Estimating the economic value of climate services for strengthening resilience of smallholder farmers to climate risks in Ethiopia: A choice experiment approach

Working Paper No. 252

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

This study estimated the economic value of agricultural climate services for strengthening the resilience of smallholder farmers to climate variability and risks in Ethiopia. Using a choice experiment approach, the study introduced a hypothetical package of improved climate services to 600 randomly selected smallholder farmers in three districts across three different agro-ecological zones in the Oromia Regional State. A generalized multinomial logit (G-MNL) model was used to estimate preferred attributes of climate services and willingness-to-pay (WTP) values. The results show that the preferred bundle of improved climate services among smallholder farmers was one that could be communicated in short text message system, provided along with credit facility, and market information and one that favors participatory decision making by smallholders. The results further reveal that the WTP value exhibited high implicit price for participatory decision-making. The study sheds light on important characteristics of agricultural climate services that may improve their acceptability and usability among smallholders. It also highlights the importance of packaging additional services including digital and ICT-based solutions, financial and market information along with climate services to promote demand-driven last mile delivery systems. Engaging smallholder farmers in a participatory manner in the decision-making process can help them make informed decision.

Keywords

Climate services; climate variability and risks; choice experiment; G-MNL model; willingness to pay; smallholder farmers; Ethiopia

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Contents

Acronyms

CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CE	Choice experiment
EIAR	Ethiopian Institute of Agricultural Research
GFCS	United Nations Global Framework for Climate Services
G-MNL	Generalized Multinomial Logit Model
ICARDA	International Center for Agricultural Research in the Dry Areas
ICT	Information Communication Technologies
IRI	International Research Institute for Climate and Society
ITRS	Interactive Text Response System
IVRS	Interactive Voice Response System
MIXL	Mixed Logit Model
MNL	Multinomial Logit Model
NMA	National Meteorological Agency
RCC	Regional Climate Centers
RPL	Random Parameters Logit
S-MNL	Scaled Multinomial Logit
USAID	United States Agency for International Development
WTP	Willingness to pay

Introduction

Agriculture remains vital to the economy of most African countries, employing more than 60% of the population and contributing to about 25% of the GDP; its development has significant implications for food security and poverty reduction in Africa (World Bank, 2008; ACET, 2017). However, climate related risks and variability will continue to have far-reaching consequences for the agricultural sector in Africa, affecting resource-poor and marginalized smallholder farming communities who depend on agriculture for livelihood (AGRA, 2014; Zougmore et al., 2016). Climate services that are demand-driven, cost-effective, timely, and easy to access and understand can help vulnerable communities in Africa to adapt to climate variability and change and empower them to build their resilience to future climate risks and improve food security (WMO, 2016).

Climate services can be defined as the production, translation, transfer, and use of climate knowledge and information in climate-informed decision making and climate-smart policy and planning (ICCS5, 2017). As climate services continue to gain prominence on national, regional and global agenda for climate adaptation and mitigation (Tall, 2013) in most African regions, there are encouraging initiatives to improve generation, delivery and use of climate services where exposure to climate variability is highest and adaptive capacity is lowest (UNDP, 2011). These initiatives include the UN Global Framework for Climate Services (GFCS) that aims to reduce the vulnerability of society to climate-related hazards through better provision of climate services (WMO, 2011), the ClimDev-Africa program that supports Africa’s response to climate variability and change by improving the quality and availability of information and analysis to decision-makers at the regional level (UNECA, 2008), and the Regional Climate Centers (RCCs) that provide online access to their services to national climate centers and to other regional users (GFCS, 2009).

Despite significant efforts supported by various organizations to promote availability, access and use of climate services, the economic value of existing or potential climate services is not well understood, particularly for smallholder farmers in Africa (e.g. Clements et al., 2013; WMO, 2015; Vaughan et al., 2018). Because climate services are provided often freely through the mass media as public goods in most countries, market value cannot be used to estimate their economic value (Gunasekera, 2010; Rollins and Shaykewich, 2003). Climate services embody two features of a global public good (Gunasekera, 2002; Freebairn and Zillman, 2002). First, climate services are non-rivalrous—once generated, the marginal cost of reproducing and supplying services to another user is very low and the use of the services by one user does not infringe on its usage by others. Second, climate services are non-excludable— it is very difficult and potentially expensive to exclude users from benefiting from these services once produced (Gunasekera, 2002; Freebairn and Zillman, 2002).

Understanding the value of climate services is important for governments and international development partners, private and public service providers, and users of the services (Gunasekera, 2004). Given the competition for scarce public funds (e.g. Rogers and Tsirkunov, 2013; Perrels et al., 2013), estimates of the economic value can help providers justify funding and guide priorities to invest in managing the impacts of weather and climate across economic sectors. A clear understanding of the value associated with climate services can help providers of the services to tailor the services to further maximize the value obtained from their use (Zillman, 2007). Similarly, the value of climate services can serve as an important communication tool in enhancing uptake and use of climate services thereby increasing total value to a given community. Furthermore, knowing the value of the services can encourage users to be willing to pay for the existing or improved climate services (Zillman, 2007).

The objectives of this study are to estimate the preferred attributes of climate services, examine preference heterogeneity[1] among smallholders, and estimate willingness to pay (WTP) values in Ethiopia. The few studies across Africa in recent years that quantify the economic value of climate services among smallholder farmers include Zongo et al. (2016); Roudier et al. (2016); Amegnaglo et al. (2017); Ouédraogo et al. (2018) in West Africa and Rodrigues et al. (2016) in five East African countries. In Ethiopia, however, no single study is available so far to provide evidence on the economic value of these services among smallholder farmers. This study uses a choice experiment (CE) approach and presents farmers with an improved climate services that constitutes a more accessible media of getting the

[1] Preference heterogeneity refers to a situation where group of respondents like or dislike different alternatives in a systematic and quantifiable way.

services, with market information and financial resources available which could help increase the usability of these services among smallholders. This study also tests how much interest smallholder farmers have in participatory decision-making process in the implementation of climate services.

The study uses a generalized multinomial logit model (G-MNL) to analyze the data. The G-MNL model was preferred to the popular random parameters logit (RPL) model because of its flexibility in the distribution of individual-level parameters (Fiebig et al., 2010), and ease of estimating the distribution of WTP directly. It provides a straight forward method of reparametrizing the model to estimate the taste parameters in WTP space, which has recently become behaviorally attractive way of directly obtaining an estimate of WTP (Train and Weeks, 2005; Scarpa et al., 2008; Daly et al., 2012).

The remainder of paper is organized as follows. The next section discusses the methodology. Section 3 present results and Section 4 concludes with some policy implications.

Methodology

Choice experiment design

The choice experiment (CE) method is an attribute-based quantitative method that can be used to estimate a monetary value for an existing good or service that may have no market, limited market or incomplete market (Champ et al. 2003, Rollins and Shaykewich, 2003). It can also be used to elicit preference of individuals for potential goods, services or policy that are yet to be introduced into the market (e.g. Bateman et al., 2002; Louviere et al., 2010). The CE method is founded on the notion that a service or a policy can be described in terms of its attributes and the levels these attributes take (Louviere et al., 2011). By varying the attribute levels, it is possible to present different services or policy options to respondents (Mansfield and Pattanayak, 2006). The focus of this study is to understand the value of alternative forms of climate services, described in terms of their attributes and the levels these attributes take. The attributes here refer to the characteristics that comprise improved climate services while the levels describe the possible values or outcomes associated with each attribute. Based on literature review, consultation of experts, focus group discussion and pre-test, five attributes of improved climate services were considered: media for accessing climate services, credit facility, market information, participatory decision making and a monetary value used to make a trade off among the attributes (Table 1).

Table 1: Attributes and levels used in the choice experiment

Attribute		Levels
1	Media	Receive climate services through radio Receive climate services through mobile phone in short text message (SMS) Receive climate services through mobile phone in interactive voice response system (IVRS) Receive climate services through mobile phone in interactive text response system (ITRS)
2	Credit	No access to credit Access to credit
3	Market information	No market information Information on selling price Information on right market location to sell their produce Information on quantity demanded and supplied
4	Decision making process	Farmer decides based on own experience, no interference by extension agents Top-down approach, extension agents dictate Farmers make informed decisions based on participatory approach
5	WTP	No increment on monthly pre-paid mobile phone bill ETB2 15-30-45-60

Farmers' preference for media used to access climate services was tested by presenting them with alternatives to the dominant radio-based delivery of weather and climate information. Dissemination of climate services through the radio has no fixed time, implying that to get the information farmers have to turn on their radio, perhaps for the entire day, and thus this may not be an effective means to disseminate the information to all farmers since they have their own setting under which they operate and likely to miss the information when they are busy with some other engagements (Feleke, 2015). The improved hypothetical media included i) Use of SMS text message that farmers can easily access through the mobile phone at any time; ii) Interactive text response system (ITRS) that allows a farmer to access information on demand through a simple menu; iii) Interactive voice response system (IVRS), where the farmer can ask questions in her or his native language. Both SMS and ITRS are one-way systems where information is disseminated from a district agricultural office or development

[2] Ethiopian Birr is currency in Ethiopia (1USD is equivalent to 23 ETB as of June 29, 2017).

agents to farmers. Since both SMS and ITRS are text messages, the farmer who receives these messages needs to be literate to read and understand the content of the message, or needs someone from the family members to read for her/him. For IVRS, the application processes the query, searches the knowledgebase, and speaks a response to the farmer. In this case, the farmer is not required to be literate to receive the service.

Access to credit can play a key role in enabling resource-poor farmers to adjust their agricultural practices in response to available forecast and early warning information and to meet any associated transaction cost (Hassan and Nhemachena, 2008; Di Falco et al., 2011). To this end, bundling climate services with access to credit was considered potentially important in improving uptake and use of climate services. In this hypothetical situation, farmers would be granted access to credit through existing microfinance institutions in their communities to alleviate the financial constraints majority of them face to make use of climate services provided to them. In order to ensure that the credit is directly used to meet the financial demand associated with climate services, the extension agents can play an important role by monitoring how the credit is being used.

Provision of market information was another useful characteristic of improved climate services introduced to the CE design. Market information enables farmers to plan their production in line with market demand, schedule their harvest at the most profitable times, decide to which market they should send their produce and negotiate on a more even footing with traders (Shepherd, 1997). Studies also suggest that bundling market information and climate services enhance farmers' decision making. For example, farmers in Ghana rated both weather and market information, accessed through mobile phones, to be very useful for their agricultural activities regardless of sex, income status or age group (Etwire et al., 2017). Similarly, Haile et al. (2015) demonstrate that integrating climate information such as seasonal rainfall pattern with market information like current and past output prices improved farmers' production decision in rural Ethiopia. Farmers' preference for availability of market information was tested through the provision of three types of hypothetical market information: selling price, market locations to sell products, and information on quantity demanded and supplied.

Three options were considered for supporting farmers' decision responses to climate services: i) a "farmer decides" model (farmers own experience) with no input from agricultural extension, ii) one-way communication of management advice from extension agents to farmers. This option is top-down and limits farmers' participation (IFPRI, 2010) and is affected by a low level of trust by farmers in the government agricultural extension system (Belay and Abebaw, 2004; Pye-Smith, 2012), and iii) participatory decision making with balanced input from farmers and government agricultural extension agents.

Finally, a monetary attribute was introduced to estimate farmers' WTP for improved climate services and the trade-off farmers would make among the different attributes. The monetary attribute was an increment of 15% to 60% over their average monthly spending on their pre-paid mobile phone bill. The levels for the monetary attribute was derived based on literature review on the average monthly expenditure on pre-paid mobile phone bill in Ethiopia (Adam, 2008).

Description of study locations and survey implementation

The study was carried out in three districts of the Oromia region: Kersana Malima, Ada'a and Dodota (Figure 1). The three districts represent three agroecological zones. Kersana Malima is highland with an elevation ranging from 1850 to 3360 meters above sea level (masl). The average annual temperature varies between 18 and 25 ^{0}C while the average annual rainfall ranges between 900 and 1400 mm. Major crops in the district are wheat, teff *(Eragrostis tef)*, barley, maize, and beans. Ada'a District mainly encompasses the mid-elevation, ranging from 1600 to 2000 masl. The district receives average annual rainfall of 860 mm, and mean annual temperature ranges from 8 to 28 ^{0}C. Major crops grown in the area are *teff,* wheat and chickpea. Dodota District, located in the Great Rift Valley, is characterized by lowland agro-ecology, and elevation ranging from 1360 to 1700 masl. The district has average daily temperature between 18 to 30 ^{0}C and average annual rainfall of 500 to 900 mm. Major cash crops of the district are haricot bean, onion, garlic and linseed.

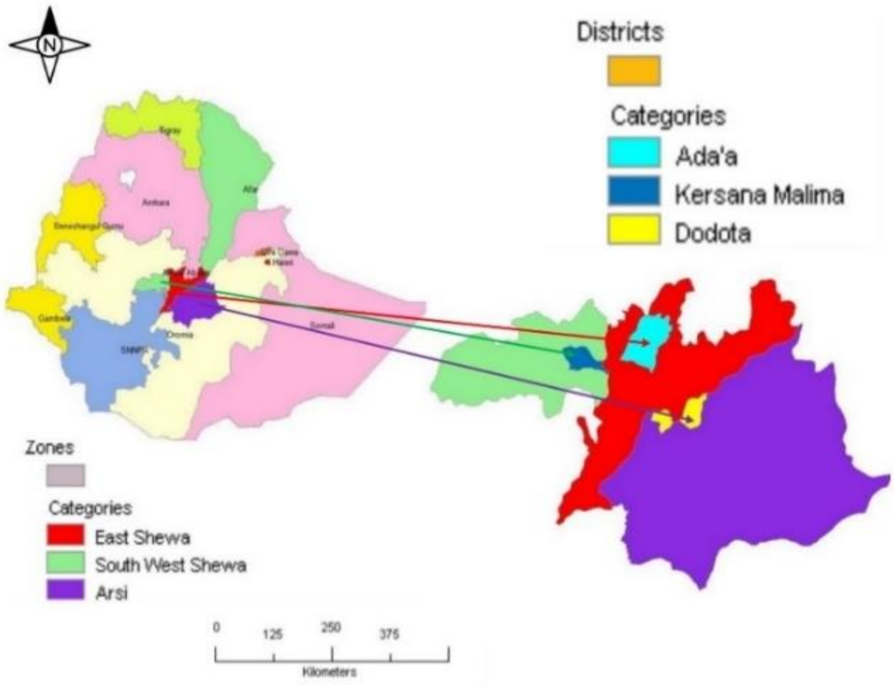

Figure 1: Location of the three study districts

Primary data were collected through a survey of 600 household heads in the three districts in October 2017. Trained enumerators interviewed 200 randomly selected farm household heads from each district, using the local language. The survey consisted of six parts. The first part focused on farm household socio-demographic characteristics. The second part was about agricultural activity and irrigation use. The third part was related to climate information services (e.g. medium for receiving the information, sources of the information etc.). Part four elicited farmers' access to market and market information. In part five, questions related to extreme weather and climate events were incorporated. Finally, the last part introduced the CE.

The CE design was generated using Ngene software version 1. Maintaining attribute level balance[3] and utility balance,[4] the design generated was efficient with D-error value[5] of 0.13. Attributes and their levels were represented using pictograms since many of the respondents

[3] Attribute level balance refers to a situation where for each attribute, each level appears an equal number of times over the choice situations. This will guarantee an even distribution of the levels, such that not just primarily high or low levels are faced by respondents.

[4] A situation where no alternative is clearly dominating other alternatives.

[5] Value that measures model efficiency.

were assumed to be illiterate. A brief training session was organized where enumerators gave training to a group of four sample respondents to clarify the content of the attributes and their levels before the data collection. The enumerators were trained to memorize a standard text that describes climate services in terms of two policy interventions, the different characteristics that comprise improved climate services, and the possible values or outcomes (levels) associated with each characteristic. Once the training was over, respondents were called individually to respond to the survey questions. The twelve cards generated with the efficient design were shown to all sample respondents. The enumerators were responsible to reshuffle the cards each time they showed them to a new respondent. An example card (Figure 2) was shown to farmers before they were shown the choice task to make sure that they understood the choice task properly. Choice cards were printed in color on a separate sheet of paper and laminated for multiple use. Farmers were given the chance to opt out, choosing neither of the two options. In such cases farmers were asked in a follow up questions why they chose the opt-out option.

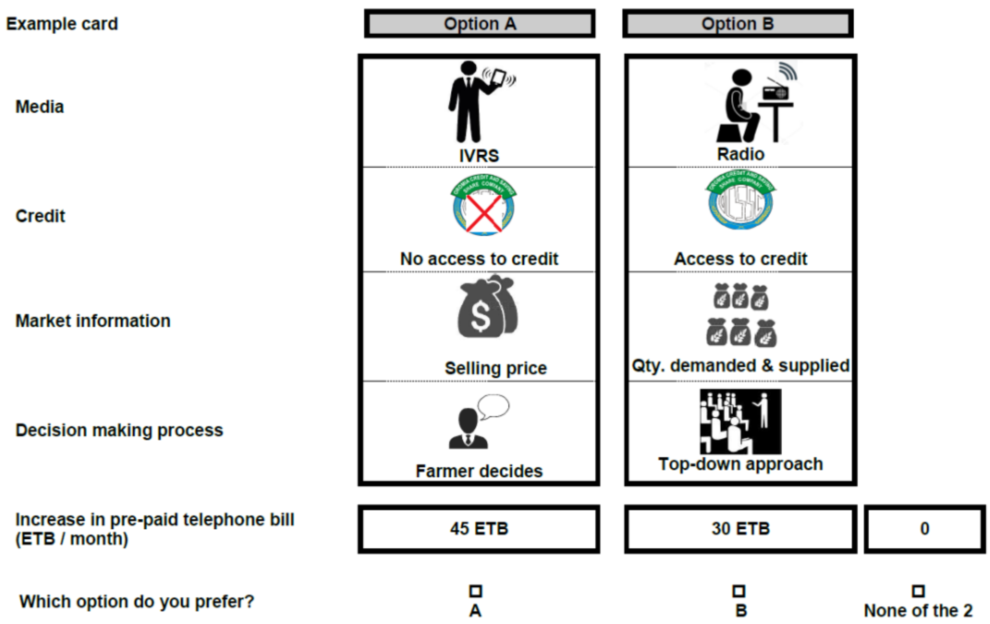

Figure 2: Example of choice card

Model specification

The G-MNL model

The main objective in discrete choice modelling is to analyze the individual's choice in relation to the characteristics (attributes) of the good or service based on the random utility theory (e.g. McFadden, 1974) and Lancaster's attribute based utility theory (Lancaster, 1991). Any random utility model can be approximated by the multinomial logit model (MNL). In the simple MNL model, the utility to individual i (i= 1, 2, … 600) from choosing alternative j (j= 0,1,2) on choice situation t (t= 1,2, …12) is given by

$$U_{ijt} = \beta_i x_{ijt} + \varepsilon_{ijt} \qquad (1)$$

where x_{ijt} is a vector of observed attributes of alternative j of improved climate services relating to sampled farmer i. β_i is a corresponding vector of utility weights (homogeneous across farmers) and ε_{ijt} ~ *i.i.d.* extreme value-I is the idiosyncratic error (Green, 2003; Kanninen, 2007). Sampled individuals are assumed to differ in terms of the extreme weather and climate events they face, and the packages of improved climate services they need depending on their conditions. In such a situation, the mixed logit model (MIXL) relaxes the independence of irrelevant alternatives (IIA) assumption, and allows preference heterogeneity (Train, 2003). In the MIXL, the utility to individual *i* from choosing alternative *j* on choice situation *t* is given by

$$U_{ijt} = (\beta + \eta_i) x_{ijt} + \varepsilon_{ijt} \qquad (2)$$

where, β is the vector of mean attribute utility weights in the population, while η_i is the individual specific deviation from the mean (taste heterogeneity). The individual error component ε_{ijt} is still assumed to be i.i.d. extreme value.

A scaled multinomial logit (S-MNL model) is a version of MIXL that allows for scale heterogeneity[6]. The S-MNL model can be understood by recognizing that the idiosyncratic

[6] Scale heterogeneity is defined as variation across individual decision-makers in the impact of factors that are not included in the model, relative to the impact of factors that are included.

error in the MIXL model has a scale or variance that has been implicitly normalized to attain identification. In the S-MNL model the utility is given as

$$U_{ijt} = (\beta\sigma_i)x_{ijt} + \varepsilon_{ijt} \quad (3)$$

Here, σ_i is the scaling parameter that uniformly shifts the whole β vector up or down for each individual (Fiebig et al., 2010).

The G-MNL model is an alternative approach to modelling heterogeneity that stays within the classical framework and retains the simplicity of use of MIXL. The G-MNL model can be obtained by nesting MIXL and S-MNL. This model avoids some of the limitations of MIXL (Greene, 2012). Estimation of G-MNL would explain whether heterogeneity is better described by scale heterogeneity, normal mixing (mixture-of normal logit or "mixed-mixed" logit) or some combination of the two (Fiebig et al., 2010). In the G-MNL model, the utility to individual i from choosing alternative j on choice scenario t is given by

$$U_{ijt} = [\sigma_i\beta + \gamma\eta_i + (1-\gamma)\sigma_i\eta_i]x_{ijt} + \varepsilon_{ijt} \quad (4)$$

The distribution parameter γ ranges between 0 and 1. The effect of scale on the individual idiosyncratic component of taste can be separated into two parts: unscaled idiosyncratic effect, that is, $\gamma\eta_i$ and scaled by $(1-\gamma)\sigma_i\eta_i$ where γ allocates the influence of the parameter heterogeneity and the scaling heterogeneity. To obtain MIXL, one sets the scale parameter

$\sigma_i = \sigma = 1$. To get the S-MNL model one sets Var $(\eta_i) = 0$. This implies that the variance covariance matrix of η_i, denoted $\sum$, is degenerate.

The G-MNL model has two special cases. First, by combining MIXL (equation 2) and S-MNL (equation 3), one can obtain what is called G-MNL-I. The utility for this model is given by

$$U_{ijt} = (\beta\sigma_i + \eta_i)x_{ijt} + \varepsilon_{ijt} \qquad (5)$$

Second, G-MNL-II is formulated based on MIXL and by making the scale parameter explicit, where $U_{ijt} = (\beta + \eta_i)x_{ijt} + \varepsilon_{ijt}/\sigma_i$, and then multiplying through by σ_i:

$$U_{ijt} = \sigma_i(\beta + \eta_i)x_{ijt} + \varepsilon_{ijt} \qquad (6)$$

In G-MNL-I or G-MNL-II, the utility weight can be specified as

$$\beta_i = \sigma_i\beta + \eta_i^* \qquad (7)$$

Scale heterogeneity is captured by the random variable σ_i, and residual taste heterogeneity is captured by η_i^*. G-MNL-I and G-MNL-II differs in that in the former case the standard deviation of residual taste heterogeneity (η_i^*) is independent of the scaling of β, while in the latter case the standard deviation of η_i^* is proportional to σ_i. G-MNL approaches G-MNL-I as $\gamma \rightarrow 1$, and G-MNL approaches G-MNL-II as $\gamma \rightarrow 0$. In the full G-MNL model γ can take on any value between 0 and 1 (Fiebig et al., 2010).

Since σ_i represents the person-specific scale of the idiosyncratic error, it must be positive; thus, a lognormal distribution with mean 1 and standard deviation τ is appropriate to use (Fiebig et al., 2010). The τ parameter is vital in capturing scale heterogeneity. As $\tau \rightarrow 0$, G-MNL approaches MIXL. If $\tau > 0$ then G-MNL approaches S-MNL as the diagonal elements of Σ approach zero. If both τ and Σ go to zero G-MNL approach the simple MNL model.

To constrain the scale parameter σ_i to be positive, an exponential transformation can be used, where $\sigma_i = \exp\left(\bar{\sigma} + \tau\varepsilon_{0i}\right)$ and ε_{0i} distributed normally with mean 0 and standard deviation 1. This implies that as τ increases the degree of scale heterogeneity increases. It is clear that as σ_i and β only enters the model as a product $\sigma_i\ \beta$, some normalization on σ_i is essential to identify β. The normalization is to set the mean of σ_i =1 so β is interpretable as the mean vector of utility weights. To get here it is important that the parameter $\bar{\sigma}$ be a decreasing function τ .

Since $E\sigma_i = \exp\left(\bar{\sigma} + \tau^2/2\right)$, in order to set $E\sigma_i = 1$, $\bar{\sigma}$ have to be equal to $-\tau^2/2$.

Therefore, the simulated choice probability in the G-MNL model can be specified as

$$P(j \mid X_{it}) = \frac{1}{D}\sum_{d=1}^{D} \frac{\exp\left(\sigma^d\beta + \gamma\eta^d + (1-\gamma)\sigma^d\eta^d\right)X_{ijt}}{\sum_{k=1}^{J}\exp\left(\sigma^d\beta + \gamma\eta^d + (1-\gamma)\sigma^d\eta^d\right)X_{ikt}} \qquad (8)$$

where $\sigma^d = \exp\left(\bar{\sigma} + \tau\varepsilon_0^d\right)$, η^d is a k-vector distributed multivariate normal with (0, Σ) and ε_0^d is normally distributed with (0,1) scalar (Fiebig et al., 2010).

Farmers’ willingness to pay for improved climate services

Recent research in redefining the ‘space’ within which a choice model is estimated as WTP space, instead of preference space, has offered encouraging evidence in reducing the range of behavioral implausibility (Hensher and Greene, 2011). A salient feature of the WTP space model is that estimated parameters are also the parameters of the implied WTP distributions (Scarpa, et al., 2008). The model in WTP space assumes normal and lognormal WTP’s, which implies coefficients that are the product of a lognormal with a normal or lognormal

(Train and Weeks, 2005). The standard practice in the estimation of WTP is calculating the ratio of the attribute's coefficient to the price coefficient. In models parameterized in terms of WTP, usually denoted as models in WTP-space, distribution of WTP is estimated directly (Train and Weeks, 2005). In such cases utility takes the form

$$U_{ijt} = \beta_i^p p_{ijt} + \beta_i^p wtp_i^{'} x_{ixt}^a + \varepsilon_{ijt} \qquad (9)$$

where P_{ijt} is price, x_{ijt}^a is a vector of non-price attributes and wtp_i is a corresponding vector of the farmer's WTP for the non-price attributes. The advantage of implementing models in WTP-space is to estimate the distribution of WTP directly, rather than estimate the distribution of utility coefficient and then derive the implied distribution of WTP (Scarpa et al., 2008).

Results

Description of farm household socio demographic characteristics

Farm household characteristics across the three districts are presented in Table 2. The majority of the sample respondents interviewed were male-headed households, with an average age of 44 years and average family size of 6. Almost three in ten of the respondents reported that they did not go to school, while 58% have joined formal education (grade 1-8). Average agricultural land holding was 1.7 hectare. On average, nine people work on the farm land (both hired and family labor). For the majority of the respondents, farming is the way of life; only 23% of the respondents supplement their farm income with off-farm activity such as petty trade. Livestock rearing is an important part of farming. All respondents own oxen, cows, sheep, goats and chickens. Teff, wheat and chickpea account for a major portion of the volume of crops produced last season. In the same season, vegetables such as onion, tomato and potato attained higher average production (Figure 3).

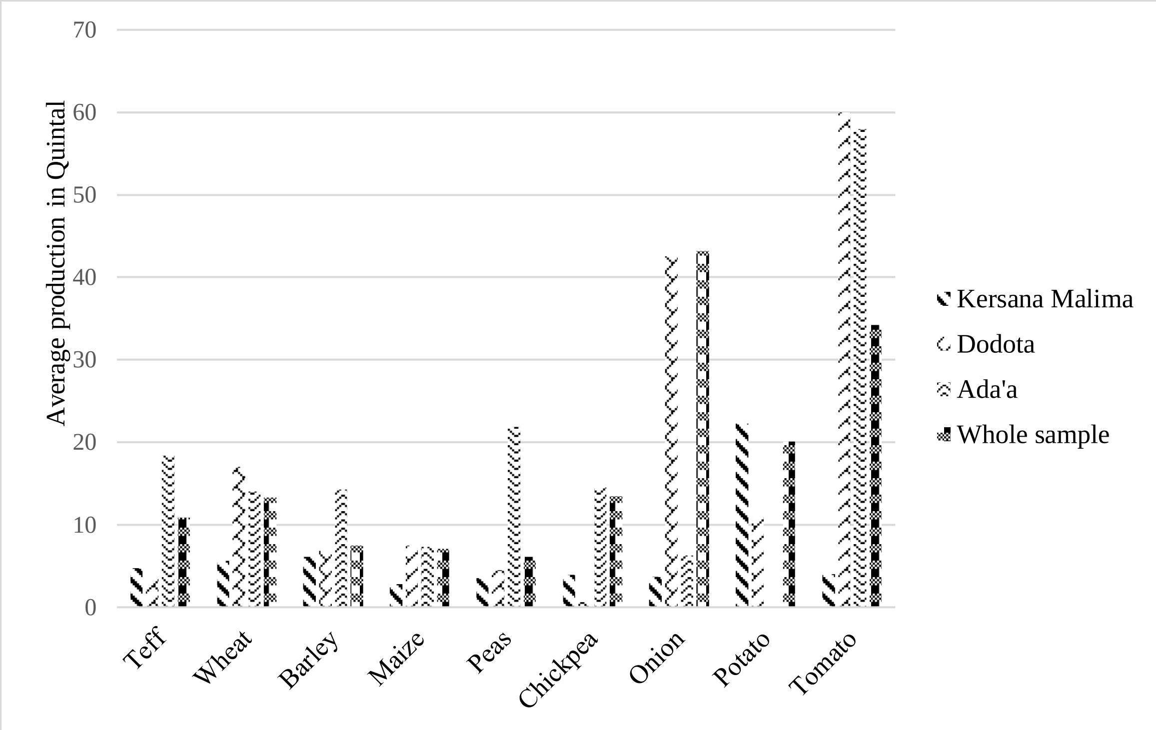

Figure: 3 Crops and vegetables production in quintal[7] across the three locations and the whole sample.

Table 2: Farm household characteristics across the three locations

Household characteristics	Kersana Malima	Dodota	Ada'a	Whole sample
Male (%)	90	82	81	84
Average age (years)	44	42	44	44
Education level (%)				
Illiterate	42	16	27	28
Grade 1-8	53	64	58	58
Greater than grade 8	5	21	16	14
Informal education	0.5	0	0	0.2
Average family size (persons)	7	6	6	6
Average land size (ha)	1.1	2.4	1.6	1.7
Labor both hired and family members (persons)	8	11	9	9
Off farm activity (%)	36	17	17	23
Irrigation use (%)	2	14	26	14
Access to credit (%)	61	74	64	66
Contact with development agents (%)	93	97	93	94

[7] One quintal is equivalent to 100 kilograms.

Access to Market information (%)	77	91	88	85

The majority of the respondents did not use irrigation for crop production. For those who use irrigation, onion and tomato were the main vegetables grown. Many of the farmers have access to credit facility mainly provided by microfinance institutes, and use credit primarily for the purchase of fertilizer. Almost all the farmers reported receiving technical advice from extension agents at least once a month. The advice included weather forecast and early warning information, agronomic management and climate-smart agricultural practices. All farmers have access to markets and 85% of them access market information such as selling price and crop type to sell mainly from traders and neighbors. Selling price was the most important market information for almost half of the respondents.

Farm household access and use of climate services

Climate services access and use in the three locations are indicated on Table 3. Almost a third of respondents reported that they did not have a radio, while the vast majority have a mobile phone. Those who have mobile phone also reported that on average two members of their household have mobile phones. They said that they use their mobile phone to communicate with relatives and friends. Almost all the respondents also stated that they receive climate services such as start of rain, and extreme events such as drought and flooding and disease and pest outbreaks. More than half of the respondents reported that the family unit received climate services while more than a third stated that the husband received the services. For the 57% of the respondents who access climate services, radio, extension agents, friends and neighbors were the main channels through which they received the services. Even though the majority of the respondents have a mobile phone, they did not receive climate services through their mobile phones. One third of those who reported accessing climate services indicated that they preferred to receive services via mobile phones, and one third preferred radio. The remaining one third preferred a combination of radio, mobile phone, friends and neighbors as channels for accessing the services.

NMA was recognized as the generator and provider of climate services by 58% of the respondents, but almost 30% of the respondents did not know the sources of climate services they received. For the majority of the respondents, sowing period was the most important information. A significant number of respondents also indicated that they used the information for the application of fertilizer and other agro-chemicals (Figure 4). Climate services were communicated both in the local language (Oromiffa) and the national language (Amharic). More than half of the farmers received climate services in the local language whereas more than a third received the information both in national and the local languages. The overwhelming majority preferred local language as means of communicating the services. When respondents were asked about the main barriers to use climate services, half of the respondents reported that media of accessing the services was the main barrier. The other half mentioned a combination of barriers such as shortage of financial resources, language of accessing the services and top-down approach.

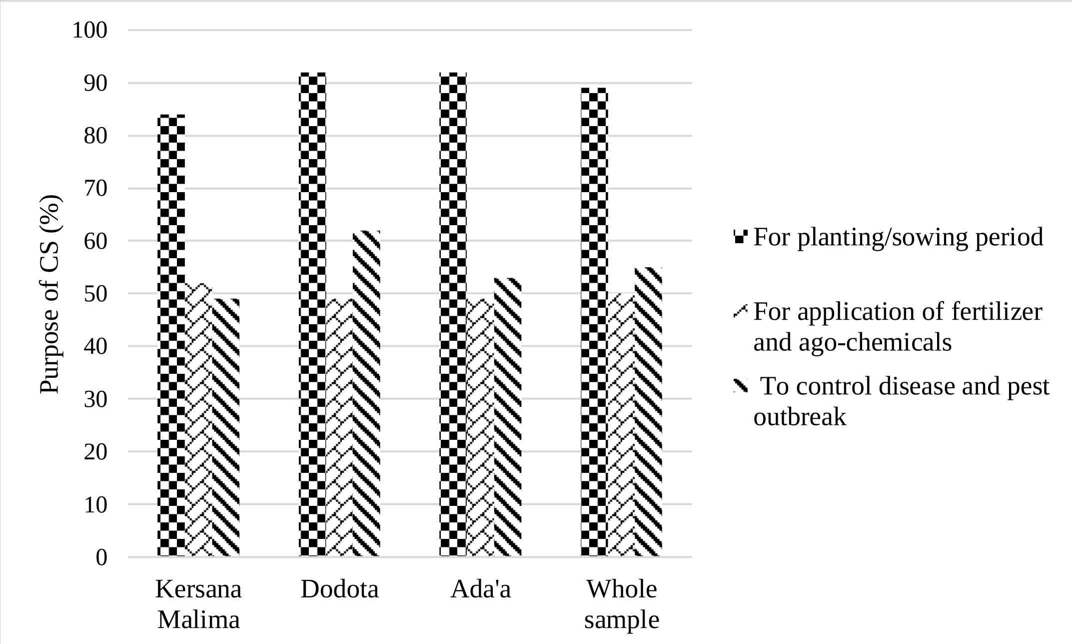

Figure 4: Purpose of using climate services

From farmers' response, it appeared that the frequency of receiving climate services was not uniform, some of the respondents reported that they received climate services daily, a few said that they got services every other day, another group indicated that they got it twice per week and a slightly higher number of respondents reported that they received the services once per week (see Table 3). Regarding the timeliness of the information, 47% said that they received the services on time (e.g. before planting season) while 45% complained that they didn't get the services on time. The majority of the respondents understood the content of the information. When asked if the services they received was sufficient, 64% said that it was not sufficient. Regarding the reliability of the climate services they received, 68% agreed that the services were reliable. A majority of sampled households disclosed that they used indigenous knowledge. When asked to compare indigenous knowledge with climate services from NMA, six out of ten disclosed that they valued information from NMA higher than the indigenous knowledge whereas a little above one tenth reported that they equally value information from both sources. Still a few claims that they trust indigenous knowledge more than information from NMA.

Table 3: Climate services access and use in the three locations (%)

Climate services	Kersana Malima	Dodota	Ada'a	Whole sample
Share radio owners	64	67	76	69
Share mobile phone owners	87	94	98	93
If household members receive climate services (CS)	91	94	94	93
Share of household members who receive CS				
Family unit	44	61	27	57
Husband	49	32	66	36
Media to receive CS				
Radio,	30	36	41	36
extension agents, friends and neighbors	61	57	52	57
Preference for media of CS				
Radio	39	24	26	30
Mobile phone	20	38	35	31
Radio, extension agents, friends and neighbors	31	32	33	32
Knowledge about the sources of CS				
NMA	58	57	58	58
I do not know	27	32	27	29
Other	6	5	9	6
Type of CS received				
Forecast on start of rain	58	66	67	64
Forecast on disease and pest outbreak	16	13	11	13
Forecast on drought and flood	22	26	14	21
Language of accessing CS				
Local language	60	56	46	54
National language	2	1	1	1.3
Both	28	37	47	38
Language preference				
Local language	89	88	71	83
National language	1.5	3	7	4
No preference	0.5	3	16	6
Frequency of receiving CS				
Daily	31	36	41	36

Every other day	10	14	13	12
Twice per week	18	22	14	18
Once per week	23	18	24	22
Timeliness of CS	49	49	44	47
Understanding contents of CS	79	86	86	84
Adequacy of CS	43	28	38	36
Reliability of CS	72	67	63	68
Use indigenous knowledge (IK)	76	74	71	74
Compare indigenous knowledge with CS from NMA	63	63	55	60
Value CS from NMA more	20	9	13	14
Trust IK more	9	12	14	12
Equally value both IK and NMA information				
Barriers to use CS				
Media of accessing CS	46	56	48	50
Other (language, financial resources, top-down approach)	54	45	52	50

Extreme events and coping strategies by farm household

The majority of sample respondents were asked if they have ever faced extreme weather events and most of them reported that they have faced extreme events, such as heavy rain, flooding, drought and occurrence of disease and pests during the past five years (Figure 5). The severity of these events depends on the location of respondents. Those who were located at higher elevations mostly suffered from heavy rain, while those in the lowland faced drought. For almost all, crop failure was the major loss associated with extreme events.

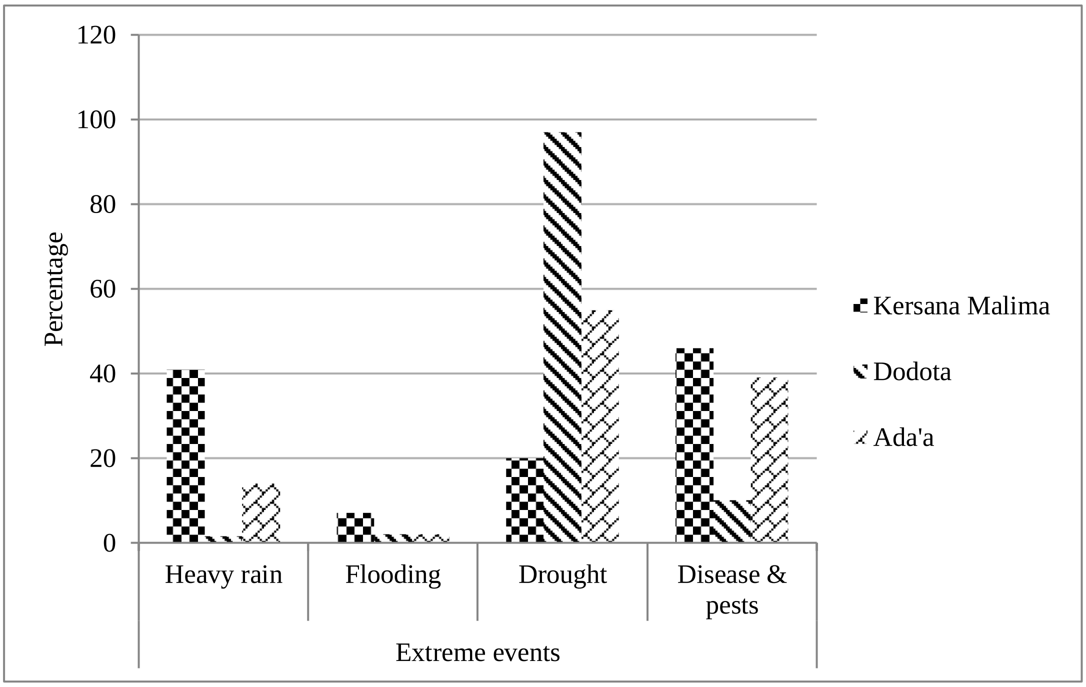

Figure 5: Extreme events respondents faced across the three locations

Even though a majority of the respondents faced extreme weather events, it was noted from their reply that no significant coping strategies were used. When respondents were asked what coping strategies they were using to reduce vulnerability to extreme events, majority of them said that they did not take one. This may indicate farmers' lack of awareness about the various coping strategies that are in place and hints at the need for development agents and others who work closely with farmers to help them understand the pros and cons of new technologies when introducing these technologies instead of imposing them and instruct farmers to use them. Figure 6 shows the different coping strategies and the share of farmers who implement these strategies.

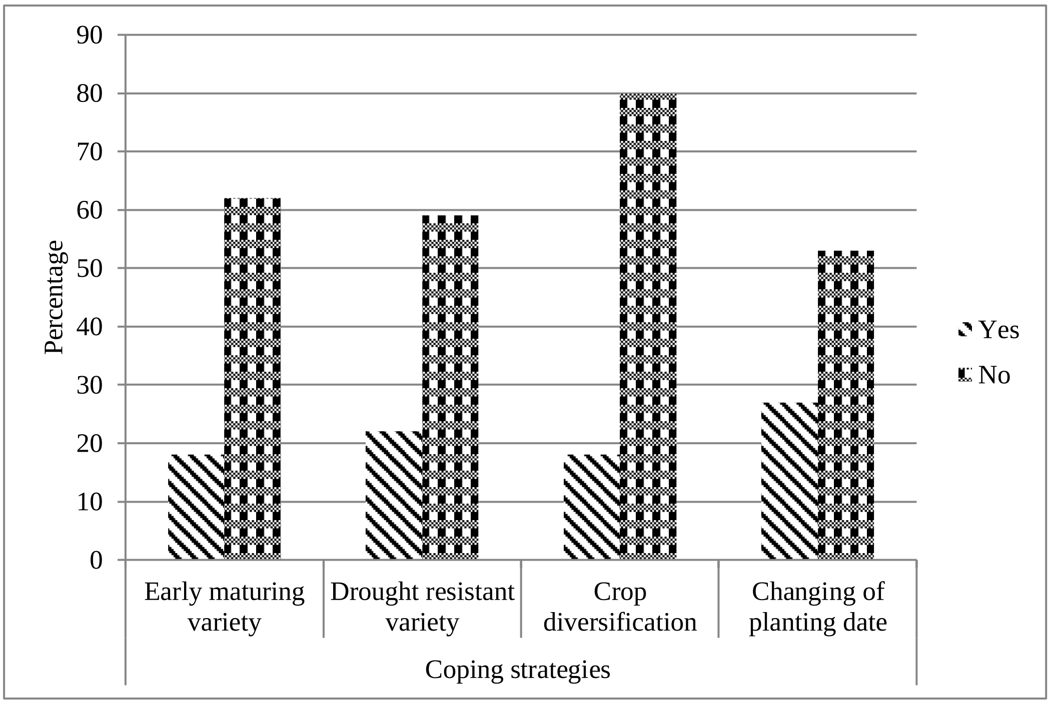

Figure 6: Coping strategies and share of respondents implementing these strategies

Estimated choice model results

G-MNL model results

All but two sample respondents selected one of the improved climate services alternatives, showing their interest for improved climate services that would help reduce crop and livestock loss. The first alternative was chosen in 48% of the cases while the second alternative was picked in 49% of the cases. Important attributes that influenced farmers' choice behavior, according to respondents, were decision making process (43%), media (37%) and market information (12%). Almost all (98%) of the respondents confirmed that the choice set presented to them was clear, understandable and credible.

The G-MNL model, with different formulations (full G-MNL, G-MNL-II (=0), G-MNL-I (=1) and G-MNL (=1)), was run to estimate attributes of improved climate services, preference heterogeneity and WTP values. The four models produced consistent results for two of the attribute levels: participatory decision making and top-down approach. Some variations were observed in the results of the remaining attribute levels. Discussion of results henceforth is based on models with more plausible results, however, all the four model results are displayed on Table 4 for comparison purpose.

In the discussion of preferred attributes of climate services among smallholder farmers, G-MNL-II (=0) model results were referred to. Accordingly, SMS short text message, market information on selling price, participatory decision-making and access to credit were positively related to the probability of choosing one of the improved climate services options. IVRS, information on market location and top-down approach were negatively related to the probability of choosing one of the improved options. The attribute media entered the model in four levels with one of the levels (radio) being the baseline. The model result indicated that farmers prefer receiving climate information through SMS over radio, but valued IVRS and ITRS less than radio. Their preference for SMS text messages compared to radio could be attributed to the handy nature of mobile phones and its facility to retain messages once received. In addition, most of the farmers were already familiar with receiving SMS text message for information other than weather and climate. Farmers preference of mobile phone to radio in our study was in line with Churi et al. (2012) who studied farmers' information communication strategies for managing climate risks in rural Semi-Arid areas in Tanzania. IVRS and ITRS are innovative means of communication compared to radio, but it was surprising to know that respondents did not pick either of these communication media. This may have to do with lack of awareness by farmers about these communication channels. One evidence of lack of unfamiliarity could be the promotion of these media throughout the country by the Ethiopian agricultural Transformation agency (IRIN, 2014).

Market information on selling price was the preferred attribute of improved climate services among smallholders when compared to information on quantity demanded and supplied (baseline category). Favoring information on selling price is consistent with other experience with smallholder farmers in Ethiopia (Tadesse and Bahiigwa, 2015; Haile et al., 2015; Ahmed et al., 2016). When examining participatory decision-making process in the use of climate services, farmers valued participatory approach positively and significantly compared to farmer decides (use of own experience) which was the baseline. When given the chance to make a choice between top-down approach and the own experience, interestingly farmers picked the latter. Their interest in a participatory approach may explain their ambition to be part of the decision-making process and getting attention for their perspective. However, it is interesting to note that the current top-down intervention that is believed to be unsatisfactory and ineffective (IFPRI, 2010) was not the farmers' choice even when compared to the use of own experience.

As anticipated, farmers considered access to credit as an important part of a package of improved climate services. Research shows that access to credit enables poor smallholder farmers, who often have limited financial resources for purchasing agricultural inputs, to adopt climate smart agricultural practices (Tesfaye and Brouwer, 2012; Tesfaye et al., 2014; FAO, 2016).

Table 4: Estimation results of the value of improved climate services in G-MNL model

Attributes	Full G-MNL		G-MNL-II (=0)		G-MNL-I (=1)		G-MNL (=1)	
	Coefficients	Std. Error	Coefficients	Std. Error	Coefficients	Std. Error	Coefficients	Std. Error
SMS short text message (SMS)	0.034	0.039	0.461***	0.092	0.026	0.044	0.412***	0.067
Interactive voice response system (IVRS)	0.158***	0.042	-0.174**	0.083	0.189***	0.048	0.028	0.072
Interactive text response system (ITRS)	0.053	0.036	0.002	0.075	0.080**	0.039	-0.084	0.059
Information on market location	0.137***	0.026	-0.130***	0.047	0.120***	0.028	0.267***	0.042
Information on selling price	0.018	0.023	0.120***	0.044	0.018	0.027	-0.126***	0.038
Top-down approach - extension agents dictate	-0.298***	0.027	-0.659***	0.056	-0.268***	0.028	-0.631***	0.051
Participatory decision-making	0.371***	0.036	0.549***	0.065	0.438***	0.041	0.864***	0.068
Access to credit	-0.011	0.015	0.130***	0.038	0.014	0.017	-0.075***	0.028
Price	-3.572***	0.183	-7.055***	0.698	-3.554***	0.174	-5.173***	0.253
Constant	-3.250***	0.040	-2.764***	0.057	-3.259***	0.048	-2.567***	0.040
Heterogeneity in Mean								
SMS short text message (SMS)	0.001	0.134	0.158	0.163	0.001	0.671	0.038	0.051
Interactive voice response system (IVRS)	0.002	0.160	0.341***	0.121	0.001	0.331	0.192***	0.037

Interactive text response system (ITRS)	0.002	0.128	0.414***	0.068	0.003	0.230	0.268***	0.036
Information on market location	0.016	0.042	0.033	0.128	0.005	0.224	0.094***	0.018
Information on selling price	0.001	0.114	0.131	0.086	0.001	0.333	0.087***	0.026
Top-down approach - extension agents dictate	0.013	0.045	0.492***	0.038	0.006	0.119	0.238***	0.023
Participatory decision-making	0.032	0.026	0.324***	0.040	0.008	0.130	0.409***	0.035
Access to credit	0.007	0.030	0.291***	0.037	0.003	0.092	0.102	0.017
Price	0.110	0.416	0.296	1.267	0.109	0.382	0.253	0.362
Tau	1.210***	0.000	0.361***	0.000	1.006***	0.000	1.000	
Gamma	0.003	0.025	0.000		1.000		-1.726***	0.007
Sigma (i)	0.917	1.236	0.990***	0.356	0.945	1.024	0.946	1.018
N	7193		7193		7193		7193	
Log likelihood function	-5801.084		-5056.087		-5779.393		-5404.389	
McFadden Pseudo R^2	0.265		0.360		0.268		0.316	
AIC/N	1.619		1.411		1.613		1.508	

Note: *, **, *** refer significance at 10%, 5%, 1% level, respectively.

Preference heterogeneity in improved climate services

Turning to preference heterogeneity, the G-MNL-I (=1) model that performed better in terms of model fit was used for the discussion of results. Table 5 shows all the four model results. Age, family size and land holding were found to be significant covariates that explain heterogeneity in taste in the choice of the attributes of improved climate services among sample respondents. Location was expected to play significant role in choice behavior, however, the interaction with taste parameters was found to be insignificant.

Older household heads exhibited preference for IVRS as medium of receiving climate services. But they were not interested in ITRS which requires the user to read the message she/he received which most older people lack the ability to do, particularly in rural Ethiopia. Similarly, households with bigger family size also preferred IVRS. Our result also disclosed that households with big family size were not interested in information on selling price. As studies such as Barrett et al. (2001) and Haggblade et al. (2007) reported, households with bigger family members involve themselves in non-farm activities to minimize household income variability and such engagement in non-farm activity may be the case for loss of interest for market information among these households. The top-down approach where extension agents dictate most of the time was preferred among older people. Possible explanation could be the conservative nature of older people where they prefer what they already know rather than a change or a new situation. But the top-down approach was not the preferred means of participation for farmers with bigger family size. As explained above, when family size increases, family members focus more on non-farm activity and care less about advisories for farm activities. Similarly, farmers with bigger farm size were not interested in the top-down approach. Bigger farm size may come with strong financial background (e.g. Kassie et al., 2017), or more connection with similar well-off farmers who could have more exposure to more timely and appropriate information and may be the reason for undermining guidance by development agents which most of the time lacks relevance and timeliness of message (Belay and Abebaw, 2004; IFPRI, 2010; Pye-Smith, 2012).

Table 5: Estimation of preference heterogeneity in G-MNL model

Attributes	Full G-MNL		G-MNL-II (=0)		G-MNL-I (=1)		G-MNL (=1)	
	Coefficients	Std. Error	Coefficients	Std. Error	Coefficients	Std. Error	Coefficients	Std. Error
SMS short text message (SMS)	-0.066	0.092	0.005	0.058	3.790***	0.113	-0.109***	0.023
Interactive voice response system (IVRS)	0.283	0.219	0.282*	0.161	-2.435***	0.394	0.279***	0.056
Interactive text response system (ITRS)	0.0991	0.135	0.102	0.093	0.753***	0.301	0.091***	0.035
Information on market location	0.0762	0.048	0.088**	0.034	0.187**	0.081	0.067***	0.013
Information on selling price	0.011	0.093	-0.003	0.059	1.708***	0.192	0.003	0.024
Top-down approach - extension agents dictate	-0.451***	0.107	-0.451***	0.074	0.422*	0.253	-0.449***	0.030
Participatory decision-making	0.369***	0.106	0.349***	0.075	1.866***	0.180	0.344***	0.029
Access to credit	0.158**	0.073	0.141***	0.052	-3.609***	0.157	0.163***	0.018
Price	-0.743***	0.015	-0.911***	0.011	-5.093***	0.090	-0.456***	0.007
Constant	-3.316***	0.120	-3.298	0.096	-2.943***	0.063	-3.327***	0.113

Observed heterogeneity								
Interactive voice response system (IVRS) * Age	-0.002	0.003	-0.018***	0.002	0.028***	0.006	0.001	0.000
Interactive voice response system (IVRS) * Family size	0.004	0.022	0.018	0.016	0.186***	0.041	-0.016***	0.005
Interactive text response system (ITRS) * Age	-0.008***	0.002	-0.003**	0.001	-0.105***	0.006	-0.002***	0.000
Information on market location * Land holding	0.030*	0.016	0.036***	0.010	0.025	0.030	0.015***	0.004
Information on selling price * Family size	0.040***	0.013	-0.063***	0.007	-0.175***	0.027	-0.015***	0.003
Information on selling price * Land holding	0.015	0.017	-0.008	0.011	0.037	0.041	-0.000	0.004
Top-down approach * Age	-0.007***	0.001	-0.005***	0.000	0.089***	0.004	0.001***	0.000
Top-down approach * Family size	0.015	0.014	-0.025**	0.010	-0.822***	0.030	0.035***	0.003
Top-down approach * Land holding	-0.001	0.010	0.001	0.006	-0.375***	0.031	-0.003	0.002
Participatory decision-making * Family size	0.124***	0.015	0.022*	0.011	0.178***	0.026	-0.029***	0.004
Access to credit * Family size	-0.030***	0.010	-0.046***	0.008	0.516***	0.024	-0.012***	0.002
Heterogeneity in Mean								
SMS short text message (SMS)	0.008	0.061	0.015	0.064	0.391***	0.085	0.007	0.008
Interactive voice response system (IVRS)	0.006	0.055	0.011	0.061	0.759***	0.070	0.005	0.008
Interactive text response system (ITRS)	0.007	0.033	0.008	0.030	1.699***	0.069	0.006	0.006
Information on market location	0.004	0.040	0.011	0.042	0.116***	0.038	0.002	0.006
Information on selling price	0.002	0.035	0.001	0.036	0.733***	0.046	0.002	0.007
Top-down approach - extension agents dictate	0.006	0.024	0.005	0.021	1.718***	0.042	0.000	0.005

Participatory decision-making	0.010	0.019	0.021	0.013	0.381***	0.030	0.007*	0.003
Access to credit	0.008	0.028	0.014	0.026	0.889***	0.036	0.000	0.004
Price	0.785***	0.006	0.822***	0.005	1.189***	0.017	0.277***	0.006
Tau	0.184***	0.002	0.478***	0.000	0.375***	0.000	1.000	
Gamma	-0.365	0.029					-0.176***	0.001
Sigma (i)	0.995	0.183	0.985**	0.472	0.989***	0.370	0.946	1.018
N	7193		7193		7193		7193	
Log likelihood function	-8421.047		-8180.293		-6627.460		-8856.184	
McFadden Pseudo R^2					0.161			
AIC/N	2.350		2.283		1.851		2.471	

Note: *, **, *** refer significance at 10%, 5%, 1% level, respectively.

Willingness to pay for improved climate services

The full G-MNL model result in Table 6[8], where the WTP estimation was performed in WTP space showed that the implicit price of participatory decision-making was very high compared to the value farmers attached to the other attribute levels. This may be related to farmers' ambition to be actively involved and recognized as equal partners with researchers and extension agents in their farming decision-making process as indicated in studies such as Chanie (2015) and JICA (2015). The high willingness to pay value attached to IVRS may be attributed to the user-friendly nature of this communication medium. The next high WTP values were put on access to credit followed by ITRS. When looking at mean WTP values, the coefficients showed that the average amount farmers are willing to pay for participatory decision making is 1.3 times higher than the amount they are willing to pay for IVRS. Farmers are also willing to pay an amount that is 1.6 times higher for participatory decision making than credit facility. Similarly, the money value they attached to participatory decision making is 3.4 times higher than the value they put on ITRS.

[8] Note that the implicit prices showed in Table 6 are not absolute values since we used effect coding in the design. To get absolute values amounts need to be multiplied by 2.

Table 6: Estimation of willingness to pay in willingness to pay space

Attributes	Full G-MNL model	
	Coefficients [a] (Std. Error)	Std. Dev. (Std. Error)
SMS short text message (SMS)	13.821	6.937
Interactive voice response system (IVRS)	-30.796***	6.867
Interactive text response system (ITRS)	-11.440*	6.231
Information on market location	-0.019	4.486
Information on selling price	-3.160	4.172
Top-down approach - extension agents dictate	40.362***	8.715
Participatory decision-making	-38.880***	9.768
Access to credit	-24.808***	3.486
Price	1	Fixed
Constant	-3.150***	0.116
Heterogeneity in mean		
SMS short text message (SMS)	7.807	15.802
Interactive voice response system (IVRS)	1.795	20.771
Interactive text response system (ITRS)	6.466	11.949
Information on market location	6.485	8.894
Information on selling price	5.404	10.367
Top-down approach - extension agents dictate	53.716***	10.179
Participatory decision-making	38.769***	7.420
Access to credit	0.621	6.789
Price	0	
Tau	0.629***	0.078
Gamma	0	Fixed
0 WTP	-0.011***	0.001
S_B0_WTP	0	Fixed
Sigma (i)	0.978	0.628
N	7193	
Log likelihood function	-5049.771	
McFadden Pseudo R^2	0.360	
AIC/N	1.409	

Note: *, **, *** refer significance at 10%, 5%, 1% level, respectively.

[a] Signs of coefficients need to be reversed as the coefficient of price was fixed to be 1.

Conclusions

The objective of this study was to understand the economic value of agricultural climate services among smallholder farmers in Ethiopia. Using a choice experiment approach, the study introduced a hypothetical bundle of improved climate services to 600 sampled farmers who live in three districts in three different agroecological zones (highland, mid altitude and low land) in the Oromia Regional State. The generalized multinomial logit (G-MNL) model was employed to estimate taste parameters, preference heterogeneities and WTP values. The key conclusions that emerged out of our findings are (i) climate services provided as a package along with credit and market information particularly agricultural produce price, communicated through short text messages (SMS) while engaging smallholder farmers in all stages of the decision making process may improve the acceptability and usability of the services, (ii) the most preferred characteristic of the package among smallholders was participatory decision making process which may hint farmers desire to get attention for their perspective and experience.

A policy that advocates enhancing livelihood and food security through the provision of climate services may need to emphasize development of digital and ICT-based solution and infrastructure for the dissemination of reliable and timely climate services. Since information is a public good, well-functioning institutions that can provide market information is crucial. In addition, financial institutions have to be strengthened to facilitate access to credit. Engaging smallholder farmers in a participatory manner in all stages of the decision-making process can help them make informed decision and enhance adoption. This will also augment policy makers and agricultural extension service providers' effort to increase agricultural productivity and livelihoods, and thereby the resilience and adaptive capacity of farmers to climate variability and risks through the provision of climate services. The study could not shed light on the relationship between location and preference heterogeneity. Characterizing the impact of location on choice behavior could inform policy makers to work towards the provision of location specific climate services. Therefore, there is a need for future investigation to explore how different locations and choice behavior are related to address this.

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