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Open Access Post-Harvest Grazing and Farmers' Preference for Forage Production Incentives

A Choice Experiment Study in Ethiopia

Hailemariam Teklewold, Alemu Mekonnen, Tagel Gebrehiwot, and Mintewab Bezabih

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A Choice Experiment Study of Ethiopia

Hailemariam Teklewold, Alemu Mekonnen, Tagel Gebrehiwot, and Mintewab Bezabih*

Abstract

Open access post-harvest grazing is widespread in mixed crop-livestock systems. This discourages conservation agriculture, which depends on keeping the soil surface covered with crop residues. One way to reduce open access grazing is through restricting communal grazing access to allow rights of exclusion, while simultaneously improving the production of livestock feeds. This paper analyzes farmers' perceptions about post-harvest free grazing on agricultural lands and identifies incentives that motivate forage production, to help inform forage development and policy. We collected data from randomly selected farm households in the Nile Basin of Ethiopia and used a choice experiment method. We found that a majority of farmers would prefer post-harvest grazing restrictions to the existing reciprocal post-harvest grazing. Farmers also had strong preferences for forage production policy incentives, but the results reveal considerable preference heterogeneity. The study provides policy makers with needed information for formulating multiple policy incentives for smallholder forage production systems, with possible implications for other areas with mixed farming systems.

Key Words: Post-harvest grazing; forage; open access; conservation agriculture; choice experiment; Ethiopia

JEL Codes: C35, Q12

1. Introduction

Crop production and livestock husbandry are commonly integrated in Ethiopia. Complementary relationships exist, with livestock, fed on crop by-products and other plant material, contributing traction power and manure to crop production; livestock also provide additional sources of food and income, savings, and a buffer against risk (Gebremedhin et al., 2007; Erenstein and Thorpe, 2010; Erenstein et al., 2011; Blummel et al., 2013). Such a mixed farming system is an example of not only diversification, where components such as crops and livestock co-exist, but also integration, where products or by-products of one component serve as a resource for the other. Livestock in this system depend on extensive grazing of natural field and crop residues during the dry season.

In the mixed crop-livestock farming system, the unavailability of grazing land is the main constraint to livestock production. In Ethiopia, with the expansion of cultivated land and resultant decline in grazing resources, crop residues are becoming an increasingly important component of livestock feeds (Duncan et al., 2016). As a result, livestock graze extensively on crop residues on private cultivated fields after harvest, in the dry season. The practice of letting livestock search for edible crop residues on farm plots is often referred to as post-harvest grazing (ESIF, 2010; Blummel et al., 2013; Corbeels et al., 2014). Access to these fields is primarily communal or open access.

In spite of Ethiopia's recent progress in individual land titling and a general recognition of individual rights to manage parcels, a traditional rule is in place in most communities. This rule basically requires landowners to allow grazing on their land in order to access others' land for grazing. The land certification act does not have any provision to compensate farmers for the actions of users who may not be the owners of a particular piece of agricultural land but enjoy usufructory rights of livestock grazing on agricultural land after the harvest of the crops. Open access grazing is also common in other African countries (Blummel et al., 2013; Corbeels et al., 2014).

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We express our gratitude to the Ethiopian smallholder farmers who kindly welcomed us, as well as to various enumerators and supervisors for the data collection. This work was supported by the Environment for Development Initiative (EfD) Research Grant No. 253 and the International Development Research Centre (IDRC) under IDRC Project Grant Number: 107745-001.

The traditional rule that allows open access to grazing on private agricultural lands discourages investment in sustainable agricultural practices to increase productivity. Conservation agriculture in particular depends on leaving agricultural residue in place to preserve moisture and soil fertility. Despite this competition between crop and livestock production for scarce crop residues, little is known about farmers' perceptions about open access post-harvest grazing on private agricultural lands. In addition, there has been little study of policy options to modify the supply side with alternative forage production schemes. The diversity of perceptions and farming styles or subcultures is a key issue, but this heterogeneity in farmers' preferences is not often characterized and evaluated in the literature (Jaeck and Lifran, 2014). Understanding farmers' perceptions of these issues is critically important for future conservation strategies.

Our study uses both survey and choice experiment data. We use survey data to examine farm households' opinions about changing the traditional rule that allows post-harvest grazing access to others' farm plots. We also consider the socio-economic factors that could affect whether farmers are willing to give up their right to graze their livestock on any privately-owned land in the community, in exchange for the right to refuse others' access to grazing on their property. We employ choice experiment data to value the preferences of smallholder farmers with respect to the different forage production policy incentives to increase livestock feed productivity. The policy incentives examined include cash subsidy for labor, provision of subsidized insurance and subsidized improved forage seeds. Our choice experiment approach asks farmers to choose among hypothetical forage production incentives to estimate the value of attributes outside the farmers' current set of experiences.

The study contributes to the literature in the following ways. First, to our knowledge, this is the first applied economic analysis that investigates farmers' perceptions on open access post-harvest grazing on private lands and the factors that determine such perceptions. This may improve understanding of farmers' behavior and thus contribute to institutional innovation at the community level for changing the patterns of land use. Second, the study adds to the growing literature that uses the choice experiment method, by analyzing smallholder preferences for various policy incentives expected to improve forage productivity as an alternative to relying on stubble for grazing. Third, this evidence addresses the interests of policy makers and other stakeholders who are concerned about the adoption and diffusion of conservation agriculture, which is considered as one of the key climate change adaptation practices in Ethiopia's climate resilient green economy strategy (see FDRE 2011).

After this introduction, the paper proceeds as follows. In the second section, we provide background information and briefly discuss the literature on post-harvest grazing. In the third section, we discuss the empirical research methodology. This includes a discussion on choice experiments and econometric models. In the fourth section, we present results and discussion of the choice model and factors determining post-harvest grazing options. The last section provides a conclusion.

2. Background and Literature Review

In Ethiopia, open access post-harvest grazing on private crop lands is a serious problem which affects the options of leaving crop residue *in situ*. As a result, farmers are generally unwilling to adopt conservation agricultural practices that require the retention of crop residues as mulch, as this competes with their livestock feed needs (Giller et al., 2009; Valbuena et al., 2012; Andersson and D'Souza, 2014; Corbeels et al., 2014; Duncan et al., 2016). Conservation agriculture includes, among other activities, planting crops with minimum tillage, where at least 30% of the soil surface must remain covered with previous crop residues (Kassam et al., 2009; Valbuena et al., 2012; Corbeels et al., 2014). In a mixed crop-livestock system, there is competition for stubble between crops and livestock whenever there is an attempt to switch into conservation agriculture. When insufficient quantities of crop residues are retained as surface mulch, reduced tillage may lead to lower yields, particularly when it is adopted alone rather than as part of a package intended to increase crop yield (Baudron et al., 2012; Corbeels et al., 2014). Thus, the demand for livestock feed has implications for the long-term sustainability of such systems, since failure to return biomass to soils has implications for soil quality and the capacity of soils to support long-term productivity (Duncan et al., 2016).

While the norm for individual farm plots to be freely open to post-harvest grazing contributes some manuring, it also results in the complete removal of all crop residues, which leads to a loss of protective ground cover and minimal nutrient recycling; destruction of topsoil structure through trampling; and damage to soil conservation structures as animals walk over them. Uncontrolled grazing makes it difficult to establish and maintain trees, shrubs and grass strips within farmlands. Grazing on crop land contributes to soil compaction and the need for frequent tillage to prepare fields for crops, making conservation agricultural practices such as reduced tillage less feasible (Gebremedhin and Scott, 2003.). Physical conservation structures such as stone terraces and soil bunds are destroyed by the freely roaming livestock. The cost of unrestricted grazing to individual households depends on the type and number of livestock owned. In the extreme case, the farmers who own the lands but who own no livestock will be forced to bear all the costs of maintaining the fertility of the land by applying commercial fertilizer or manure, or face the consequence of lower yields.

Thus, in areas where farmers open their fields to free grazing for others during the post-harvest season, investment in improving the productivity of existing lands with sustainable agricultural practices is discouraged. As a result, Ethiopian farmers have been reluctant to adopt conservation agriculture. From the farmers' perspective, the motivations for adopting conservation practices are complicated. It takes a few years to see the crop yield results of using residues for mulch and reducing tillage. In addition, delays in benefits occur as farmers invest in learning, local adaptation and fine-tuning and institutional change (Erenstein 2003). For a farmer whose own livestock was at least partly relying on the farmer's own land for grazing, both crop yields and stock yields may be lower for a few years (Pannell et al. 2014; Jaleta et. al. 2013, 2015). Subsistence farmers tend to have short-term planning horizons and high discount rates (Panell et al. 2014).

There has been considerable research interest in identifying the factors that influence participation in conservation agriculture (Andersson and D'Souza, 2014). However, most studies are based on actual participation behavior rather than behavior that is contingent on a possible scenario – in this case, a change in grazing rights coupled with incentives to increase forage production. Alternative forage production schemes could encourage the use of inputs such as insurance and forage seeds. Several incentives have been proposed to encourage smallholder farmers to adopt sustainable conservation practices and prevent further land degradation by offsetting any associated shorter or longer term financial and food security risks associated with those practices (Marenya et al., 2014). These incentives include fertilizer and seeds subsidies, which have been widely used for a variety of incentive purposes (including adopting conservation agriculture) in Ethiopia and other sub-Saharan countries.

3. Methodology

3.1 Study Areas and Sampling

The current study is based on data from the farm household survey conducted as part of the "Adaptation to Increase Resilience to Climate Change in Ethiopian Agriculture" project, which was implemented by the Environment and Climate Research Center at the Policy Studies Institute in Ethiopia. The survey was conducted from March to May 2016. The target population is drawn from the five regions in the Blue Nile Basin of Ethiopia: Amhara, Oromia, Tigray, Benshangul-Gumuz and the Southern Nations, Nationalities and Peoples (SNNP) Region. The basin covers about two-thirds of Ethiopia's land mass and contributes nearly 40% of its agricultural products and 45% of its surface water (Erkossa et al., 2014). The areas selected represent different agro-ecological settings, with altitudes ranging from 800 to over 3000 meters above sea level. The farming system of the basin can be broadly categorized as a mixed crop-livestock farming system, where over 98% of the area is covered by annual crops (Erkossa et al., 2014).

The sampling frame considered the traditional typology of agro-ecological zones in the country. These are *Dega* (cool, humid, highlands), *Weina-Dega* (temperate, cool sub-humid, highlands), *Kolla* (warm, semi-arid lowlands), and *Bereha* (hot and hyper-arid). The sampling frame selected *woredas*[1] in such a way that each agro-ecological zone in the sample matched the proportions of agro-ecological zones in the entire Nile basin. Accordingly, the survey was carried out in a total of twenty *woredas* from the five regional states (three from Tigray, three from Benshangul-Gumuz, six from Amhara, seven from Oromia, and one from SNNP). This resulted in a random selection of 50 farmers from each *woreda*. After cleaning inconsistent responses, the sample for this study is composed of a total of 901 farm households.

3.2 Data Collection and Questionnaire

Survey data was used to determine preferences for post-harvest grazing. The survey was administered in March and April of 2017 with face-to-face interviews by trained and experienced enumerators with knowledge of the local language, under close supervision by trained supervisors. A structured questionnaire was prepared, and data were collected from household heads. The questionnaire is organized in two parts. The first part includes data on household characteristics, including asset endowments, quantity of livestock, crops produced, agricultural practices used, and other farming operations. Information was gathered on farmers' perceptions about farm characteristics, forage production, etc. The survey also recorded geo-referenced household-level latitude and longitude coordinates using hand-held Global Positioning System (GPS) devices, which allow for the linking of household-level data to historical temperature and precipitation data. The second part includes opinion questions regarding farmers' perceptions about post-harvest grazing. This part of the survey includes the choice experiment. The choice experiment evaluates preferences for alternative policy incentives for forage production.

3.3 Farmers' Perceptions Towards Post-Harvest Grazing

Farmers were asked questions aimed at assessing their attitudes and perceptions on the emergence of new norms towards open access post-harvest grazing on private lands. The respondents registered their perceptions for variants of post-harvest grazing options, such as reciprocal grazing option, two-way grazing restrictions, free riding, and altruistic opportunities. The reciprocal grazing option means that anyone who wants to graze his livestock on others' private parcels must allow others to graze their livestock on his parcel. With two-way grazing restrictions, a particular farmer would restrict grazing on her parcel, and that individual would not be able to freely graze her livestock on others' parcels. We also found free-riding farmers, who would keep the residue in their parcel for conservation agriculture, and then graze their own livestock on others' private parcels. Such farmers would benefit from free access to others' land while reaping private benefits from increasing

[1] A *woreda* is an administrative division equivalent to a district. It is the third-tier administrative unit in Ethiopia, after region and zone.

productivity through conservation agriculture on their own parcel, a classic case of free-riding. By contrast, an altruistic farmer would provide rights for anyone who wants to graze livestock, but the altruistic farmer could not freely graze her livestock on others' parcels.

The primary purpose of recording farmers' attitudes is to assess in quantitative terms farmers' perceptions of post-harvest grazing and to determine how this is influenced by different socio-economic characteristics of the farmers. Because the perceived importance of post-harvest grazing among farmers differs from farmer to farmer and is influenced by socio-economic characteristics, a better understanding of these issues can be obtained by examining individual farmer's perceptions of the various arrangements for post-harvest grazing.

3.4 Choice Experiment Approach

A sample choice set was introduced to the respondents to make sure they understood the task of choosing among hypothetical alternatives or opting out (maintaining the status quo or baseline of open-access grazing). Each respondent was then asked to choose from two alternative scenarios or the status quo. The choice situations were framed as forage production scenarios with different access options and different policy incentives. Based on discussions with experts and review of relevant literature, we identified and described five important attributes and their levels associated with forage production incentives. The chosen attributes and their levels are presented in Table 1. Three of our attributes reflect policy-based incentives: cash subsidy (to partially cover the cost of hiring labor for forage production); distribution of partially subsidized improved forage seeds; and subsidized insurance (50% subsidized index-based insurance coverage). These attributes are proposed to encourage smallholder farmers to participate in forage production and increase forage productivity by offsetting any associated shorter or longer term financial and food security risks associated with forage production (Cox 2006; Marenya et al., 2014). Farmers would partially cover the costs of labor, seed and insurance. The last two attributes included in the choice sets are related to the forage outcomes: average yield per hectare and gross profit margin.

Yield and gross profit margin attributes were included to account for the relative advantage of the proposed production incentives (Coffie et al 2016). It is common practice in the choice experiment literature to consider the gross margin attribute as the monetary attribute. The levels of the yield and profit margin attributes were chosen to capture the trade-offs farmers make when considering different attributes. Since labor is usually scarce during the production season, the cash subsidy for hiring labor is an essential component of the forage production system. We include the distribution of subsidized forage seeds to capture the constraints of forage production systems due to lack or high cost of improved forage seeds. Risk and uncertainty of agricultural production in developing countries is a major concern to most smallholder farmers and farmers are typically assumed to be risk averse

(Coffie et al., 2016). We therefore also examine farmers' preferences for subsidized insurance coverage in a forage production system. This is a weather index-based insurance contract in the production of forage crops.

With four attributes and four associated levels each, and one attribute with two levels, shown in Table 1, the full factorial range of combinations of forage production profiles was too wide to collect the farmers' opinion on all of them. Orthogonal experimental design methods (see Louviere et al., 2000) are carried out using Stata software to structure the presentation of the levels of the five attributes into choice sets and recover only the main effects. The orthogonal design is widely used in the literature and selects the choice sets that procure the maximal information without any *a priori* information on the population's preferences. To limit the number of choice tasks per respondent, sixteen pairwise comparisons of production incentive profiles are randomly blocked into two different versions. The respondent farmers were randomly assigned to one of the two choice blocks, each comprising eight choice sets. An option to opt out (i.e., to choose the baseline or status quo alternative of open-access) was available to respondents during each choice task. The presence of a baseline alternative is vital for the understanding of farmer choices in terms of welfare economics and is consistent with demand theory (Louviere et al., 2000). Thus, each farmer is presented with a version of the eight choice sets, each of which contains two forage production profiles/alternatives and the decision to 'opt out' by selecting neither of the production profiles presented to them (the baseline or status quo). To facilitate understanding of the choice task and ease the cognitive burden from the experiment, the choice exercise was demonstrated with relevant pictures and presented to farmers on colored printed laminated cards (see Table 2 for an illustrative example of a choice set card).

4. Econometric Model

4.1 Multinomial Logit Model

We employ a discrete choice multinomial logit model to examine factors affecting farmers' perceptions on open access grazing options on private farmland. A farmer is assumed to have preferences over a discrete set of alternative grazing options – a choice problem that requires application of multinomial discrete choice models. A multinomial logit model of a qualitative response variable characterizes discrete choices of farmers' perceptions as a function of various socio-economic characteristics of the individual. A certain grazing option is chosen by a given household, if and only if the expected utility from the selected option is greater than the utility obtainable from other available alternatives. Because of its analytical and computational tractability, the model has been applied extensively to discrete choice processes in fields of economics with great success (Manski and McFadden 1981).

The dependent variable, farmers' perception of post-harvest grazing options, is coded to represent the options shown in Table 3. In order to identify unique coefficients for the different options, one of the categories in the multinomial logit model is normalized to zero. We select a comprehensive set of drivers that could potentially affect farmers' preferences on the different post-harvest grazing options and include these in our empirical specifications. Basic information about these farm and household characteristics of the respondent in the study areas are provided in Table 4. These include gender of the head, household composition, education, asset ownership (including livestock ownership), farm size in hectares, walking distance of plot from residence, livestock feed system, participation in credit and off-farm activities, social capital and networks (membership in formal and informal organizations; kinship network), current shocks/stresses experienced in crop production, perception of government support in case of crop failure, participation in extension services, land tenure, temperature, intensity and variability of rainfall[2].

4.2 Choice Experiments

We use discrete choice experiments (DCEs) to study farmers' preferences for attributes of forage production incentives. DCEs are based on Lancaster's theory of consumer choice, which postulates that consumption decisions are determined by the utility or value that is derived from the attributes of the particular good being consumed (Lancaster, 1966). The Random Utility Model (RUM) is the econometric basis for DCEs. The main assumption of RUM is that farmers choose the alternative based on a utility maximizing framework (McFadden, 1974). Statistical analyses of the responses obtained from DCE can be used to derive the marginal values for attributes of a good or policy. Thus, the main aim of the econometric analysis is to estimate the economic value of the forage production incentive design attributes.

Choice experiments have been used in a wide variety of agricultural and natural resources contexts. For example, Waldman et al. (2017) and Roessler et al. (2008) estimate discrete choice models to evaluate farmers' preferences, respectively, for perennial attributes of pigeon pea intercropped with maize in Malawi and for pig breeding traits in different production systems in Vietnam. Chakir et al. (2016) conduct a discrete choice experiment among a representative sample of the French population to provide an economic valuation of environmental and private characteristics affected by the Asian ladybird's invasion. Coffie et al. (2016), Ortega et al. (2014) and Jaeck and Lifran (2014) examine farmers' willingness to adopt good agricultural practices in Ghana, China, and France, respectively. Marenya et al. (2014) use choice experiments to examine the preferences of smallholder farmers in Malawi

[2] We don't provide a detailed description of these variables here for the sake of space, but the information is available in Teklewold et al. (2017).

with respect to fertilizer subsidies, cash payments, and subsidized insurance contracts used as incentives for them to adopt conservation practices. Kassahun and Jacobsen (2015) estimate both the willingness to contribute labor and willingness to accept incentives that motivate land users to participate in an innovative integrated watershed management program in Ethiopia.

Based on RUM, farmers are assumed to maximize the utility derived from their forage production decision. More formally, we specify the underlying latent variable U^*_{njk} of farmer *n* for choice *j* made in choice set *k* as the sum of two components: the systematic component, $U(X_{njk}, \beta_n)$; and the random component ε_{njk}, representing unmeasured variation in preferences. Farmer *n* will choose alternative *j* so long as $U^*_{njk} > U^*_{nik} \ \forall \ j \neq i$. Indirect utility U^*_{njk} is not directly observed but we observe the actual utility maximizing choice U_{njk}, where:

$$U_{njk} = \begin{cases} 1 \text{if } U^*_{njk} = \max(U^*_{n1k}, U^*_{n2k}, \ldots, U^*_{nJk}) \\ 0 \quad \text{otherwise} \end{cases} \tag{1}$$

As suggested in the literature, it is a standard practice to assume that indirect utility is linear in parameters to ensure that the marginal utility is strictly monotonic in the specified attributes (Useche et al., 2013). The n^{th} farmer's utility function can be written as:

$$U^*_{njk} = \beta X_{njk} + \varepsilon_{njk} \tag{2}$$

where X_{njk} is a vector of attributes associated with production alternative *j* for the n^{th} farmer; and β is a vector of parameters, a weight mapping attribute levels onto utility.

We expect substantial heterogeneity in farmers' preferences. For instance, Teklewold et al. (2017) observed differences in farming practices in the Nile Basin areas where this study focuses. Accounting for this heterogeneity enables unbiased estimation of individual preferences and enhances the accuracy and reliability of estimates of demand, participation, and marginal and total welfare (Greene, 1997). To investigate heterogeneity in attribute preferences, we use a random parameter logit (RPL) model. Under the assumption that the stochastic error terms are identically and independently distributed across farmers and choices and takes a predetermined (or Gumbel) distribution – and following the RPL specification in **Train (2003)** – the probabilistic response function is given by:

$$\text{Prob}(U_{njk} = 1 \mid X'_{n1k},\ X'_{n2k}, \ldots,\ X'_{njk}, L) = \int \frac{\exp(X'_{njk})}{\sum_{j=1}^{J} \exp(X'_{njk})} f(\beta \mid L) d\beta \tag{3}$$

where L refers collectively to the parameters characterizing the distribution of the random parameters which the researcher can specify.

5. Results and Discussion

5.1 Factors Affecting Grazing Preferences

Table 3 presents farmers' perceptions of a set of proposed rearrangements of post-harvest grazing options. In spite of the notable heterogeneity, the overall response pattern indicates support for options contrary to the current reciprocal grazing practice. While 81% of farmers prefer an option other than reciprocal grazing, only about 19% of farmers show a preference to continue with current reciprocal grazing access. Surprisingly, however, there is support for "two-way grazing restrictions". A majority of the farmers (about 71%) show a preference contrary to reciprocal grazing options but the two extreme post-harvest grazing options – free riding and altruism – are the least preferred options (4 to 5% of farmers). Thus, the farmers can be categorized into four groups based on preference for reciprocal grazing, two-way grazing restrictions, free riding, or altruism.

The results suggest the importance of new norms, which demonstrates the possibility of institutional innovation at the community level in the face of *de jure* shifts in ownership originating from national-level policy. This case illustrates the important role of social sanctions in establishing and maintaining cooperation of farmers in restricting post-harvest grazing. The result is consistent with Lindberg (1996), who stated that, through a by-law issued by the Babati District Council in Tanzania in 1987, all grazing on cultivated fields was made illegal, in an attempt to promote soil conservation. According to Lindberg (1996), grazing practices are indeed gradually changing in Babati District.

Farmers were also asked to score on a scale of 1–7 the extent to which they agreed or disagreed with each statement on post-harvest grazing problems, where 1 = strongly disagree and 7 = strongly agree and 3 = neither agree nor disagree. The responses to the attitudinal questions are shown in Table 4 below. Overall, these scores reflect farmers' concerns about post-harvest grazing being a major problem if they want to leave crop residue for conservation agriculture. Moreover, many of the farmers were convinced that a rule that prevents open access on-farm post-harvest grazing could substantially reduce the diminishment of stubble. Similarly, many of the farmers believe incentives for forage production could increase feed availability to substitute for post-harvest grazing.

The estimated results from the multinomial logit model for the choice of post-harvest grazing options are presented in Table 6. We keep the 'reciprocal grazing options' as the base category to which results are compared (i.e., the estimated effects are relative to preferring reciprocal grazing options). The Wald test that all regression coefficients are jointly equal to zero is rejected [$\chi2(81) = 6473$; $p = 0.000$], suggesting the model fits the data reasonably well.

It is expected that these grazing options have differential effects on land owners depending on differential bargaining power. Those with many livestock requiring greater access to pasture have incentives to keep their land available to others, while those with few livestock may benefit by enclosing their land and leasing it for cultivation or grazing. In line with expectations, the results reveal a negative correlation between the number of livestock owned and preference for post-harvest grazing restrictions. This is perhaps because farmers with a greater number of livestock have high demand for forage and consider post-harvest grazing as a source of feed. Consistent with this, households with a high number of livestock are less likely to be altruistic in allowing their plots to be used by others for post-harvest grazing.

Farmers' preference for grazing restrictions is positively correlated with adoption of a high number of sustainable agricultural practices. The result suggests that farmers may wish to restrict animals from open access post-harvest grazing in order to protect the sustainable practices from destruction and damage by free-roaming animals (Gebremedhin and Scott, 2003). With adoption of a greater number of sustainable practices, biomass production, which will be used for stall feeding, increases (Duncan et al., 2016; Teklewold et al., 2013).

The plot-level shock variable is captured by an index derived from the presence of the most common disturbances affecting crop production, such as flooding, drought, erratic rainfall, hailstorm, pest and disease pressures. Responses to whether the household had experienced each of these shocks (either yes or no) in the past year were coded as unfavorable or favorable outcomes. When averaged over the number of questions asked (five questions), we could find an index that provides a value close to one for the worst outcome (presence of shocks) and zero for the best outcome (absence of shocks). The result indicates that farmers' preferences for post-harvest grazing restriction are positively influenced by the presence of plot-level shocks.

The results also indicate that smallholder farmers' perceptions of post-harvest grazing options are related to variation in temperature and rainfall. Changes in precipitation influence the probability of farmers' preferences for post-harvest grazing restrictions. In high rainfall areas, climate change can contribute to land degradation by exposing unprotected soil to more erosion. In this regard, restricting post-harvest grazing can be seen by the farmers as an important adaptation practice due to its role of protecting the soil from water erosion. Farmers often prepare for the possibility of climate shocks by engaging in risk management strategies *ex ante* (Shiferaw et al., 2014). Similarly, because leaving crop residue on the field leads to sustainable improvements in efficient use of water and nutrients – by improving nutrient balance and availability, infiltration and retention by the soil, as well as reducing water loss due to evaporation and improving the quality and availability of ground and surface water

(Arslan et al., 2013) – farmers' preferences for post-harvest grazing restrictions are high under high moisture variability conditions.

5.2 Choice Model Results

The results of the RPL model for the full sample with and without socio-economic characteristics are shown in Table 7[3]. Since this choice experiment involves generic instead of labeled options, the alternative specific constants (ASC) were set equal to 1 when either the first or second alternative was chosen, and to 0 when the farmers' own forage production was chosen (Louviere et al. 2000). The model fit statistics and the significance of the estimated standard deviation of the profit attributes on the RPL model specification support the hypothesis of preference heterogeneity. The results in both models showed a positive and significant ASC, which indicates that farmers disliked opting out and had a higher propensity to choose one of the alternatives (respondents chose the status quo in less than 10% of the 7208 options). The coefficient on the opt-out variable is very large, revealing that many farmers gain more utility from choosing the proposed alternatives than staying in the status quo. In addition, there is a statistically significant and positive correlation between attributes – implying that a farmer motivated by change in one of the attributes is also motivated by change in the other attribute. The utility coefficients in Table 7 also reveal that all attributes have statistically significant and positive effects on farmers' utility. The seed and insurance attributes have the largest coefficients, indicating that these attributes are the most important determinant of forage production incentive choice. When the gross margin attribute is used as the normalizing variable, the most important forage production input attribute is the distribution of subsidized improved forage seeds, followed by the subsidized insurance coverage attribute. The two coefficients are large and twice as important to farmers as a labor subsidy for the forage production attribute. The coefficients on yield and gross returns are positive in both models, as expected; yield is valued by farmers as approximately equal to gross returns.

We also estimated RPL models for each of the post-harvest grazing options individually, allowing for correlation of attributes (Table 8). Similar to the overall model, in each group, there is positive and significant correlation between attributes. The utility coefficients show that, both for farmers who prefer the reciprocal post-harvest grazing option and for those who demand grazing restrictions, higher levels of profit and subsidized cash payment for hiring labor have positive and significant effects on utility. While a higher level of profit is only a marginally significant determinant of choice for free riders, it doesn't have a statistically significant effect for altruistic farmers. The significance of the standard deviation coefficients

[3] The choice data are analyzed using the LIMDEP 9.0 software program (Econometric Software, Inc., Plainview, NY, USA), particularly the NLOGIT 4.0 package.

on profit suggests that there is a subset of the population in these groups that has a higher value for this attribute. The coefficients on partial coverage of subsidized insurance for forage production have positive and statistically significant effects in all groups of farmers, but with varying marginal utility. Yield is still the most important attribute to farmers who prefer reciprocal grazing access. The coefficient on the opt-out variable is positive and statistically significant (with values even larger than the ASC coefficients from the over-all sample). This implies those farmers in these two groups gain more utility, even higher than the average farmers in this study, from choosing the proposed alternatives rather than staying in the status quo. However, the ASC coefficients are not statistically significant for the remaining groups of farmers (free riders and those who prefer reciprocal grazing), indicating that the utility of these farmers is independent of the choice of the alternatives.

The marginal value of each attribute represents the farmer's willingness to accept (WTA) compensation to adopt this attribute, where the numerical results represent the percentage increment of forage returns that farmers are willing to accept in order to adopt an attribute. The results from estimation in Table 9 capture farmers' valuation of the forage production attributes. None of the attributes consistently provide a similar effect across the four groups of farmers; we observed variations in the rankings of the attributes and their impact on utility. The results suggest the importance of analyzing heterogeneity of farmers' preferences. The average farmers are only willing to substitute a very small amount of gross profit (1% of profit) for an increased forage yield and this is only significant at the 10% level. However, forage yield has the highest and statistically significant marginal utility for those farmers who prefer reciprocal grazing access. These farmers are willing to substitute 3% of profit for an increased forage yield.

The results also show that the average farmers are willing to substitute a larger portion of their gross returns from forage (about 17%) for a higher level of subsidized improved forage seed distribution and subsidized insurance coverage and are willing to substitute 8% of their profit to reach a higher level of subsidy for hiring labor for forage production. Similar to the overall model, those farmers who prefer reciprocal grazing and those who prefer grazing restrictions derive the same positive marginal utility from the attribute of cash subsidy for hiring labor. These groups of farmers – those who prefer reciprocal grazing access and those who prefer post-harvest grazing restrictions – derive the highest utility from the subsidized insurance attribute compared with other attributes. However, compared to those farmers who prefer reciprocal grazing access, those farmers who prefer grazing restrictions would need to derive the highest marginal utility from subsidized insurance coverage; in other words, they have the highest WTA.

Based on WTA estimates, free rider and altruistic farmers are the least reluctant farmers to adopt the proposed attributes. Thus, the results of this choice experiment support the *a priori* assumption that, in general, the multiple attributes of the forage production system incentives provide private benefits to the farm households of the study areas. However, the findings also demonstrate that there is significant heterogeneity in preferences among farmers in the mixed farming system of the Nile Basin areas. This should be taken into consideration when designing programs to enhance forage productivity, as well as strategies for adoption and diffusion of conservation agriculture.

6. Conclusions

While livestock is an integral component of the mixed crop-livestock farming system, there is still competition between the crop and livestock system over the limited feed resources, leading to open-access grazing. Under such conditions, the adoption and diffusion of conservation agriculture among smallholder farmers, which is an important climate change adaptation strategy, is less likely. The main purpose of this study is to identify incentive packages that motivate farmers to participate in forage production in the Nile Basin area. This paper has, therefore, investigated farmers' preferences for open access post-harvest *in situ* grazing on private lands and valuation of forage production incentives in the mixed farming system of Ethiopia. A choice experiment survey was conducted with a random sample of about 901 farmers from the five regional states of Ethiopia. We identify the characteristics of farmers that differentiate farmers based on their preferences for different post-harvest grazing options. A random parameter logit model (RPL) was estimated in order to value farmers' preferences for the following forage production attributes: cash subsidy for partial payment for hired labor, distribution of subsidized improved forage seeds, 50% subsidized insurance coverage, forage yield and gross returns from forage production. Derivation of welfare estimates from the RPL, combined with the different post-harvest grazing rules, enabled us to characterize the farmers in terms of their propensity to adopt the different production attributes and their need for specified levels of outcomes in order to be willing to pay for policy incentives in forage production.

Based on their preferences for post-harvest grazing options, four groups of farmers are identified: farmers who prefer reciprocal grazing access, two-way grazing restrictions, free riding and altruistic opportunities. About 71% show a preference for two-way grazing restrictions, where a farmer may restrict access to his parcel, but then may not freely graze his livestock on others' parcels. This is contrary to the existing post-harvest grazing practice, which is open access reciprocal grazing. This is an important indication that adoption and diffusion of conservation agriculture – which requires covering the soil surface with crop residues – has the potential to take place. Post-harvest grazing restrictions, however, demand increasing farmers' forage production through various policy incentives.

Thus, the results of this choice experiment support the *a priori* assumption that there is a need for multiple policy incentives for smallholder forage production systems, such as cash subsidy for labor, distribution of subsidized forage seed, and subsidized insurance coverage. In particular, distribution of subsidized improved forage seed and partial insurance coverage provide more benefits to the farm households of the studied sites. However, the findings also demonstrate that there is heterogeneity in farmers' preferences for policy incentives, which should be given consideration when designing programs to increase livestock feed. These findings have implications for the current agricultural policy of adoption and diffusion of conservation agriculture in Ethiopia, which is a cornerstone of the climate resilient green economy strategies.

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Table 1. Choice Experiment Attributes and Levels

Attributes	Descriptions	Levels
Cash subsidy	Amount of cash subsidy for use to hire labor for forage production, Birr/ha	400, 800, 1200, 1600
Seed subsidy	Distribution of improved forage seed with a subsidy equivalent to (Birr/ha):	100, 200, 300, 400
Subsidized insurance	Whether or not there is a 50% subsidized index insurance coverage for forage production	50% subsidized index insurance is available Vs 50% subsidized index insurance is not available
Yield	Yield (tons/ha)	2, 3, 4, 5
Gross margin	Profit margin ('000 Birr/ha)	20, 35, 50, 65

Table 2. Example of the Choice Set

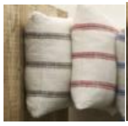
Improved fodder production attributes	**Option – 1**	**Option -2**	**Option-3 (Status-quo)**
Cash payment for labor, Birr/ha	 1600	 800	0
Distribution of improved forage seed with a subsidy equivalent to (Birr/ha):	 300	 200	0
Subsidized insurance coverage	No	 Yes	No
Yield, dry matter (quintal/ha)	  40	  30	 10
Profit margin (Birr/ha)	 50,000	 35,000	 15,000
YOUR CHOICE (Write the chosen option number)			

Table 3. Farmers' Perceptions of Various Post-Harvest Grazing Options

Post-harvest grazing options	Response (%)
Reciprocal grazing access	19.25
Two way grazing restrictions	71.13
Free riding	5.2
Altruistic	4.42
Total N	901

Table 4. Summary Statistics and Description of Variables

		Reciprocal grazing access		Grazing restrictions		Free riding		Altruistic		Total	
Variables	Descriptions	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Gender	Sex of the head (1=if male)	0.84	0.37	0.85	0.36	0.89	0.31	0.93	0.27	0.85	0.35
Age	Age of the head, years	53.70	13.49	52.52	12.99	47.62	13.55	51.23	11.72	52.43	13.10
Education	Household education, years	1.79	3.28	2.07	3.20	2.40	3.03	2.80	3.78	2.06	3.23
Household Size	Family size	7.79	2.68	8.05	2.39	7.79	2.43	7.38	2.59	7.96	2.46
TLU	Livestock size	4.15	2.95	3.83	3.04	4.14	3.57	3.67	2.49	3.90	3.03
Farm size	Farm size, ha	3.19	1.81	3.25	2.90	3.68	2.80	2.97	1.77	3.25	2.68
Asset value	Asset value, ('0000 Birr	5.21	22.76	5.70	50.96	3.28	5.52	2.19	2.38	5.32	44.14
Off-farm	1=if any household member participates off-farm	0.75	0.43	0.72	0.45	0.72	0.45	0.83	0.34	0.73	0.44
Extension contact	Frequency of extension contact per month	7.34	3.51	7.55	3.35	7.81	3.65	7.83	3.62	7.53	3.40
Extension confident	1=if the household is confident with the skill of the extension agent	0.73	0.21	0.69	0.25	0.72	0.24	0.74	0.21	0.71	0.24
Rely Govt	1=if rely on government assistance in case of crop failure	0.63	0.48	0.65	0.48	0.60	0.50	0.65	0.48	0.64	0.48
Relative	Number of relatives in and outside the village	15.76	22.19	17.48	24.58	9.45	16.10	13.18	18.31	16.54	23.57
Group	Number of groups where a farmer is a member	4.63	2.26	4.67	2.11	5.17	2.92	5.20	2.41	4.71	2.21
Plot distance	Walking distance of the plot from home, minutes	14.14	12.65	14.20	15.17	15.32	24.30	11.74	14.66	14.14	15.30
Tenure	Share of own plot	0.87	0.23	0.87	0.24	0.87	0.20	0.85	0.30	0.87	0.24
Parcel	Number of parcel	3.12	1.58	3.57	2.00	2.65	1.58	2.16	1.13	3.38	1.90
Number SAP	Number of Sustainable Agricultural Practices Adopted	2.67	1.07	2.85	1.15	2.51	1.07	3.12	1.63	2.81	1.16
Plot shock	Plot level disturbance index (1=worst)	0.17	0.28	0.19	0.26	0.15	0.25	0.11	0.20	0.18	0.26
Stall feeding	1= if use stall feeding	0.17	0.38	0.19	0.39	0.11	0.31	0.08	0.27	0.18	0.38
Grazing illegal	1=if think post-harvest grazing is illegal	0.52	0.50	0.68	0.47	0.64	0.49	0.63	0.49	0.64	0.48
Average rainfall	Long term mean monthly rainfall in mm (1983-2014)	108.46	27.93	102.57	32.08	126.70	22.99	132.82	25.24	106.30	31.61
CV rainfall	Long term monthly coefficient of variation of rainfall (1983-2014)	1.06	0.20	1.12	0.19	0.90	0.22	0.83	0.23	1.09	0.21

Average temperature	Long term average daily temperature in ^{0}C (1983-2014)	26.69	25.48	24.74	21.91	24.96	21.51	21.29	13.85	24.98	22.33

Table 5. Percentage of Farmers Scoring at Each Level of Agreement to the Attitude Statements

Statement	Strongly disagree	Disagree	Slightly disagree	Neither agree or disagree	Slightly agree	Agree	Strongly agree
Allowing public grazing on private agricultural lands is important	15.98	38.07	5.11	3.22	6.55	25.19	5.88
A rule that restricts open access of post-harvest grazing is a solution to leaving crop residue	4.03	10.25	4.38	2.53	11.98	49.65	17.17
Encouraging individual farmers to produce forage feed on their own lands is important to stop post-harvest grazing	2.42	5.65	2.65	2.3	10.14	51.73	25.12

Table 6. Parameter Estimates of the Multinomial Logit Model

	Grazing restrictions		Free riding		Altruistic	
Variables	Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error
Gender	0.211	0.268	0.500	0.633	0.824	0.772
Age	-0.007	0.008	-0.028*	0.017	0.012	0.015
Education	0.008	0.038	-0.045	0.062	0.053	0.067
Household Size	0.057	0.042	0.002	0.080	-0.073	0.087
TLU	-0.078**	0.033	-0.084	0.066	-0.154*	0.079
Farm size	0.036	0.040	0.088*	0.053	0.070	0.080
Asset value	0.000	0.001	-0.014	0.015	-0.100**	0.044
Off-farm	-0.339	0.248	-0.078	0.432	0.669	0.590
Extension contact	0.008	0.027	-0.032	0.057	-0.044	0.073
Extension confident	-0.817*	0.471	-0.446	0.881	-0.313	0.810
Rely Govt	-0.055	0.190	-0.158	0.395	-0.206	0.443
Relative	0.002	0.004	-0.018	0.019	-0.000	0.012
Group	-0.035	0.047	0.025	0.088	-0.055	0.087
Plot distance	-0.003	0.006	0.017*	0.010	0.016	0.010
Tenure	0.197	0.407	0.960	0.734	0.906	0.835
Parcel	0.113*	0.062	0.087	0.132	-0.121	0.125
Number SAP	0.160*	0.084	0.039	0.179	0.370**	0.181
Plot shock	1.592**	0.776	1.019	1.632	1.733	1.809
Stall feeding	0.026	0.260	-0.682	0.582	-1.555**	0.739
Grazing illegal	0.661***	0.187	0.367	0.354	0.391	0.407
Average rainfall	0.027***	0.010	-0.034*	0.020	-0.018	0.024
CV rainfall	5.735***	1.644	-4.903	3.112	-6.697**	3.041
Average temperature	-0.024***	0.009	-0.012	0.019	-0.016	0.024
Constant	-7.752***	2.672	-5.895	5.267	5.345	5.226
Joint significance of location variables χ^2 (4)	8.09*		353.74***		2.89	
Number of observations = 901; Wald $\chi^2(81)$ =6473 ; p >χ^2 = 0.000						

Table 7. Random Parameter Model Results

Attributes/variables	Model-I	Model-II
Random parameter		
Profit	0.0201*** (13.871)	0.0203*** (13.821)
Random parameter		
Profit	0.0288*** (6.932)	0.0296*** (7.167)
Fixed parameter		
Labor	0.1661*** (4.261)	0.1784*** (4.320)
Seed	0.3616** (2.529)	0.2876* (1.642)
Insurance	0.3416*** (20.739)	0.3429*** (20.310)
Yield	0.0269** (1.825)	0.0284* (1.906)
ASC	0.7868*** (8.763)	0.8099*** (8.491)
Gender		0.0156 (0.853)
Age		-0.0007 (0.343)
HHSize		0.0107 (0.883)
Farm size		0.0219** (1.972)
TLU		-0.0089 (0.880)
Tenure		0.0468 (0.391)
Rely Govt		0.1106** (1.838)
Extension contact		-0.0035 (0.415)
Average rainfall		-0.0041*** (4.632)
CV rainfall		0.1273 (1.047)
Average temperature		-0.0008 (0.604)
Grazing illegal		0.1982*** (3.360)
Stall feeding		-0.1046 (1.374)
Model fit statistics		
N	7208	7208
Log-likelihood	-6020	-6020
AIC	1.672	1.672
BIC	1.679	1.679

Note: *, ** and *** indicate statistical significance at 10, 5 and 1% level; t-values are in parentheses

Table 8. Random Parameter Model Results for Different Post-Harvest Grazing Options

Attributes/variables	Reciprocal grazing	Grazing restriction	Free riding	Altruistic
Random parameter - mean				
Profit	0.0299*** (7.600)	0.0212***(11.630)	0.0071* (1.712)	0.0049 (1.135)
Random parameter – Std. Dev				
Profit	0.0481***(5.049)	0.0297***(5.965)	0.0009 (0.039)	0.0009 (0.037)
Fixed parameter				
Labor	0.2426** (2.430)	0.1824***(3.886)	0.1109 (0.742)	-0.1263 (0.805)
Seed	0.4566 (1.252)	0.2681* (1.563)	0.1924 (0.342)	1.2733** (2.092)
Insurance	0.3120*** (7.546)	0.3889***(18.885)	0.1169** (2.007)	0.1497***(2.469)
Yield	0.0859** (2.277)	0.0183 (1.035)	-0.0262 (0.453)	0.0469 (0.771)
ASC	-0.0713 (0.347)	1.1223***(9.830)	0.4395 (1.410)	1.4611***(3.873)
Model fit statistics				
N	1384	5128	376	320
Log-likelihood	-1259	4002	-385	-273
AIC	1.830	1.564	2.086	1.748
BIC	1.857	1.573	2.159	1.830

Note: *, ** and *** indicate statistical significance at 10, 5 and 1% level; t-values are in parentheses

Table 9. Post-Harvest Grazing Options Specific Valuation of Forage Production Attributes

Attributes	Total sample	Reciprocal grazing	Grazing restriction	Free riding	Altruistic
Labor	8.27(1.96)***	8.13(3.39)**	8.61(2.24)**	15.62 (2.59)	-25.62 (39.39)
Seed	17.99 (7.29)**	15.29 (12.50)	12.66 (8.26)*	27.08 (80.23)	258.18 (246.87)
Insurance	16.99 (1.25)***	10.45 (1.63)***	18.36 (1.51)***	16.47 (13.37)	30.35 (31.31)
Yield	1.34 (0.75)*	2.88 (1.33)**	0.87 (0.85)	-3.69 (8.11)	9.52 (15.33)
All	44.59 (8.08)***	36.75 (13.69)***	40.50 (9.17)***	55.48 (87.98)	272.44 (262.22)

Note: *, ** and *** indicate statistical significance at 10, 5 and 1% level; Standard errors are in parentheses; Welfare measures are calculated with the Delta method of the Wald procedure contained within LIMDEP 9.0 NLOGIT 4.0. Numbers represent percentage change in total forage profit.