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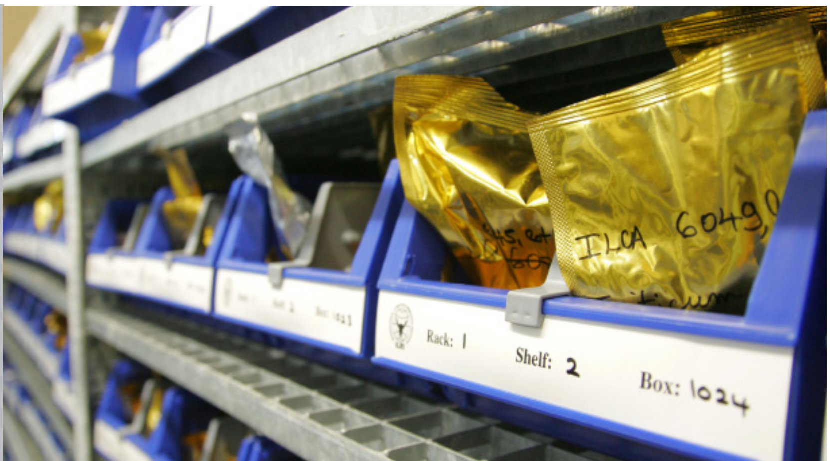

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Ex-ante assessment of demand for improved forage seed and planting materials among Ethiopian smallholder farmers: A contingent valuation analysis

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International Livestock Research Institute

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The Africa Research In Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research for development projects supported by the United States Agency for International Development as part of the U.S. government's Feed the Future initiative. Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three regional projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads the program's monitoring, evaluation and impact assessment. https://africa-rising.net/

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Contents

Tables

Executive summary

Growth in incomes, population and the rate of urbanization in Ethiopia are driving demand for more and better quality livestock products. Yet, shortages in the availability of forage seed and planting material (FS and PM) are large part impeding the supply of adequate animal feed. FS and PM shortages act as critical constraints in preventing Ethiopia from taking advantage of the development and market opportunities offered by the increased demand for livestock products in terms of improving the livelihoods of livestock producers and contributing to national income growth. This study, a contingent valuation (CV) study accompanied by a break-even-point (BEP) analysis, provides insight into the potential for the development of a commercial forage seed industry in Ethiopia.

Objectives of the study

Currently, a fully-functioning market for FS and PM does not yet exist and many potential buyers, particularly smallholder livestock producers, are unaware of market prices. The limited supply of FS and PM available is bought by NGOs and government entities (regional state offices) for distribution to farmers at subsidized prices or free of charge. Therefore, this study seeks to assess the 'potential' market demand for improved commercial FS and PM among smallholder farmers in Ethiopia, specifically to:

1. Elicit information on farmers' awareness, attitudes, perceptions and interest in purchasing improved FS and PM;
2. Estimate livestock farmers' willingness to pay (WTP) for improved FS and PM;
3. Determine the factors which influence farmers' WTP for FS and PM; and
4. Determine whether the estimated livestock farmers' WTP shows there is a sufficient incentive for entrepreneurs to invest in establishing enterprises to produce and market FS and PM.

The farmers' WTP and variables affecting farmers' WTP in this study were estimated through the use of a contingent valuation (CV) survey. The data in this study comes from a sample of 450 farm households randomly drawn from pilot project clusters in four regions in Ethiopia: Oromia; Amhara; Southern Nations, Nationalities, and Peoples (SNNP); and Tigray. The farmers' WTPs for FS and PM were elicited using two CV questioning formats: the closed-ended double-bounded dichotomous choice (DBDC) and the open-ended formats (for details, see: Mitchell and Carson 1989). The break-even point (BEP) analysis was also conducted to assess the commercial viability of FS and PM production and marketing businesses in light of the current involvements by NGOS and public sector in the forage seed distribution and marketing.

Key findings

- There is already a significant level of awareness, but a relatively low level of adoption of improved forage crops among smallholder farmers. Approximately 87% of the farmers reported they are aware of improved forage crops of some kind, while only 51% of the sample respondents reported ever using improved forage crops.

- There is significant potential market demand for improved FS and PM among smallholder farmers in Ethiopia. Between 64–81% of the farm households surveyed were willing to buy improved FS or PM, if commercially available in the market.
- The estimated WTPs were found to be 44–675% of the FS and PM prices observed in the market. The highest percentage of market price, 675%, was observed for the WTP for Napier grass, indicating significant potential demand for Napier grass PM. Meanwhile, the estimated WTPs for alfalfa, Rhodes grass, pigeon pea, cow pea, lablab and vetch, were ETB 291, 211, 143, 150, 135 and 24 per unit, respectively. Lower than current observed market prices indicated limited potential demand for these FS and PM types. However, the prices for oats, desho and Napier grass at ETB 14, 2.7 and 1.6 per unit of PM, respectively, were found to be higher than current market prices, even though the current prices were mainly those charged to NGOs and government distributors of FS and PM.
- The econometric analyses revealed the most important factors positively influencing farmers' WTP were their awareness of FS and PM. This finding indicates the critical importance of extension services in raising awareness of the likely benefits of feeding animals improved forage, as well as how to grow FS and PM. There is also a need to use promotional materials and advertising to raise awareness of, and generate demand for, FS and PM among smallholder farmers.

The CV survey data analysis supports the potential of substantial incentives in the establishment of a FS and PM industry to sell some FS and PM to smallholder farmers in Ethiopia. However, the lack of a vibrant private FS and PM industry is an indication that current NGO and government practices of giving FS and PM away to farmers for free or at subsidized prices is impeding the sustainable development of the industry. Public or NGO engagement in the distribution of FS and PM may make sense in areas in which private sector involvement is not currently profitable and/or too risky. However, ultimately, potential investors will need to be able to require operate profitably for their businesses to be sustainable. Thus, there is a need to delineate where the public and private sectors can and need to invest, to encourage private investment in the establishment of potentially profitable FS and PM enterprises, and public investment or private–public partnerships (PPPs) in specific FS and PM value chains.

Observed market prices in the study were those mainly charged to NGOs and government distributors of FS and PM. That the estimated farmers' WTP for some FS was below the price paid by NGOs to seed producers (to distribute to farmers for free or at subsidized prices) indicates that the price structure for some FS may not be sustainable in the future. Since the prices are currently not attractive to farmers, FS prices would have to drop significantly to make their purchase by farmers more attractive. This could occur if future demand from NGOs disappeared or declined greatly.

Moreover, the profitability of FS and PM for seed producers also needs to be assessed. Such an analysis requires further study to assess their costs of production. A detailed study on FS and PM costs of production would make it possible to determine the break-even price (BEP), which compared to the estimated WTP gives an indication of the potential profitability of investments in FS and PM businesses. This price information would also be needed to inform policymakers whether and where a price support (subsidy) or other incentives would be required to encourage investment in the establishment of FS and PM businesses, and under what specific market conditions.

FeedSeed project conclusions and policy recommendations

Twenty-five potential commercial seed businesses—public and private entrepreneur investors, smallholder farmers, and cooperative members, who demonstrated the capacity to produce and sell quality forage seed—were trained and mentored to help them create viable forage seed businesses. They had sufficient land and appropriate facilities to begin producing on a small scale, but with potential to expand. The FeedSeed project provided them with technical and business training to help build viable forage seed businesses. To develop their businesses further, and to become sustainable businesses, the following conclusions and policy recommendations of the FeedSeed pilot project need indicate the key obstacles they face and areas where they need support:

i. Even though most experts and farmers maintain that is the main constraint on herd size and animal productivity in Ethiopia, there is a lack of effective public extension focused on forage growing and feeding in particular and livestock production in general.

ii. Improving forage seed production, distribution and promotion has been given little attention in donor-funded development projects, but such activities are increasing rapidly.

iii. Most forage seed presently produced by smallholder farmers is meant to satisfy their own demand. They maintain seeds for the next cropping season rather than sell them.

iv. The majority of forage seed presently grown is exchanged among farmers in informal non-monetary transactions. About 60–70% of forage seed used by smallholder farmers is saved on-farm or exchanged among farmers (possibly because most seed is open-pollinated), and only 20–30% are borrowed or purchased locally.

v. Smallholder mixed crop-livestock farmers have not yet developed the culture of purchasing forage seed since they can often get it free or at subsidised prices from NGOs and regional agricultural bureaus.

vi. While demand from NGOs and regional agricultural bureaus is rapidly growing, there is a growing shortage of seed and feed to meet this demand, and prices are increasing.

vii. The prices paid by NGOs and regional agricultural bureaus are high, also indicating there is not enough forage seed available relative to the quantity demanded.

viii. Proof of rapidly growing market demand and willingness to pay for seed and feed is, however, provided by the experiences of many innovative farmers who participate in development projects and are taught to produce and sell better seed and/or feed, resulting in substantial increases in the productivity of their livestock and incomes. This evidence of rapidly growing demand, however, is circumstantial and needs to be further investigated. In addition, analysis is needed to identify the appropriate species of forages demanded in different regions with varying agro-ecological and market conditions.

ix. Most smallholder farmers—with the exception of those commercially-oriented smallholder farmers involved in dairy, poultry or fattening for meat—are unable to produce improved forage crops because they use the little land they possess for the production of food and cash crops, rather than forages.

x. The formal seed supply system is underdeveloped, in part, due to a lack of technical and business expertise in seed production, processing and marketing.

xi. Most improved forage seed varieties are open-pollinated. The development of a formal seed supply system is hindered by a lack of hybrid seed varieties which would allow seed companies investing in developing improved seed varieties to hold intellectual property rights and thus capture the profits needed to pay for the research and development, as well as cover the costs of seed production, processing and marketing.

Policy recommendations

i. To meet rapidly growing demand, policies encouraging land allocation by the federal and regional governments for the commercial production of forage seed and forage by large-scale investors are urgently needed.

ii. To meet rapidly growing forage seed demand and reduce the existing gap between increasing demand and stagnant supply, strengthening public and private sector capacity is urgently needed to help create an organized forage seed system throughout Ethiopia.

iii. Adequate seed quality standards and regulations—such as variety release procedures, intellectual property rights, certification and contract laws, as well as practical enforcement—are lacking, negatively influencing the structure and performance of the seed system.

iv. No public regulatory body is effectively dealing with forage seed regulations and policies. Since assuring seed quality is a major factor in the creation of a functioning forage seed system, a national body for forage seed certification and quality control needs to be established urgently.

1. Introduction

1.1 Background and justification

Livestock is a very important multipurpose productive asset owned by smallholder farmers in Ethiopia. At household level, it plays a significant role in income generation, as well as providing manure and draft power, among other products and benefits. At national level, livestock are an important resource. They help meet domestic food demand, earn foreign exchange through exports and generate employment.

Rising demand for animal feed is driven by increasing consumer demand for more and better quality livestock products. Consumer demand is in turn driven by growth in incomes, population and the rate of urbanization. While low genetic potential and a higher incidence of disease—internal and external parasites coupled with poor livestock husbandry practices—are important constraints limiting smallholder livestock productivity and production in Ethiopia, feed is also a critical constraint. The Ethiopia livestock master plan (MoLF 2015) indicates that the country has substantial potential to expand livestock production to meet the growing domestic and export demand provided adequate investment, and policy and institutional support, for this key input of livestock feed can be met.

Several factors impede traditional smallholder animal feeding systems in developing countries, like Ethiopia, from becoming more productive, commercialized, profitable and sustainable. First, most of the traditional supply of feed for animal production comes from natural grazing pastures and crop residues, supplemented with household by-products, which are often inadequate and, less productive and nutritious as animal feed. Second, this problem is compounded by the decreasing availability of communal grazing land resources due to increased demand for land for food crop production for human consumption.

Smallholder farmers increasingly have smaller parcels of land with which to grow food, both for their own subsistence, as well as to generate necessary cash income. This makes it difficult to allocate a reasonable portion of their land for pasture and forage crop production. Therefore, the introduction of improved forage seed to increase the quantity and quality of forage crop production per unit of available land is critical if smallholder farmer intensification of production per unit of land, labour and capital is to increase. The opportunity costs of land for alternative uses also needs to be carefully evaluated.

There are many other potential uses for cultivated (improved) forage crops and planting materials. For instance, fodder trees can contribute to the improved food security, income and livelihoods of smallholder farmers (Franzel et al. 2014). Improved forage crops can be used to help rehabilitate degraded agricultural land: as cover crops and in alley cropping, used in crop rotation, planted on roadsides to reduce soil erosion, or as boundary crops which can also be potentially used as animal feed.

Government projects and donor-supported NGOs have a long history of providing improved FS and PM free-of-charge to smallholder farmers in Ethiopia. This is understandable in the absence of a well-developed forage seed sector or during disaster relief operations. However, the main problems with such an approach are: unsustainability, insufficient scale or coverage of farmers, and the poor quality of implementation at farm level. While there is emerging private sector interest in engaging in commercial forage seed production, distribution and marketing in Ethiopia, unless carefully targeted, the subsidization of seed may hinder the development of a sustainable private seed industry and seed quality certification and control.

The International Livestock Research Institute (ILRI)-led FeedSeed project, financed by *Gesellschaft für Internationale Zusammenarbeit,* has been providing technical FS and PM production, and agribusiness and market facilitation, support to new forage seed growers (commercial and smallholder farmers, individually and through cooperatives). There is scant empirical evidence on the nature of the potential demand, and the size of the market, for commercial FS and PM among smallholder farmers in Ethiopia. The development of a sustainable private commercial forage seed sector requires the existence of sufficient demand of economic significance (or market size) for forage seed by livestock producers and other buyers of commercial FS and PM.

Small livestock keepers in Ethiopia most commonly rely on traditional sources of animal feed, especially grazing land. Thus, the marketing of cultivated improved forage and fodder crops, seeds, and purchased manufactured animal feeds are not well developed. There is a lack of information on livestock keepers' awareness, perceptions, and adoption of improved forage crops and forage seeds, and their impact on the likelihood of purchase and WTP for FS and PM.

The main purpose of this research is to investigate the potential market demand for commercial FS and PM among smallholder farmers in Ethiopia, given the current government and NGO practices of subsidizing the provision of FS and PM to farmer. In other words, do the aforementioned practices crowd out private sector participation in commercial forage seed production, distribution and marketing by dampening smallholder interest in buying the private sector? Another question is whether smallholder farmers are ready and willing to pay for commercial FS and PM, and if so, how much? In general, before embarking on a commercial scale enterprise and scaling-up efforts, prospective entrepreneurs want to know whether there is significant market demand and profit potential. This study is meant to determine whether and how much livestock keepers are willing to pay for FS and PM**.**

This study measures WTP for FS and PM. However, in order to determine the profitability of forage seed production by seed growers the information on the break-even price for the seed growers is also required. For example, a WTP greater than the BEP, a price at which the producer just covers its costs, would imply potential profitability, while a WTP less than the BEP indicates potential loss. Thus there is also a need for a detailed further study on costs of production in order to determine the BEP and consequently the potential profitability of seed enterprises.

The approach used in this study allows for an ex-ante assessment of the potential market demand for commercially produced improved FS and PM among smallholder farmers. The study generates price and other information that would inform the decisions of commercial forage seed growers and producers of planting materials (commercial forage plant nurseries) and other seed system value chain actors' to operate efficient, profitable and sustainable businesses. For the policymakers, understanding livestock keeper production and marketing behaviour related to using and buying FS and PM will help to develop extension messages and inform the public debate on the need for price support and market development policies to private FS and PM production and marketing firms. It will also help entrepreneurs developing promotional, marketing, and scaling-out strategies. Thus, the study findings inform public policy and investment decisions related to extension services, and price support for the development, promotion and scaling-out of sustainable commercialization of improved FS and PM.

1.2 Objectives of the study

The overall objective of this study is to assess the market demand for improved FS and PM among smallholder livestock keepers in Ethiopia. The specific objectives are to: (1) elicit information on farmers' awareness, attitudes, perceptions and potential interest in purchasing improved FS and PM, (2) estimate the WTP **(amounts or prices)** for improved FS and PM, and (3) determine the factors which influence farmers' WTP for FS and PM.

2. Research methodology

2.1 Conceptual framework

In order to evaluate *ex-ante* the financial profitability of and demand for improved FS and PM, information on the economic values or the prices of improved FS and PM that potential buyers (in our case, smallholder livestock keepers) would be willing to pay is very important. In Ethiopia, as discussed earlier, smallholder livestock keepers' access to improved FS and PM has been mainly based on free-of-charge or subsidized distribution through donor NGO and/or government-supported projects. Since the market for commercial FS and PM production have not been developed, the information on forage seed prices cannot be obtained from observations of market transactions. In such situations where the market does not exist, or is not well-developed, and where there is no actual or reported data on forage seed prices, the common practice of deriving economic value or prices is the use of non-market valuation techniques (Just et al. 2004). In this regard, the livestock keepers' WTP for forage seed can be used as a proxy for economic value or price of forage seed through the use of the CV survey method. In a CV survey, the economic agents are provided with detailed hypothetical market information for the goods or services and open-ended and/or closed-ended question formats can be used to elicit their WTP for the good or service in question contingent upon the hypothetical market situation presented to the respondents.

The theoretical development of CV survey methods is rooted in the welfare economics theory of random utility (RU) maximization behaviour by rational economic agent (Just et al. 2004). The respondent's response to CV questions is interpreted as a response consistent with the economic agent's random utility maximization objective subject to their income constraints. In other words, in the CV model, the economic agents are assumed to choose their bids (decide how much they are willing to pay or how much they are willing to accept) in such a way that they maximize their utility given the income and other constraints they face. Mathematically, following Haab and McConnel (2003), the linear additive RU model representing economic agent's preference for a given good or service is given as:

$$WTP_i^* = \beta * \boldsymbol{X} + \varepsilon_i , \quad \varepsilon_i \sim N(0,\sigma^2) \tag{1}$$

where $WTP_i^* WTP_i^*$ is the unobservable random utility for the i^{th} economic agent; $\boldsymbol{X}$ is a vector of explanatory variables affecting households utility; $\varepsilon_i \varepsilon_i$ is the random error with mean zero and variance of $\sigma^2 \sigma^2$; and $\beta \beta$ is a vector of parameters to be estimated. The RU model determines the probability that an economic agent declines or accepts the stated bid price providing observable discrete response of 'yes' if the $WTP_i^* WTP_i^*$ is greater than or equal to the stated bid price or a 'no' response if the $WTP_i^* WTP_i^*$ is less than the stated bid price. Then, based on the observable discrete responses or continuous responses, several econometric models can be specified to estimate the mean and median values of WTP and to assess the determinants of WTP.

The WTP obtained through the CV survey data represents either the total economic value of the good or service under consideration or represents the additional amount (e.g. price premiums) the economic agent is willing to pay for additional desirable products or additional attributes or services. In the case of FS and PM, the livestock producers' WTP is how much the FS or PM is worth to the livestock producer. In other words, the WTP can be thought of as the price that would be received by seed producers in the case of direct sale of the FS and PM to livestock keepers or animal feed producers, or it could be thought of as the price that would be received by any final FS and PM seller from the livestock keeper or animal feed producer. In the latter case, the WTP also includes the margins for forage seed intermediaries. In this survey, the WTP obtained represents the total economic value or price of FS and PM.

2.2 Contingent valuation survey design and implementation

Contingent valuation survey question formats

In general, the elicitation of the economic agent's maximum WTP is made either directly using the stated preference approach or indirectly using the revealed preference approach (Just et al. 2004). The CV method is one of the direct methods of eliciting economic agents' responses to WTP questions whereby the actual market behaviour of economic agents are not observed either because the product is new or not marketed. On the other hand, in the revealed preference approach the value of goods or services is determined indirectly based on the observed market transactions and behaviour associated with the actual purchase of goods or services (Just et al. 2004). This study uses the CV approach.

There are various techniques of elicitation for responses to CV questions that are found in the literature: the bidding game; the payment card; the open-ended question format; and the closed-ended discrete choice with or without follow-up questions. In general, the choice of the elicitation method to CV responses depends on the nature of good or service investigated in the study, the structure of market envisaged, time and cost considerations, and whether mail survey or an interviewer is used to administer the survey instrument[1].

In this study, both closed-ended DBDC and open-ended CV question formats are used. In the case of DBDC question formats, the initial bid and the follow-up bid prices (lower and higher bid) were determined based on the results of descriptive analysis of forage seed price survey data conducted by ILRI (See Appendix 2). Accordingly, the initial bid price, lower second bid price and higher second bid price were based on the average, minimum and maximum prices, respectively, obtained from the survey data. For example, in the case of alfalfa, the initial bid price chosen was ETB 670 per kg, while the follow up lower and higher bid prices were ETB 500 and 800 per kg, respectively (Appendix 2). The sample question format for both question formats is given in Appendix 3.

The selection of improved forage crops

Nine commercial FS or PM were identified for inclusion in the CV survey based on consultative discussion with ILRI FeedSeed and Africa RISING project staff. These crops include: Alfalfa, Rhodes grass, pigeon pea, desho, lablab, cowpea, oats, vetches and Napier grass. The selected FS and PM provide multiple benefits (as feed, fertilizer and food) to farmers and have been tested for adaptation and recommended for wide dissemination in the agro-ecological zones of Ethiopia. For each selected forage crop, a two-page pamphlet was prepared and used as information guide by survey enumerators to explain their production advantages and feed benefits, etc. before administering the CV questionnaires to the respondents. The pamphlets contained important agronomic and production information, such as the methods of land preparation, planting, fertilization, harvesting, yield, storage and utilization, as well as pictures taken in the field. The enumerators were trained to conduct the CV survey using the prepared survey questionnaire along with the pamphlets on the selected improved FS and PM. The detailed descriptions of the hypothetical markets and the bidding process for a valid CV survey are provided by Carson (2000), Carson et al. (2001) and Arrow et al. (1993).

1. The recent review of theoretical and empirical development of CV is found in Mitchell and Carson (1989). The detailed discussion of various CV question formats used is given in Appendix 1.

Selection of sample farm households

A structured survey questionnaire, developed and administered by trained and experienced enumerators, was given to the heads of 450 farm households randomly chosen in four regions of Ethiopia: Oromia, Amhara, SNNP and Tigray. The survey data was completed for all 450 sample households for all FS and PM, except for Napier grass which was included in the list of selected forage crops at a later stage of the survey work. Hence the sample size for Napier grass was only 295. The sample households were selected using the multistage sampling technique. The selection of the clusters representing Africa RISING and the ILRI FeedSeed project sites in four regions of Ethiopia was made in the first stage. In the second stage, a sample of households within each project site was selected randomly. The use of multistage sampling was designed to reduce the costs of data collection and also aimed at informing future Africa RISING and ILRI FeedSeed project interventions in animal feed technologies. The survey data collection, data entry into appropriate software, and data cleaning activities were outsourced to an experienced data collection firm. The survey data collection was implemented in June and July of 2015.

2.3 Econometric models

Several econometric models were used in the analysis of the CV survey data in order to obtain the WTP values and parameters depending on the question formats used: closed-ended or open-ended formats. The application of more than one econometric models helps to assess the robustness of the estimated WTP parameters and values, since similar results for different models increases our confidence in the estimated values and parameters, and hence the conclusions drawn from the study. The following sections discuss and provide specifications of econometric models considered and used.

Econometric model for the closed-ended CV question format

One of the problems with the closed-ended dichotomous question format, due to its discrete nature, is that it is not possible to estimate the mean and median WTP directly from the survey data. The specification and estimation of appropriate econometric models to fit the discrete data collected are required in order to obtain WTP point estimates. The well-tested interval regression method, or ordered probit model, was selected and specified here following Hanemann and Kanninen (1999) in order to analyse the determinants of WTP FS and PM. The point estimate was not made from the closed-ended DBDC CV question format because the initial and follow-up bids were not randomized among the sample households due to technical and logistical reasons.

In DBDC question format, a given respondent is confronted with two bids: initial and follow-up bids. Let us define the first (initial) bid value as B_i and the second (follow-up) bid as B_{ih} if the respondent's answer to the first bid is 'yes' or as B_{il} if the respondents answer to the first bid is 'no'. Consequently, there are four naturally ordered discrete observable possible outcomes for closed-ended DBDC question format: 'no–no'; 'no–yes'; 'yes–no'; and 'yes–yes'. For instance, in the case of 'no–no', the respondent says 'no' to both the initial and follow-up bids; while in the case of 'yes–yes', the respondent says yes to both initial and follow-up bids, and the follow-up bid represents the highest bid. Thus, the follow-up bid could be higher or lower than the initial bid depending on the respondent's response to the initial bid. The DBDC provides bounds on the WTP, rather than the actual WTP. Taking into account the economic agent's utility maximization objective, the two bids and the two possible responses for each bid would give four bounds on the WTP value:

$$WTP^* < B_{il} \quad for \text{ "}no - no\text{" } response \tag{2}$$

$$B_i > WTP^* \geq B_{il} \quad for \text{ "}no - yes\text{" } response \tag{3}$$

$$B_i \leq WTP^* < B_{ih} \quad for \text{ "}yes - no\text{" } response \tag{4}$$

$$WTP^* \geq B_{ih} \quad for \text{ "}yes - yes\text{" } response \tag{5}$$

The probability density functions for the four outcomes generated from the combinations of responses to the first bound and second bound questions are defined as follows:

$$P_i^{nn} = 1 - \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_{il}}{\sigma}\right) \quad (6)$$

$$P_i^{ny} = \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_i}{\sigma}\right) - \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_{il}}{\sigma}\right) \quad (7)$$

$$P_i^{yn} = \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_{ih}}{\sigma}\right) - \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_i}{\sigma}\right) \quad (8)$$

$$P_i^{yy} = 1 - \Phi(Bid_{ih}/\sigma - X_i'\beta/\sigma) \quad (9)$$

where P^{nn} P^{ny}, P^{yn}, P^{yy}, denotes the probability of 'no–no', 'no–yes', 'yes–no', and 'yes–yes' outcome, respectively; and Φ is standard normal cumulative distribution function.

Given a sample of *N* households and assuming a normal distribution, the corresponding log-likelihood function for obtaining the parameters of WTP and value of WTP is defined based on the probability density functions (6) to (9) as follows:

$$LnL(\beta,\sigma|X_i) = \sum_i^N \left[I_i^{nn} * \ln\left(1 - \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_{il}}{\sigma}\right)\right) + I_i^{ny} * \ln\left(\Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_i}{\sigma}\right) - \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_{il}}{\sigma}\right)\right) + I_i^{yn} * \ln\left(\Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_{ih}}{\sigma}\right) - \Phi\left(X_i'\frac{\beta}{\sigma} - \frac{Bid_{il}}{\sigma}\right)\right) + I_i^{yy} * \ln\left(1 - \Phi\left(\frac{Bid_{ih}}{\sigma} - X_i'\frac{\beta}{\sigma}\right)\right)\right] \quad (10)$$

where I^{nn}, I^{ny}, I^{yn}, and I^{yy} are indicator variables that take the value of 1 or 0 depending on the relevant outcome for each individual; $\boldsymbol{X_i}$ is a vector of constant and other explanatory variables; and β and σ are the parameters to be estimated. The parameters of WTP for the closed-ended double bounded CV question format are estimated by implementing the ordered probit regression model using the STATA *OPROBIT* command.

Econometric models for open-ended CV question format

In the open-ended question format, after providing the details about FS and PM, the survey respondents were asked to openly state their maximum WTP for a given forage seed in Ethiopian currency (ETB/unit). In this case, the response to the WTP question is a continuous variable and the mean and median of the WTP values can be obtained directly from the survey data collected[2]. One of the empirical issues in the econometric analysis of the WTP response from the open-ended CV question format is how to differentiate and treat the stated zero WTP values and non-responses. The challenge is to determine whether the zero responses represent the true preferences of the respondents' lack of utility from the good or service in question and hence represent no interest to pay for it or whether zero values are due to protest responses. For example, in our case, it is possible that the respondent's response to WTP question is not zero in reality, but the respondents are giving zero responses because they do not favour the idea of being charged for forage seed given they are used to the free-of-charge distribution system. If in reality the WTPs are zero, deleting them would also overestimate the mean WTP, while keeping the protest zero responses would also underestimate the mean WTP.

The non-response to the WTP questions could also be due to lack of the understanding of the CV questions. The non-response can result in bias of WTP estimates in two different ways (Eklof and Karlsson 1997). First, non-response occurs when at least some of the population characteristics are unknown. Thus, non-response can result in biased WTP estimates if the non-respondents differ from others in observable characteristics that may influence the estimates. Second, even if non-respondents are similar to respondents in observable characteristics, the WTP may differ due to unobservable characteristics. In our survey, we did not find a significant non-response problem.

2. Alternatively, the mean and median of the WTP values can also be estimated using various econometric estimation techniques such as OLS and Tobit regressions.

Therefore, in this study, we did not have sufficient evidence that those who gave zero WTP are protestors, and in order to provide a conservative estimate of WTP parameters and values, we kept zero responses in the econometric estimation.

In general, the OLS regression model for WTP response from the open-ended question format is given as:

$$WTP_i = \beta * \mathbf{X} + \varepsilon_i , \quad \varepsilon_i \sim N(0,\sigma^2) \tag{11}$$

where WTPi is an observed continuous variable; X is a vector of independent variables that explain the variations in households' WTP; $\beta \beta$ is a vector of parameters to be estimated and $\varepsilon_i \; \varepsilon_i$ is the error term normally distributed with mean zero and variance $\sigma^2 \sigma^2$. However, since the WTPi variable could be censored at zero, the results of OLS could be biased and to correct for censoring the Tobit model is specified instead. The Tobit model left censored at zero is specified as:

$$WTP_i = \begin{Bmatrix} WTP_i^* & if \; WTP_i^* > 0 \\ 0 & if \; WTP_i^* \leq 0 \end{Bmatrix} \tag{12}$$

where $WTP_i^* \; WTP_i^*$ is a latent or unobservable willingness to pay variable; WTP_i is the dependent variable and the other variables are defined as before. The Tobit model is the preferred specification for censored WTP responses as it uses information from the full sample. The econometric estimations are made using the Tobit command in the STATA software version 13.1.

2.4 The break-even point analysis

The estimated WTP values can be used as a proxy for the potential open market prices facing the FS and PM seed growers or investors. In this regard, the WTP can be used to assess the total revenue (TR) that can be generated from the FS and PM businesses. However, the TR figure alone does not provide enough information to assess the financial profitability of FS and PM production and marketing business. The seed producers must earn acceptable level of profit if they are to sustainably engage in commercial FS and PM production and marketing. Therefore, understanding the financial profitability of FS and PM businesses would require, in addition to obtaining the WTP and TR, a further study to assess seed producer's production costs and comparing it against the potential revenue that can be generated. This study uses the standard break-even point (BEP) analysis to assess the threshold level of price or yield required for profitable commercial production of FS and PM.

The BEP analysis is based on the notion of firm's profit maximization and determines the threshold quantity of output or price level at which the total revenue is equal to total cost (or profit is equal to zero). The firm's profit function is given as the difference between total revenue and total cost as:

$$\pi = P * Q - TC \tag{13}$$

Where π denotes profit; P denotes the price per unit of FS or PM; Q denotes the yield or quantity of FS or PM produced per hectare; P*Q denotes the TR generated; TC denotes the total costs (variable plus fixed) of production. Mathematically, by equating the profit function given in equation (13) to zero and rearranging, the break-even point (price or quantity produced) is obtained. For example, the break-even price (P_{be}) is given as:

$$P_{be} = \frac{TC}{Q} \tag{14}$$

The break-even price is the output price needed to just cover all the costs at a given out put level. Similarly, the quantity of forage seed production per hectare required to break-even (Q_{be}) is also computed as:

$$Q_{be} = \frac{TC}{P} \tag{15}$$

The Q_{be} is the yield necessary to cover all the costs at a given output price. The break-even point analysis provides the insight into whether or not revenue from the FS and PM business has the ability to cover the relevant costs of production and how the FS and PM prices and production levels per unit of area affect seed producers' profit. In general, the BEP indicates the yield level or selling price where the profit began to be positive for the investors in FS and PM business. In the short-run, the seed producers can produce as long as variable costs are covered or if the price per unit of output is above the average variable costs. However, in the long-run, the seed producer has to cover total (variable plus fixed) costs. Consequently, the break-even yield or price value based on total costs is important in assessing the financial profitability and long-term sustainability of FS and PM production and marketing business.

The resulting break-even price can be compared with the estimated WTP and the comparison provides insight towards commercial viability (or profitability) of FS and PM business and price risk bearing ability for the seed producers. For example, one important question is that whether the FS and PM producers' break-even price is lower than or higher than the WTP for FS and PM. In other words, is the estimated WTP enough to cover all the costs of production and generate high enough return to motivate the seed producers to invest in the FS and PM business? The break-even yields can be also compared with the current yield levels for different forage seeds in order to gage the level of productivity improvement required in FS and PM production in order to be profitable and sustainable.

In general, a WTP greater than the BEP indicates that there exists the potential that seed producers can make profits from FS and PM businesses in the open market, with the size of potential profit dependent upon the size of the difference between the BEP and WTP. The more the WTP exceeds the BEP, the greater the profit. Conversely, a WTP lower than the BEP indicates that forage seed production is unlikely to be profitable for private seed producers without some kind of price support. Therefore, in the short-run, the provision of seed price subsidies to potential seed investors might be considered to stimulate private investment in FS and PM. Comparing the WTP and BEP would also help to assess the level of risk facing FS and PM producers due to price falls if sales to NGOs were to disappear. The BEP price can be also compared with the current average FS and PM prices in order to assess whether the current forage seed interventions by NGOs and/or public sector are required, the BEP greater than the current average price implies the seed producers might need some kind of price support to stay in business.

3. Empirical results

3.1 Description of sample households

Table 1 provides descriptive statistics of the key variables for the sample households, which might have significant influence on farm households' WTP for FS and PM. The means for dummy variables multiplied by 100 represent response frequencies as percentages. The key variables analysed include: household head; farm household; farm; adoption and awareness; institutional; and regional dummy variables. The main objective of the descriptive analysis is to identify the existence and degree of heterogeneity among the sample households in terms of these independent variables which might explain the differences in the interests of sample households in production, technology adoption and purchasing behaviour, and hence the WTP for FS and PM.

Characteristics of the head of household

The description of the characteristic of the head for the sample households is made in terms of the household head's gender, age, and educational attainment (whether the head is illiterate, had primary, secondary or higher level of formal education). It was found that about 84% of the sample households are female headed. The heads of sample farm households are also relatively young, the average age for the sample households being 47 years. In terms of education, significant proportion of respondents are illiterate. About 36% of the heads of household were illiterate, while 39% and 24% household heads had primary, and secondary or a higher level of formal education, respectively. In general, most of the respondents were illiterate or had only primary education.

Characteristics of farm households

The surveyed farm households are characterized mainly in terms of family labour endowment, which is a limiting factor for both livestock and crop production. The family labour endowment is measured in terms of the total household size and adult equivalents. The family size is divided into different categories based on the age groups of family members (children, adults and old) to derive the dependency ratio. The average family size of the surveyed farm households was found to be six. The average number of children aged 15 or less years is about 2.3, indicating higher level of dependency ratio.

Table 1. Descriptive statistics of the selected socioeconomic and demographic variables for survey respondents

Variable name	Variable description	Mean	SD	Min	Max	N
	Characteristics of household head					
Gender	Sex (dummy, 1=Male, 0=Female)	0.84	0.37	0	1	450
Age	Age (years)	46.65	12.51	19	90	450
Illiterate	Illiterate (dummy, 1=yes, 0=no)	0.36	0.48	0	1	450
Primary	Primary education (dummy, 1=yes, 0=no)	0.39	0.49	0	1	450
Secondary	Secondary or higher education (dummy, 1=yes, 0=no)	0.24	0.43	0	1	450
	Characteristics of farm household					

Variable name	Variable description	Mean	SD	Min	Max	N
Household size	Household size (numbers)	5.59	2.14	1	12	450
Children	Family members aged less than 15 years (number)	2.29	1.62	0	7	450
	Farm characteristics					
Farm size	Cultivated land per household (ha)	1.87	1.76	0	31.8	450
TLU	Livestock owned per household (TLU)	5.31	4.44	0	1	450
	Awareness and adoption of forage seed technologies					
Heard forage	Ever heard about forage seed crops (dummy, 1=yes, 0=no)	0.87	0.33	0	1	450
Used forage	Ever used improved forage seed (dummy, 1=yes, 0=no)	0.44	0.50	0	1	450
Training	Ever received training in forage seed use (dummy, 1=yes, 0=no)	0.33	0.47	0	1	450
	Access to formal and informal institutions					
Milk cooperatives	Membership in milk marketing cooperatives (dummy, 1=yes, 0=no)	0.02	0.15	0	1	450
Service cooperatives	Membership in service cooperatives (dummy, 1=yes, 0=no)	0.32	0.47	0	1	448
Marketing cooperatives	Membership in marketing cooperatives (dummy, 1=yes, 0=no)	0.07	0.25	0	1	448
Amhara	Amhara region (dummy, 1=yes, 0=no)	0.23	0.42	0	1	450
Oromia	Oromia region (dummy, 1=yes, 0=no)	0.43	0.50	0	1	450
SNNP	SNNP region (dummy, 1=yes, 0=no)	0.23	0.42	0	1	450
Tigray	Tigray region (dummy, 1=yes, 0=no)	0.11	0.31	0	1	450

Source: Based on survey data.

Farm characteristics

Land size and livestock assets are the major variables used to describe the sample household's farm assets. The existence and the degree of farm households' heterogeneity in terms of their access to these assets is hypothesized to explain the households' crop and livestock production practices and hence their FS and PM buying behaviour and WTP. The average area of cultivated land per sample farm household was 1.87 hectares with a standard deviation of 1.76 hectares. The size of land to which the households have access, which affects the farmers' capacity to allocate a portion of their land to forage seed and forage crop production besides crop production, is thus expected to influence the farm household's WTP. Shrinking farm size is noted as one of the major challenges facing smallholder farmers' ability to increase production in developing countries like Ethiopia (Jayne et al. 2014). Almost all sample farm households have access to at least one livestock species. For the sample households, the percentage of farm households owning livestock are 96%. The average number of livestock owned per household is about 5.3 TLU with standard deviation of 4.4 TLU.

Awareness and adoption of forage seed technologies

The farm households' awareness and adoption of improved forage crops is expected to positively affect their WTP. The level of farm households' awareness and adoption of improved forage crops is assessed in terms of the household heads' knowledge of the existence of forage crops, and their use and/or participation in training programs related to forage crops is expected positively affect their WTP. It is observed that about 87% of the sample farm households were aware of improved forage crops and FS and PM. It was also observed that about 44% of the farm households had already used improved forage crops and seed, and that 33% of the sample farm households had received training in forage crop use.

Access to formal and informal institutions

Farm households access to formal and informal institutions are expected to be positively associated with WTP. Three variables were used in assessing the sample households' access to formal and informal farm institutions. These include: sample households membership in milk marketing cooperative, service cooperatives and memberships in general marketing cooperatives. It was observed that about 2% of the sample farm households are members of milk marketing cooperatives, while about 7% and 32% of the sample farm households are members of service cooperatives and general marketing cooperatives, respectively.

Regional variables

The sample respondents are randomly drawn from four regions in Ethiopia. Accordingly, 23%, 43%, 23% and 11% of the sample households are drawn from the Amhara, Oromia, SNNP and Tigray regions, respectively. It is assumed that there are certain variations among sample farm households' WTP due to their regional variations in terms of their access to public goods and services, access to infrastructure, and level of development of infrastructure and their spatial proximity to community and market centres. These variations represent the geographic capital affecting the farm household's access to input and output markets by influencing the costs of accessing these markets. Regional dummy variables were included in the regression to capture these differences.

3.2 Estimation of WTP

Closed-ended double bounded dichotomous choice format

The frequency distribution of survey respondents' response categories to closed-ended double-bounded dichotomous choice question format is given in Table 2. The WTP responses are given in five naturally ordered response categories based on the recent price ranges for FS and PM. For example, for those who are not willing to pay at all their WTP is considered to be zero (see column 1 in Table 2). For the 'no–no' response category, their WTP lies exclusively between zero and the lower bid offer; for 'no–yes' response category their WTP is greater than or equal to the lower bid offer, but less than the initial bid offer; for 'yes–no' response category the WTP is greater than the initial bid offer, but lower the higher bid offer; and for the last 'yes–yes' category the WTP is equal to or greater than upper bid offer. The initial bid price used was the average price, while the lower and upper bid offers are the minimum and maximum prices, respectively, from the price survey data obtained from secondary sources (ILRI 2015).

Table 2. Frequency distribution of farm households' responses to closed-ended double-bounded dichotomous contingent valuation question format

Type of forage seed or planting materials	Percentage (%)				
	Not willing to buy (rejection) (1)	Willing to pay less than current minimum price (2)	Willing to pay between the current minimum and average price (3)	Willing to pay between the current average and maximum price (4)	Willingness to pay more than the maximum price (5)
Alfalfa	19	57	6	5	13
Rhodes	21	54	4	6	15
Pigeon Pea	29	44	4	7	16
Desho	23	7	4	4	62
Lablab	33	44	5	4	14
Cowpea	36	38	4	5	16
Oats	22	3	10	18	47
Vetch	29	18	6	6	40
Napier	23	4	4	3	66

Source: Household survey data.

Given the recent price structure for improved FS and PM, it is observed that about 19% to 36% of respondents are not willing to buy any improved forage seed or planting materials at any price (Table 2). The highest frequency of willingness not to buy was observed for cowpea (36%) followed by lablab (33%). On the other hand, the lowest percentage of willingness not to buy was observed for alfalfa (19%).

It was also observed that a significant percentage of respondents are willing to pay for improved FS and PM, but this is provided the prices are lower than the minimum observed market price. This is true, for alfalfa, Rhodes grass, pigeon pea, cow pea and lablab. For alfalfa, Rhodes grass, pigeon pea, cow pea and lablab forage crops, about 38% to 57% are willing to pay for improved forage seed, but only if the prices are lower than the minimum observed market prices, i.e., outside current price ranges. The proportion of households willing to at least pay the current minimum price or at most the maximum current maximum price varied only from 24–75%, depending the type of FS and PM considered indicating heterogeneity among FS and PM in terms of market demand. This is the proportion of respondents which falls in the current FS and PM price structure. These results indicate that the prices of these forage crops are relatively over-priced and if the NGOs pull out of the forage seed purchase and distribution system there would be a significant decrease in the prices and quantity demanded for improved forage seed.

On the other hand, it is observed that for desho, oats, vetch and Napier grass, large percentages of respondents are willing to pay even more than the maximum prices observed currently in the market. For example, for Napier grass, desho, oats and vetch about 66%, 62%, 47% and 40%, respectively, of the respondents are willing to pay even more than the current maximum prices used for FS and FM. In general, there is heterogeneity among forage crops and planting materials in terms of farm households' ordered WTP responses.

Open-ended CV question format

The summary statistics of farm households' WTP for FS and PM based on the open ended CV question format for the whole sample households is given in Table 3. The mean WTP varied from ETB 1.6 per unit of planting material for Napier grass to ETB 291 per kg for alfalfa seed. It is also important to note that the average WTP as a percentage of the current market price varied from 44% to 675% (with 100% indicating the maximum WTP (MWTP) is equal to the current observed market price). Thus, both the closed-ended and open-ended CV question formats indicate that a significant proportion of farmers are willing to buy FS and PM, but at prices lower than the current market prices.

Furthermore, almost in all cases, very large standard deviations are observed for WTP indicating the existence of high variability in the estimated WTP. Despite higher variability, the median MWTP indicates that the price the farm households are willing to pay for any FS or PM is less than or equal to ETB 100 per kg for all FS and PM except alfalfa. This indicates the current price expectation of seed producers is unrealistic in the future if the NGOs withdraw from the forage seed purchase and distribution. Thus, while NGOs are currently providing timely and critical support, they may be distorting the market and the formation of realistic future price expectations among different actors in FS and PM value chains.

Table 3. Summary statistics of farm households' MWTPs for forage seed and planting materials from open-ended question format for the sample with positive WTP (ETB/unit) 2015

Type of Seed	Mean	Median	Standard deviation	Min	Max	Percentage of current Mean price	N
Alfalfa	291.2	150.0	280.5	5	900	43.5	365
Rhodes	211.4	100.0	196.8	4	650	47.0	357
Pigeon Pea	143.0	100.0	111.6	1	500	57.2	317
Cowpea	150.4	100.0	108.7	1.0	400	60.2	286
Lablab	134.6	100.0	109.7	1.5	400	53.8	300
Vetch	24.4	30.0	11.3	1.0	100	97.6	320
Oats	14.3	15.0	8.1	1.0	100	143.0	353
Desho	2.7	1.0	7.8	0.1	75	675.0	345
Napier	1.6	1.0	1.6	0.2	10	213.0	227

Note: The cases with zero WTP were excluded from the computation of summary statistics. Seed quantities are measured in kilograms for all except the desho and Napier grasses which are propagated using root splits or stem cuttings and measured in batch of root splits or stem cuttings.

3.3 Results of break-even point analysis

The findings of the break-even point analysis for FS and PM production in Ethiopia are given in Table 4. The data on the total costs of production, yields and prices used in the BEP analysis were obtained from the case study of private FS and PM producers[3]. It is assumed that alfalfa, Rhodes grass and lablab are produced with irrigation and harvested

3 The samples upon which the estimates of prices, costs and yields were made might not be representative. However, they provide indicative break-even prices and yields for different FS and PM. But in the future, break-even point analysis should be made based on detailed enterprise budget data.

twice a year, while the other FS and PM are produced under rain-fed conditions and harvested once. The annual production of forage seed varied from 250 kg/ha for alfalfa to 1400kg/ha for lablab. The average annual quantity of PM per hectare obtained for desho grass was about 40,000 units of root splits, while for Napier grass about one million stem cuttings (with three-four nodes) was obtained per hectare. The annual total (variable and fixed) costs of production were assessed per hectare of land used. The annual total costs of production varied from ETB/ha 21,000 for vetch to 130,000 ETB/ha for alfalfa.

The break-even price for alfalfa, vetch, oats, and Rhodes grass seeds were found to be greater than their respective WTPs. Assuming the WTPs are the potential market prices facing the seed producers, this indicates, there are no profit incentives for alfalfa, vetch, oats and Rhodes grass seed producers. This also suggests the appropriate role of NGOs is in subsidizing these forage seeds and their withdrawal from FS and PM markets might make some FS and PM production unprofitable for seed producers—unless the government takes up the role of NGOs buying the FS and distributing it to farmers at subsidized prices.

On the other hand, the break-even prices for pigeon pea, cow pea, lablab FS production and the break-even prices for desho and Napier grass PM production were lower than their respective WTP values. This indicates the seed producers could at least cover their costs of production and the provision of a price subsidy might not be necessary if NGOs stop buying and distributing the FS and PM for these forage crops. However, this depends on how much higher the WTP is than the BEP prices.

Improving productivity is one way of increasing the competitiveness of FS and PM production. Assuming the WTP figures reflect the potential market prices facing the seed growers, the level of productivity per hectare required to cover the total per hectare production costs was also assessed by determining the break-even production of seed per hectare. For instance, for alfalfa, at the observed WTP, the break-even production required was about 446 kg/ha, implying the need to increase alfalfa per hectare yields by 78% to break even at current WTP. Similarly, productivity increases of about 24%, 23%, and 118% would be required for Rhodes grass, vetch and oats, respectively, in order to break even given their respective WTPs. The results indicate substantial yield improvements are required for alfalfa, Rhodes grass, vetch and oats to cover total production costs. However, for other forage crops, their break-even yields were lower than the estimated yield levels, and although yield improvement is desirable in the short-run, it is not as pressing as for the seed production of other forage crops.

Table 4. Break-even point analysis of commercial FS and PM production in Ethiopia

Type of forage seed	Total production costs (1000 ETB/ ha/year)	Production (kg/ ha/year)	WTP (ETB/kg)	Sales price (ETB/ kg)	Break-even point price (ETB/kg)	Production (kg/ ha/year)
Alfalfa	130	250	291.2	670.0	520.0	446.4
Rhodes grass	105	400	211.4	450.0	262.5	496.7
Pigeon pea	70	900	143.0	250.0	78.0	489.5
Cow pea	85	650	150.4	250.0	131.0	565.2
Lablab	85	1400	134.6	250.0	61.0	631.5
Vetch	21	700	24.4	25.0	30.0	860.9
Oats	25	800	14.3	10.0	32.0	1,748.2
Desho grass	25	40,000	2.7	0.40	0.63	9259.3
Napier grass	78	1,000,000	1.6	0.75	0.08	48,461.3

Source: Compiled by the authors based on the survey data and interview with private FS and PM producers in Ethiopia.

3.4 Results of econometric analysis

The determinants of WTP for different types of FS and PM were assessed using two econometrics methods. First, using the closed-ended DBDC question format, farmers' WTP responses to ordered FS and PM price intervals based on the current prices was formed. For each FS and PM, there were five ordered price intervals. The ordered probit model given in equation (10) was estimated to assess the determinants of respondents ordered WTP responses. Second, the point estimates of the WTP for FS and PM was made based on the open-ended question format. In this case, the determinants of WTP were estimated using the Tobit model given in equation (13). The description of variables used in these econometric analyses is already given in Table 1.

Results of the ordered probit regression

The results of maximum likelihood estimates of the five-choice ordered probit model for nine forage crop seeds and planting materials are given in Table 5. The ordered probit model is estimated to identify the important determinants of households' ordered WTP[4] responses. The log-likelihood ratio test was applied to assess the overall significance of the independent variables in explaining the variations in smallholder farmers' ordered WTP responses for different FS and PM types. The model chi-square indicates that the overall goodness-of-fit of the ordered probit model is statistically significant at a probability of less than 1% for all regressions. Jointly the independent variables included in the ordered probit model explain the variations in the households' ordered WTP responses for different FS and PM. The cut-off points were ordered which implies that the categories of WTP responses are ordered indeed. Detailed discussion of the key results is given below.

The effect of the gender of the head of household is found to be positively associated with households' ordered WTP responses in all cases except for oats. Male-headed households are willing to pay more than female-headed households. However, the effect of gender is statistically significant at a probability of less than 5% only for alfalfa, Rhodes grass, pigeon pea and cow pea. The age of household head is negatively associated with ordered WTP responses in all cases, as the head gets older they are less willing to pay more for FS and PM. At a probability of less than 5%, the impact of the age of household head is significant only for alfalfa and Rhodes.

There is no clear pattern of association between household head educational attainment and the ordered WTP response. Either positive or negative effects are observed but a statistically significant effect was observed only for vetch. The effects of the size of household, number of children less than 15 years old, size of livestock herd and total land holdings on households' ordered WTP responses were not found to be statistically significant at a probability of less than 5% in the case of household size for lablab.

Table 5. Determinants of WTP for forage seed and planting materials: results of ordered probit regression

Independent variable	Alfalfa	Rhodes grass	Pigeon pea	Cowpea	Lablab	Vetch	Oats	Desho	Napier grass
Gender	0.329 (0.155)**	0.421 (0.162)***	0.404 (0.152) ***	0.312 (0.159)**	0.139 (0.154)	0.159 (0.172)	-0.036 (0.158)	0.181 (0.171)	0.116 (0.229)
Age	-0.013 (0.005)**	-0.014 (0.005)**	-0.009 (0.005) *	-0.006 (0.005)	-0.005 (0.005)	-0.008 (0.005)	-0.003 (0.005)	-0.001 (0.006)	-0.006 (0.008)
Primary	0.024 (0.145)	0.024 (0.153)	0.012 (0.140)	0.201 (0.153)	0.054 (0.144)	0.026 (0.148)	0.216 (0.144)	0.128 (0.162)	0.212 (0.219)
Secondary	-0.085 (0.181)	0.028 (0.180)	-0.070 (0.177)	-0.030 (0.185)	-0.073 (0.180)	-0.463 (0.183)**	-0.245 (0.181)	-0.057 (0.193)	-0.212 (0.265)
Household size	0.066 (0.040)	0.043 (0.037)	0.037 (0.039)	0.059 (0.036)	0.082 (0.037)**	-0.001 (0.041)	0.038 (0.041)	0.014 (0.042)	0.014 (0.056)
Children	-0.051 (0.052)	-0.001 (0.050)	-0.061 (0.052)	-0.061 (0.048)	-0.035 (0.048)	0.021 (0.055)	-0.020 (0.055)	0.021 (0.058)	-0.050 (0.073)
Farm size	-0.020 (0.042)	-0.011 (0.037)	-0.021 (0.048)	-0.025 (0.034)	0.003 (0.040)	0.078 (0.044)*	0.082 (0.045)*	0.001 (0.023)	-0.025 (0.067)
TLU	0.024 (0.017)	-0.011 (0.020)	0.001 (0.019)	0.002 (0.016)	-0.003 (0.017)	-0.019 (0.019)	-0.011 (0.017)	0.011 (0.018)	0.037 (0.029)
Heard forage	0.955 (0.237)***	0.484 (0.229)**	0.874 (0.242)***	0.751 (0.232)***	0.645 (0.218)***	0.479 (0.203)***	0.712 (0.217)***	0.435 (0.211)**	0.398 (0.276)

4. The coefficients of ordered probit model estimation denote the direction and statistical significant of the effects of independent variables on the ordered WTP responses. Due to the non-linearity of the ordered probit regression model, these coefficients are not directly interpreted as the marginal (magnitude) effects of the independent variables. Therefore, the marginal effects of independent variables on the probabilities of households' different WTP response categories are computed from the ordered probit model. However, the marginal results are not reported here for space and can be obtained from the authors upon request.

Independent variable	Alfalfa	Rhodes grass	Pigeon pea	Cowpea	Lablab	Vetch	Oats	Desho	Napier grass
Used forage	-0.159 (0.133)	0.030 (0.130)	-0.114 (0.127)	-0.198 (0.136)	-0.281 (0.136)**	-0.086 (0.129)	-0.079 (0.134)	-0.175 (0.139)	-0.166 (0.192)
Training	0.356 (0.135)***	0.375 (0.129)***	0.335 (0.132) **	0.430 (0.138)***	0.306 (0.134)**	0.159 (0.136)	0.187 (0.137)	0.262 (0.146) *	0.223 (0.194)
Milk cooperatives	0.360 (0.339)	0.608 (0.356)*	0.431 (0.313)	0.256 (0.422)	0.561 (0.264)**	-0.198 (0.410)	-0.079 (0.437)	-0.096 (0.427)	-0.196 (0.547)
Service cooperatives	-0.141 (0.119)	-0.290 (0.126)**	-0.246 (0.117)**	-0.137 (0.117)	-0.179 (0.117)	0.561 (0.131)***	0.417 (0.135)***	0.296 (0.148)**	0.962 (0.212)***
Marketing cooperatives	-0.072 (0.156)	-0.206 (0.135)	0.205 (0.153)	0.149 (0.142)	0.255 (0.141)*	0.724 (0.231)***	1.220 (0.301) ***	0.004 (0.193)	0.372 (0.244)
Amhara	0.090 (0.209)	-0.282 (0.203)	-0.392 (0.190)**	-0.342 (0.209)	-0.216 (0.181)	-0.583 (0.180) ***	-0.521 (0.176)***	-1.010 (0.214)***	-0.783 (0.253)***
Oromia	0.807 (0.219)***	1.106 (0.200)***	0.686 (0.203) ***	0.808 (0.206)***	0.445 (0.194)**	0.707 (0.207) ***	0.896 (0.205) ***	0.004 (0.222)	0.186 (0.278)
SNNP	0.282 (0.183)	0.290 (0.166) *	0.209 (0.168)	0.396 (0.171)**	-0.088 (0.166)	-0.046 (0.193)	0.453 (0.194) **	-0.358 (0.218)	-0.064 (0.270)
Constant									
a1	0.236	-0.172	0.330	0.836	0.430	-0.143	0.317	-0.317	-0.396
a2	2.065	1.635	1.663	2.009	1.689	0.444	0.454	0.071	-0.223
a3	2.310	1.793	1.823	2.173	1.871	0.638	0.801	0.056	-0.089
a4	2.590	2.106	2.118	2.420	2.084	0.844	1.438	0.165	0.027
N	448	448	446	448	448	448	448	448	295
Log likelihood	-488.520	-474.212	-534.042	-528.424	-542.837	-547.322	-501.374	-453.989	-252.401
Model chi-square	115.67***	156.11***	113.77***	124.19	66.29***	144.54***	190.59***	86.00***	79.77***

Note: 1Figures in the parenthesis are heteroscedasticity-consistent (Huber-white) standard errors; 2 Tigray is the omitted regional dummy variable; illiterate is the omitted household heads educational attainment variable; ***, **, * indicate statistical significance at a probability of less than 1%, 5%, and 10%, respectively.
Source: Based on household survey data, ILRI (2015).

Awareness of improved forage crops and access to FS and PM and related training were found to be the most important variables and positively associated with households' ordered WTP responses. The effect of previous information about improved forage crops on ordered WTP responses was positive in all cases and statistically significant at a probability of less than 5% in all cases except Napier grass. Similarly, the effect of past forage-related training was also significant at a probability of less than 5% for several forage crops. These results highlight the importance of awareness raising about improved forage crops and provision of training in order to promote the uptake of forage crops. It is important to note that past use of FS and PM is negatively associated with ordered WTP responses in all cases, though it is not statistically significant at a probability of less than 5% for lablab. This result indicates the resistance of farm households to purchase farm inputs after getting used to free or subsidized distribution.

The effects of institutional factors hypothesized to affect households ordered WTP responses were also analysed. Households' membership in milk marketing cooperatives was found to be positive and statistically significant at a probability of less than 5% in the case of lablab. In the case of service cooperatives, the effect is negative and statistically significant in the case of Rhodes grass and pigeon pea and positive and significant at less than 1% in the case of vetch, oats and desho and Napier grasses. The participation in marketing cooperatives has a significant impact on farmers ordered WTP response only for vetch and oats.

Significant regional effects on farm households' ordered WTP responses is also observed for all improved FS and PM. The Oromia regional dummy variable was found to be positively associated with household's ordered WTP responses. Given that the Tigray region dummy variable was the omitted regional dummy variable, this indicates that households in Oromia region are willing to pay a higher price as compared to households in Tigray region. However, the farm households in Amhara region are less likely to pay more for FS and PM as compared to the Tigray region. The households in SNNP are also willing to pay more than the households in Tigray region for cow pea and oats. On the other hand, households in Amhara region are less likely to pay more for FS and PM as compared the households in Tigray region. The potential market demand for FS and PM varies from region to region which could be due to differences in their socioeconomic and market situations, and hence different market incentive structures for seed producers.

Results of Tobit regression

The maximum likelihood estimates of the Tobit regression coefficients for households' WTP[5] are given in Table 6. These coefficients indicate the effects of independent variables on households' WTP but cannot be directly interpreted as marginal effects[6]. The model chi-square for the Tobit model regression indicates that the overall goodness-of-fit of the Tobit model is statistically significant at a probability of less than 1% in all cases. This indicates that jointly the variables included in the Tobit model explain the variations in the household's MWTP. The detailed discussion of the key results is given below.

The results of ordered probit and Tobit regression model estimations are very similar. The effect of household head gender is found to be positively associated with households' WTP responses in all cases. However, the effect of gender is statistically significant at a probability of less than 5% only for alfalfa, Rhodes grass, pigeon pea and cow pea. Male-headed households are willing to pay more than female-headed households. The age of household head is negatively associated with WTP in all cases. As household heads gets older they are less willing to pay more for FS and PM. However, at a probability of less than 5%, the negative effect of the age of household head is significant only for alfalfa and Rhodes grass.

Table 6. Determinants of WTP for forage seed and planting materials: results of Tobit regression

Independent variable	Alfalfa	Rhodes Grass	Pigeon Pea	Cowpea	Lablab	Vetch	Oats	Desho	Napier Grass
Gender	107.673 (39.443) ***	72.996 (29.347)**	44.805 (19.073)**	42.706 (20.906)	25.391 (19.658)	2.416 (2.623)	0.189 (1.181)	1.443 (0.813)*	0.383 (0.250)
Age	-3.183 (1.444) **	-2.282 (1.017)**	-0.941 (0.648)	-0.648 (0.669)	-0.633 (0.715)	-0.048 (0.082)	-0.027 (0.044)	-0.012 (0.038)	-0.002 (0.011)
Primary	25.505 (38.394)	10.766 (27.016)	11.810 (17.548)	32.291 (19.580)	6.257 (18.381)	0.208 (2.111)	2.060 (1.030)**	0.785 (0.916)	0.126 (0.259)
Secondary	13.016 (46.503)	12.241 (31.868)	0.292 (21.762)	0.922 (24.148)	0.141 (23.284)	-4.552 (2.846)	0.088 (1.558)	-0.948 (1.059)	0.180 (0.367)
Hsize	12.480 (9.726)	0.735 (6.885)	4.759 (4.779)	6.425 (4.636)	9.699 (4.544)**	0.060 (0.612)	0.500 (0.314)	-0.370 (0.413)	0.033 (0.069)
Children	-11.678 (13.088)	2.318 (9.284)	-5.886 (6.281)	-5.418 (6.326)	-3.332 (6.189)	0.690 (0.776)	-0.019 (0.436)	0.416 (0.491)	0.075 (0.101)
Farm size	-5.400 (9.417)	-6.146 (5.756)	-2.616 (5.849)	-3.163 (4.505)	-0.609 (4.655)	1.005 (0.486)**	0.904 (0.381)**	0.142 (0.261)	0.017 (0.075)
TLU	6.635 (4.670)	1.049 (3.387)	0.512 (2.279)	0.748 (2.157)	0.189 (2.253)	-0.359 (0.263)	-0.123 (0.127)	0.070 (0.110)	-009 (0.029)
Heard forage	227.382 (58.730)***	67.340 (42.070)	109.946 (28.616)***	103.817 (31.173)	81.503 (28.604)***	7.311 (3.212)**	6.049 (1.973) ***	-0.273 (1.374)	0.490 (0.498)
Used forage	-49.459 (34.155)	-11.280 (23.064)	-21.173 (15.333)	-27.884 (17.226)	-34.280 (17.236)**	-2.064 (1.916)	-1.721 (1.037) *	0.606 (0.972)	-0.243 (0.298)
Training	104.324 (34.115)***	70.572 (22.361)***	37.037 (15.531)**	52.949 (16.964)	38.894 (16.699)**	3.379 (1.994)*	2.259 (1.046)**	0.724 (1.076)	0.420 (0.299)
Milk cooperatives	156.241 (89.192) *	137.908 (64.300)**	68.516 (44.076)	49.005 (55.682)	94.572 (39.422)**	0.888 (6.140)	2.358 (3.555)	-2.078 (1.665)	-0.099 (0.500)
Service cooperatives	-74.589 (30.807)**	-65.631 (22.691)***	-47.926 (14.665)***	-34.518 (15.429)	-31.084 (15.378)**	5.720 (1.832)***	1.435 (0.984)	-0.012 (1.108)	0.399 (0.218)*
Marketing cooperatives	-45.982 (45.966)	-63.939 (27.569)**	22.545 (19.573)	34.703 (17.774)	14.203 (19.781)	7.727 (2.525)***	3.679 (1.199)***	2.417 (3.097)	-0.047 (0.233)
Amhara	51.004 (53.237)	-22.542 (35.822)	-43.167 (23.664)*	-44.775 (29.139)	-27.359 (24.469)	-11.126 (3.139)***	-5.138 (1.610) ***	-4.716 (1.597)***	-1.099 (0.406)***
Oromia	195.964 (54.807)***	179.601 (35.178)***	83.155 (24.441)***	103.471 (27.035)	49.427 (25.288)**	8.077 (3.095)***	5.515 (1.573)***	0.516 (1.523)	0.392 (0.433)

5. An attempt was not made to retrieve the WTP from the ordered response data econometrically because the initial and follow-up bids were fixed (the bids were not varied among the sample households, technically, not randomized). Instead, the sample households were asked to state the MWTP using an open-ended question format.

6. Thus, separate marginal analyses were conducted but results were not presented here for space. First, the marginal effects of changes in independent variables on the probability that a household with zero WTP is willing to pay a positive amount of money for improved forage crops was computed from the Tobit model. Second, the marginal effects of changes in the independent variables on actual WTP were computed in two ways: (1) conditional on a positive amount of WTP, and (2) unconditional changes considering the entire sample.

Independent variable	Alfalfa	Rhodes Grass	Pigeon Pea	Cowpea	Lablab	Vetch	Oats	Desho	Napier Grass
SNNP	3.548	17.468	25.628	33.912	-36.843	-1.450	3.042	-0.561	-0.040
	(46.420)	(29.056)	(21.087)	(23.178)	(21.733)**	(3.036)	(1.594)*	(1.574)	(0.382)
Constant	-107.104	41.657	-55.083	-114.927	-51.034	4.092	-1.557	0.820	-0.205
	(106.137)	(72.040)	(47.483)	(52.028)	(50.786)	(6.474)	(3.409)	(2.443)	(0.755)
Sigma	280.655	196.787	130.038	136.859	135.462	16.726	9.471	7.890	1.742
	(10.166)	(6.721)	(5.183)	(5.954)	(5.367)	(1.078)	(1.231)	(1.260)	(0.210)
N	448	448	447	448	448	448	448	448	295
Log likelihood	-2646.379	-2461.941	-2096.371	-1930.534	-2019.401	-1469.756	-1378.401	-1265.368	-500.703
Model chi-square	7.38***	9.17***	7.00***	7.79***	4.17***	8.65***	9.52***	1.79**	3.22***

Note: [1]Figures in the parenthesis are heteroscedasticity-consistent (Huber-white) standard errors; [2] Tigray is the omitted regional dummy variable; illiterate is the omitted household heads educational attainment variable; ***, **, * indicate statistical significance at a probability of less than 1%, 5%, and 10%, respectively.
Source: Based on household survey data, ILRI (2015).

There is no clear pattern of association between household head educational attainment and the WTP. The effect of head education is significantly and positively associated with MWTP only for oats. The effects of household size on WTP is positive in all cases but statistically significant at a probability of less than 5% only in the case of lablab. The signs of children and TLU are mixed but none are statistically significant at a probability of less than 5%. The effects of farm size on alfalfa, Rhodes grass, pigeon pea, cow pea and lablab are negative but statistically not significant. On the other hand, the effect of farm size on MWTP for vetch, oats, desho and Napier grass is positive but statistically significant at a probability of less than 5% only for vetch and oats.

In the case of WTP, the awareness about improved forage crops and participation in forage-related training were also found to be the most important variables positively associated with households' WTP. The effect of previous information about FS and PM on ordered WTP was statistically significant at a probability of less than 5% for alfalfa, pigeon pea, lablab, vetch and oats. The previous use of improved forage crops is negatively associated with MWTP in all cases except for desho but statistically significant only in the case of lablab. Similarly, the effect of past forage-related training is also significant at a probability of less than 5% for several forage crops (alfalfa, Rhodes grass, pigeon pea, lablab and oats). This Tobit result highlights again the importance of awareness raising and training in order to promote the uptake of improved forage crops among smallholder farmers.

The effects of institutional factors hypothesized to affect households MWTP were also analysed and show the household membership in milk marketing cooperatives to be statistically significant at a probability of less than 1% only for Rhodes grass and lablab. The effect of service cooperatives is negative and statistically significant in the case of alfalfa, Rhodes grass, pigeon pea and lablab, and positive and statistically significant at probability less than 5% in the case of vetch. The participation in marketing cooperatives has a significant and negative effect on WTP for Rhodes grass and has positive and significant effects on WTP for vetch and oats.

It is observed that there are significant regional effects on farm household WTP. For example, the Oromia regional dummy variable was found to be positively associated with household's MWTP for all improved forage crops, but statistically significant only for alfalfa, Rhodes grass, pigeon pea, lablab, vetch and oats. Given that the Tigray region dummy variable was the omitted regional dummy variable, this indicates that households in the Oromia region are more willing to pay higher prices for improved forage crops as compared to households in the Tigray region. On the other hand, households in Amhara region are less likely to pay more for improved forage seed as compared to households in Tigray region. In general, the households in SNNP are also less likely to pay more than the households in Tigray region for improved forage crops.

4 Conclusions and implications

The animal feed presently available on the market in Ethiopia is inadequate, largely due to a shortage of FS and PM. A fully-functioning market for FS and PM does not yet exist in Ethiopia and many investors are unaware of the potential market demand and market prices needed to assess the commercial viability of establishing an FS and PM industry. The study of farmers' WTP for FS and PM and the BEP analysis of FS and PM production and marketing businesses were undertaken to fill this information gap. Furthermore, the econometric analysis was employed to assess the key factors affecting the WTP for FS and PM.

The assessment of farmers' WTP for different FS and PM reveals that there is potential market demand for some commercially produced improved FS and PM among smallholder farmers in Ethiopia. Between 64%–81% of survey respondents stated they were willing to buy FS and PM. However, farmers' degree of willingness to pay was found to differ by FS and PM type.

In relation to the current market prices of some FS and PM, the estimated WTPs were found to be lower than the current observed market prices for alfalfa, Rhodes grass, pigeon pea, and cow pea, lablab and vetch. The fact that the estimated farmers' WTPs for some FS and PM were below the current FS prices paid by NGOs to seed producers indicates that the NGO price structures for some FS may not be sustainable in the future. In such situations, FS and PM prices would have to drop significantly in order to make farmer purchases directly from seed producers or seed dealers more attractive. Such decreases in market price could be expected to occur if NGOs stop buying seed and subsidizing FS. For oats, vetch and Napier grass, the estimated WTPs were greater than the observed market prices, indicating the stability of the NGO price structure and existence of potential market demand for FS and PM businesses, even without the involvement of NGOs and public projects in the provision of free or subsidized seed distribution.

The break-even prices for alfalfa, vetch, oats, and Rhodes grass seeds were found to be greater than their respective WTPs. Assuming the WTPs are the potential market prices facing the seed producers, this indicates there are no profit incentives for alfalfa, vetch, oats and Rhodes grass seed producers without some kind of price support. This also suggests the appropriate role of NGOs is in subsidizing the marketing and distribution of these forage seeds and their withdrawal from the FS and PM market might make some FS and PM production unprofitable for seed producers—unless the government takes up the role of NGOs buying the FS and distributing it to farmers at subsidized prices. Alternatively, the break-even prices for pigeon pea, cow pea, lablab FS production and the break-even prices for desho and Napier grass PM production were lower than their respective WTP values. This indicates the seed producers could at least cover their production costs and the provision of a price subsidy might not be necessary if NGOs stop buying and distributing the FS and PM for these forage crops.

Improving productivity is one way of increasing the competitiveness of FS and PM production. Assuming the WTP figures reflect the potential market prices facing the seed growers, the level of productivity per hectare required to cover the total per hectare production costs was also assessed by determining the break-even production of seed per hectare. For instance, for alfalfa, at the observed WTP, the break-even production required was about 446 kg/ha, implying the need to increase alfalfa per hectare yields by 78% to break even. Similarly, productivity increases of about 24%, 23%, and 118% would be required for Rhodes grass, vetch and oats, respectively, in order to break even given their respective WTPs. The results indicate substantial yield improvements are required for alfalfa, Rhodes grass, vetch and oats for seed producers' to cover total production costs and earn some profit. However, for other forage crops, their break-even yields were lower than the estimated yield levels, and yield is not as pressing as for the seed production of other forage crops.

The econometric analysis revealed that one of the most important factors positively influencing farmers' WTP was household awareness regarding forage feeds. This highlights the importance of increasing farmers' awareness about the advantages, suitability and positive impacts of feeding improved forage to their animals. This also highlights the importance of the provision of extension services to help farmers develop their technical skills in the production and feeding of forage crops. Extension services are also important to the expansion ofexpand commercial forage seed and forage crop production in Ethiopia through the improvement in the supply of quality FS and PM to farm households at the right time and place.

In general, the results observed varied depending on the FS and PM considered. This indicates the policy and investment interventions to develop the FS and PM production and marketing businesses need to be carefully tailored to the circumstances facing different seed producers based on the objectives of seed producers and type of FS and PM they produce.

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Appendix 1. Detailed description of CV question formats

The bidding game is identical to auction markets whereby the interviewer iteratively changes the stated amount of money to be paid or received until the highest amount (respondent's WTP) or the lowest amount (respondent's WTA) is precisely identified. The payment card is a multiple-bound dichotomous discrete choice which is like a menu whereby different WTP or WTA values, stated along with different institutional arrangements and market contexts for a given good or service in question, are presented to the respondents who each make one choice.

In the case of open-ended CV question format, after describing the hypothetical market situation for a good or service in question, the respondent would be asked to state freely their maximum WTP or the minimum WTA and the amount is recorded. The open-ended CV format allows to obtain the actual maximum WTP or minimum WTA. However, it is argued that such open-ended question format is difficult for the respondents and tend to produce an unacceptably large number of non-responses or protest zero responses to the WTP questions (Desvousgas et al. 1983; Arrow et al. 1993). As a result a closed-ended CV surveys are widely used.

Closed-end formats are either single-bounded dichotomous choice (SBDC) (also known as dichotomous choice, take-it or leave it, or referendum style) or DBDC (also known as discrete choice with follow-up)). In SBDC, the respondent is presented with a good or service at a fixed price and gives a 'yes' or 'no' answer as to whether or not s/he would be willing to pay this amount. Thus, there are two possible responses to SBDC questions. It is argued that this format is more similar to the real market situation where the sellers present their products with their initial price offerings and the buyers usually make decisions whether to take-it-or leave it at the offered prices. In the case of DBDC, in addition to yes or no answer to the first stated price offer, there is a follow-up 'yes' or 'no' answer to higher price offer in case the response to the first offer is 'yes', or there is a follow-up 'yes' or 'no' answer to a lower price offer in case the response to the first stated price offer is 'no'. In general, the DBDC question format leads to four possible responses to the WTP questions: 'yes–yes', 'yes–no', 'no–yes' and 'no–no'.

The DBDC question format was proposed by Hahnemann et al. (1991) to elicit WTP and is preferred to other elicitation formats for many reasons. First, the DBDC has properties for incentive compatible or truthful revelation of preferences. Second, it minimizes the occurrence of many biases which sometimes occur in CV survey data. Third, it has higher statistical efficiency in welfare estimates over the SBDC bounded model. The problem with any discrete choice method is that only a discrete indicator of maximum WTP is obtained instead of the actual maximum WTP amounts as opposed to the open-ended question format. Therefore, further assumptions are required for the specification and estimation of econometric models in order to estimate the parameters and value of the WTP based on the discrete WTP responses.

Appendix 2. The initial and follow-up bid prices used in the closed-ended double-bounded dichotomous choice contingent question formats (ETB/Unit)

Type of seed	Initial bid price	Second or Follow-up bid price	
		Lower bid price	Higher bid price
Alfalfa	670.00	500.00	800.00
Rhodes	450.00	400.00	500.00
Pigeon Pea	250.00	200.00	300.00
Desho	0.40	0.30	0.50
Lablab	250.00	200.00	300.00
Cowpea	250.00	200.00	300.00
Oats	10.00	5.00	15.00
Vetch	25.00	20.00	30.00
Napier	0.75	0.50	1.00

Source: Computed based on ILRI price survey data (ILRI 2015).

Appendix 3. A sample contingent valuation survey question format for Alfalfa

I Introduction

For the alfalfa forage crop described to you (in words and picture), answer the following questions

II General question

2.1. Will you be interested to buy alfalfa seed? ___ (1=yes, 0=no)

III Closed-ended double bounded dichotomous choice question format

3.1 If yes to 2.1, are you willing to pay ETB 670 per kg for alfalfa seed? ___ (1=yes, 0=no; not applicable if no to 2.1)

3.2 If yes to 3.1, are you willing to pay ETB 800 per kg for alfalfa seed? ___ (1=yes, 0=no)

3.3 If no to 3.1, are you willing to pay ETB 500 per kg for alfalfa seed? __ (1=yes, 0=no)

IV Open-ended choice question format

4.1 In general, what is the maximum you are willing to pay for this seed? ____ETB/kg

Note: The initial, follow

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