 455.21, and 433.58 birr year, respectively.

To show the effect of decision maker characteristics on the choice of agro-biodiversity attribute, and the utility of farm households, conditional logit model with interaction terms was regressed. To avoid multicollinearity four decision-maker characteristics with the lowest VIF were selected. These are household size, age, education, and income, which are 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 and organic farming increases with older age and a higher level of education.

Generally, based on the findings this study draws the following policy implication for the conservation of agro-biodiversity.

The results of a choice experiment study show that farmer's 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 simply because of the central focus of policy makers and extension agents currently being on the promotion of use of chemical inputs by smallholder farmers with a view to boost the productivity in the agricultural sector. However, the roles of the government, agricultural research institutes, and biodiversity conservation institutes are also critical in motivating farmers towards organic farming through setting and announcing premium prices for organic crops, introducing certification process for organic crops, 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. The government should also increase the capacity of gene banks to restore lost crop varieties.

References

Amhara National Regional State, Bureau of Plan and Economy (ANRS-BoPE). (2007). Annual report, Bahir Dar, Ethiopia.

Bateman, I. J., Cooper, P., Georgiou, S., Navrud, S., Poe, G. L., Ready, R. C., & Vossler, C. A. (2005). Economic valuation of policies for managing acidity in remote mountain lakes: Examining validity through scope sensitivity testing. *Aquatic Sciences*, *67*(3), 274-291.

Baumgärtner, S., & Quaas, M. (2010). What is sustainability economics? *Ecological Economics*, *69*(3), 445-450.

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

Brookfield, H., & Stocking, M. (1999). Agro-diversity: definition, description and design. *Global environmental change*, *9*(2), 77-80.

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

Burie District Agriculture Office Report (BDAOR). (2015). District annual report of livestock. Unpublished survey article.

Central Statistical Authority (CSA). (2017/18). Large and Medium Scale Commercial Farms Sample Survey 2007/2008 (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.

________. (2011). Central Statistical Authority Abstract of Federal Democratic Republic of Ethiopia. Addis Ababa, Ethiopia

________. (2007). Large and Medium Scale Commercial Farms Sample Survey 2007/2008 (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.

Federal Democratic Republic of Ethiopia (FDRE). (2005). National Biodiversity strategy and action plan. Institute of biodiversity conservation, Addis Ababa, Ethiopia.

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

Green, P. E., & Rao, V. R. (1971). Conjoint measurement-for quantifying judgmental data. *Journal of Marketing research*, *8*(3), 355-363.

Haan, P. (2006). Much ado about nothing: Conditional logit vs. random coefficient models for estimating labour supply elasticities. *Applied Economics Letters*, *13*(4), 251-256.

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

Joint FAO/WHO Expert Committee on Food Additives. Meeting, & World Health Organization. (2007). *Evaluation of certain food additives and contaminants:*

sixty-eighth report of the Joint FAO/WHO Expert Committee on Food Additives (Vol. 68). World Health Organization.

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.

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

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

Ministry of Water Resources. (2009). Ethiopian Water Resources Management Policy, unpublished survey result.

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

Narloch, U., Drucker, A. G., & Pascual, U. (2011). Payments for agrobiodiversity conservation services for sustained on-farm utilization of plant and animal genetic resources. *Ecological Economics*, *70*(11), 1837-1845.

Organisation for Economic Co-operation and Development. (2004). *Handbook of market creation for biodiversity: Issues in implementation*. Organisation for Economic Co-operation and Development.

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

Rose, J. M., Hensher, D. A., & Greene, W. H. (2005). Recovering costs through price and service differentiation: accounting for exogenous information on attribute processing strategies in airline choice. *Journal of Air Transport Management*, *11*(6), 400-407.

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

Sivaraj, P. (2016). A scale to measure attitude of farmers towards organic farming in western zone of Tamil Nadu. *International Journal of Agriculture Sciences, ISSN*, 0975-3710.

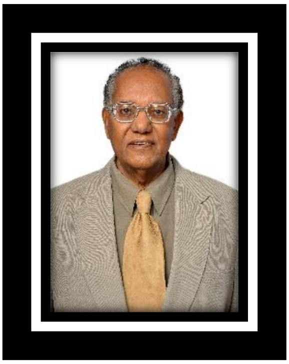
Villa, T. C. C., Maxted, N., Scholten, M., & Ford-Lloyd, B. (2005). Defining and identifying crop landraces. *Plant Genetic Resources*, *3*(3), 373-384.

Wale, 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.

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.

World Health Organization, & Joint FAO/NACA/WHO Study Group on Food Safety Issues Associated with Products from Aquaculture. (1999). *Food safety issues associated with products from aquaculture: report of a joint FAO/NACA/WHO study group* (Vol. 883). World Health Organization.

Condolence message on the passing of Prof. Teshome Mulat



The Editor-in-Chief, together with the Editorial Board Members of the Ethiopian Journal of Economics (EJE), and the Executive Committee of the Ethiopian Economics Association (EEA) express their sadness over the recent passing of the Honorary Advisory Board Member, Prof. Teshome Mulat. Prof. Teshome was a founding member of EEA, an Editorial Board Member of EJE from 1992 – 1993 and an Honorary Advisory Board Member since 1994.

In 2011, the EEA awarded certificate in recognition of his considerable contribution to the teaching of economics in Ethiopian higher learning institutions.

He contributed publications on the EJE. His contributions to the journal and to the EEA in general were tremendous, and we greatly missed him.