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Research Paper

Economic Value of Livestock Loss on Pastoralists' Livelihood: An Analysis of Ethiopian Pastoralist Households.

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ABSTRACT:- *This study estimates the value of livestock loss among Ethiopian Highland pastoralists using a method of valuation that explores their willingness to pay to prevent livestock loss should a disaster occur from the marginal productivities of the breeds that they keep. The theoretical linear household production model motivates the study since it explains households profit maximizing behavior given certain constraints. A normal linear model was estimated using Bayesian methodology with Gibbs sampling algorithm to get the marginal productivities of the two genetic resources namely; local and cross breed cows that the household use as animate inputs which is fundamental for the valuation exercise. Crossbred cows had higher marginal productivity than local breeds as expected. The value of economic loss from both the cross breed and local cows was calculated as $34,332,395,932.65 and $38,720,845,644.67 in 2012 value respectively. The amount of loss has a ripple effect that spreads from the household level to the National level and that the marginal productivities of the breeds that households keep influences the number of improved breeds that they own and also reflects the non-traded value.*

Keywords:- *Bayesian analysis, Disaster, livestock loss, Pastoralist, Semi-arid dry lands.*

I. INTRODUCTION

Livestock production is fundamental in agricultural economies especially where climatic conditions and environmental location make livestock farming the most practicable option since they play multifaceted roles in the livelihoods of households who keep them (Waters-Bayer and Bayer, 1992; Randolph, *et al.,* 2007; Cecchi,*et al.,* 2010). For pastoralists in developing countries, livestock provides a backbone for most families and their communities as it helps provide their nutritional necessities in addition to the opportunity to sell excess livestock produce in markets to earn income (Blench, 2001). Pastoralismalso contributes immensely to the gross domestic product of certain countries with contributions of over 80% in countries such as; Sudan, Niger and Mongolia and between 20to 80% in countries such as Senegal (78%), Somalia (65%), Kenya (50%), Kazakhstan (42%), Ethiopia, (40%) Chad (34%)and Burkina Faso (24%) (Hatfield, *et al.*,2006).

In order to continue benefitting from livestock production, improved breeds of livestock have been crossbred with local onesby research institutions and these crossbred livestock have been adopted by pastoralist households in addition to the local breeds that they keep to increase productivity and income from sales of their products. However, most countries inAfrica are developing and are not adequately prepared for the aftereffects of disasters. Disasters occur frequently in the drylands which lead to livestock loss that expose pastoralists to higher risks with endangered livelihoods as a result of exposure to the shock that comes with it(Wilhite, 2000). Over 12 million people were estimated to have suffered in 2011 from the adverse effects of disaster in the horn of Africa as a result of the negative impact of drought on earnings from livestock production arising from climate change (World disaster report 2011). Livestock losses usually associated with climate change and environmental instability have been found to affect the way livestock is produced and also disrupt every aspect

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of the livelihoods of households that earn their living from their production (Kabubo- Mariara, 2009; Thornton*et al*., 2009; Speranza 2010).The fact that most households are already facing shortage even before the occurrence of such shocks further exacerbates the impact it has on them (Speranza, *et al.,* 2008). With this in mind, most households that depend on livestock for their livelihoods face a compromise between rearing livestock in adverse conditions, adopting other livelihood strategies in addition to pastoralism or shifting from pure pastoralism to include crop production (Herrero,*et al.,* 2009).

This compromise is because they have to maximize the utility they get from what they produce, consume and how resources are allotted among household members subject to constraints that determine the level of output they can get from the inputs used in production (Becker, 1965; Singh *et al*; 1986). When thisis related to the pastoral households,the decision to continue rearing livestock in the presence of the risks and uncertainties associated with disaster could restrict the amount of livestock that households can keep and invariably other benefits associated with livestock production. When livestock is lost in a disaster situation and herd size decreases considerably, pastoralists households are forced to dabble in other livelihood strategies due to decline in their earnings and properties leading to negative impact on the income, livelihoods and role of the households inhabiting the areas where such catastrophic shocks occur (Mcpeak, 2004; Nkedianye,*et al.,* 2011; Campbell and Knowles, 2011). To curb such losses associated with livestock production in disaster situations,pastoralism which involves the movement of herd (nomadic or transhumant) to areas where feed in the form of pasture and water can be made available to them is embarked upon. Mobility is core to the livelihoods of nomadic pastoralists and vital to managing risk in disasters and volatile environments that leads to loss of livestock among households (Niamir-Fuller, 1999). However, evidence suggests that although, pastoralists move their livestock in order to avoid mortality during drought periods in search of pasture and water, they only end up delaying the loss of livestock that would still occur since their livestock are still exposed to vulnerable and harsh conditions when they move (Nkedianye,*et al*., 2011).

This study is motivated by a recent study by (Holloway, 2012) on the value households place on livestock loss associated with an unexpected shock. Pastoral households in the horn of Africa have been facing exogenous shocks especially disasters which results in the loss of their livestock. The aftermath of such shocks could have significant negative impact in the economy of pastoral households whose livelihoods depends on livestock either partially or wholly. A significant amount of research has been done on pastoralism in Africa due to the need mostly to improve the conditions in which pastoralists keep their livestock in order to increase productivity. To our knowledge relatively little work has been done on valuation of livestock loss and its impacts on the livelihoods of pastoralists should any disaster occur. Even when livestock valuations are made little attention is paid on the contributions from livestock as a result of their genetic make-up. Evidence suggests that there is a wide gap between the actual value that improved genetic animal input contributes to the economy than is been accounted for (Scarpa, *et al.,* 2003). This poses the question what impact livestock loss would have on households who keep them should any catastrophic shock occur and how much these households would be willing to pay to prevent such loss. Being able to estimate with precision the value of livestock loss that pastoralist households face from their produce and inputs (Campbell and Knowles, 2011; Holloway, 2012) in this context can be a significant eye-opener to assessing the vulnerabilities and threats to livelihoods that they face. It would also significantly improve and adequately influence the types of policies and development strategies that can be embarked upon for households that depend on livestock for the bulk of their earnings. When households are faced with exogenous shocks, they make decisions to meet their immediate needs and these decisions can push them into paucity and loss of livelihood means (Kassahun, *et al*., 2008). Does the value of livestock that they lose influence their decision to enter into other livelihoods means and does the income that they get or expect to get from other livelihood strategies affect their decision to diversify? It has been suggested that even though diversifying into other strategies help pastoral households survive shock periods, it can take the place of the pastoralism practiced amongst them (Davies and Bennett, 2007).

This study seeks to utilize a linear household production model as the starting point as in Holloway, (2012) using marginal productivities of livestock products to find out the economic value of livestock loss among pastoralist households. A good understanding of the value of livestock loss that pastoralist households facedwhen exposed to exogenous shockscan help policy makers provide timely interventions to prevent negative outcomes that could have ripple effects on the livelihoods of such households. Despite its significance for food security, poverty reduction and its vast contribution to the livelihoods of most countries in the drier parts of Africa or Arid and semi-arid lands (ASALs) as they have been called, the fundamental impact and value of livestock loss in rural households is hardly considered when such losses are associated with catastrophic events like droughts. An understanding of the value of livestock and welfare losses resulting from such events that push pastoralists into other livelihood activity choices is fundamental and relatively no work has been done in this area (Hatfield, *et al*, 2006). In effect, this study is aimed at finding out what and how households outputs and inputs requirements would change when triggered by an exogenous shock.

1.1 External Shocks in Developing Countries and Livestock Production

Globally, almost 200 million people depend on pastoralism for the bulk of their income where plant cropping is impossible or constrained (IFAD, 2009). The dynamics experienced in pastorals settings and uncertainties faced as result of risks makes sustainability in pastoralism appear like a mirage (Moritz, *et al.*, 2009). This is mostly attributed to the misinterpretation of sustainability in the pastoral context, high level of mobility of livestock alongside herders' families and the need to keep the traditional pastoral cultures that make the issues pertaining sustainable pastoral frontier difficult to tackle (Ayantunde, 2011). However, sustainable pastoral system especially amongst transhumant pastoralists is still attainable and it depends mainly on having a good knowledge of the challenges that they face. This challenges could also hinder investments which are a necessary criterion for sustainability (Davies, 2008).Indigenous and international intervention would go a long way to improve how pastoralists respond to interventions and help improve the time that households need to build up herd when they are lost (Hesse and Cotula, 2006).

The impact of external shocks in developing countries especially those with significant number of people practicing pastoralism becomes important since it explains theoretically the impacts any exogenous disruption could have in a pastoral setting. Natural disasters cause enormous shocks that result inshortfall in production and invariably what is available to consume in countries where they occur, disrupting lives, communities and most times outputs from agricultural production (Hallegatte and Przyluski, 2010).These negative impacts of disasters are more pronounced in developing or least developed countries but they may not be the reason why such countries are lagging behind. This assertion is consistent with that of (Raddatz, 2007) that in, low income countries, disasters constitute a major cause of damage to people and their means of livelihoods. Most studies have analyzed what happens before external shock occurs and how the effects of such shocks can be minimized as noted by (Noy, 2009) whose study compared the cost of disasters indifferent countries and income levels after such shock have occurred. His finding suggests that GDP is affected when external shock (disaster) occurs and that countries with larger economies are better able to cope with the aftermaths of disasters.This is further supported by the findings of Berg (2010) who examined the "potential dynamics" of natural disasters on the livelihood of affected households in Nicaragua using cluster analysis and found that some households have been shifted between livelihood strategies as a result of disaster, but at a lower status than they were before the disaster.

In pastoral societies, damages to livelihoods and reduction in level of welfare can be as a result of livestock loss that happens during disasters leading to food scarcity and the need for the development of strategic survival mechanisms among others (Speranza, 2010; Huho, *et al.*, 2011). This is because livestock production constitutes a fundamental source of their livelihood and their ability to cope with the risks that comes with such disasters is always minimal due to limited access to basic resources that further exacerbate the impact of such shock(Paavola, 2008; Campbell and Knowles 2011). Also down streaming coupled with the poor institutional support when shocks occur in pastoral communities have been found to significantly affect how they respond such changes (Kassahun, *et al.,* 2008). As noted by Mcpeak and Barrett (2001), pastoralists especially those in developing countries depend on natural pastures to feed their livestock and natural water bodies such as rivers to provide them with water. As such, any disaster that affects pasture and water supply ultimately leads to livestock loss. In effect, disasters such as droughts and floods affect the availability of fodder for livestock grazing and water supply all of which explicitly lead to livestock loss.

1.1 Economics of Livestock Value in Pastoral Systems

A good understanding of how livestock is valued amongst livestock dependent households is critical for this study. This is because it what households loss influences their level of consumption, production and sales. Two types of livestock values have been emphasized in the empirical literature.These are the direct and indirect values. Direct value involves products that can be quantified such as milk, meat, sales of livestock, savings, cultural requirement among others while the indirect value entails tangible and less tangible values like source of livelihood, social support, market assess, and food security among others (Campbell and Knowles, 2011).

1.1.1 Valuing Direct and Indirect Impacts of Livestock

The literature on livestock loss as a result of a catastrophic shock has been scanty at the micro-economic level and little attention has been drawn to the impact such loss can haveon the livelihoods of households that depend on them. When losses are being calculated after a disaster, livestock loss is seen as merely a proportion of the loss that should be part of the total loss valuation and little attention is drawn on the impact such losses can have on the livelihoods of households that depends on them. However, attention is been drawn to this area recently (Campbell and Knowles, 2011).While direct loss values involve the physical assets and properties that are loss during the disaster, indirect loss values represent the impact the loss has on the livelihoods of those affected both in the short and long run and products lost which has no market value and mostly immeasurable (Campbell and Knowles, 2011;Cavallo and Noy, 2010;Hallegatte and Przyluski, 2010;Noy, 2009). In order to estimate the value of cattle and goats in Zimbabwe, Scoones, (1992) performed a cost-benefit analysis based on the "replacement cost assessment". Livestock have dynamic and multiple benefits. So wheneconomic valuation is carried out, it should involve the traded and non-traded benefits associated with the livelihoods of those involved in livestock production (Dovie, *et al.*, 2003; Dovie, *et al*., 2006). Desta and Coppock(2002) utilized the livestock changes that occur among different Boran pastoralists across wealth classes in Ethiopia to estimate the economic loss that arises due to mortality of livestock during and after periods of drought. Although this method takes into account the changes in household livestock system, it fails to capture other aspects of pastoralists' livelihoods that are affected when they lose livestock in a disaster.

Ayalew, *et al.* (2003) puts forward an economic valuation that covers the multifarious benefits and limits of livestock production in Ethiopia by aggregating total output of production for both traded and non-traded benefits. Their study revealed that local breeds performed better, and has greater value when the conditions in which they are kept are managed properly. In the same vein, Scarpa, *et al*. (2003) valued genetic qualities of cattle breeds in Kenya using choice experiments. They argued that there is a great variation between the value households place on livestock traits and what it is actually worth in economic terms. As such, traded or non-traded benefits should be captured when value is placed on livestock as together they constitute the reasons why households keep livestock in the first place.Benefits from livestock production can be passed to non-livestock producing households through gifts of livestock products and draught animals and this should be part of the valuation too. Ouma, *et al.* (2007) utilizes mixed logit and latent class model to obtain indirect value of livestock traits among households that keep cattle in Kenya by exploring their willingness to pay. Although the procedures used in estimating the direct and indirect values of livestock traits using choice experiments are correct, they are subjective since valuation is done based on what livestock keepers deem as important to them.

Dovie, *et al*. (2006) presents the monetary value of livestock products in Thorndale, South Africa simultaneously with respect to other livelihood strategies that households are engaged in as oversight of such strategies which tend to undermine the latent value of livestock. Nkedianye,*et al.*, (2011) estimated loss of livestock in Kenya using the only the price from market sales, thereby ignoring other non-marketable values that are affected as result of such loss.Comparing and analyzing households' diary production in Zambia, Sri Lanka and Kenya (Moll, *et al.*, 2007) found that non-marketable gains and products other than milk that was neglected during valuations forms a significant part of the total income in all the households involved. Despite the importance of both direct and indirect values on livestock, when households are faced with catastrophic shocks that results in livestock loss, only direct impact is valued. However, Holloway, (2012) propagates a formal procedure for valuing livestock losses among households that depend on livestock. Using data from dairy households in Ethiopia, household production model was combined with standard Monte Carlo methods and Gibbs sampling, Holloway valued the loss associated with catastrophic incidence putting into account heterogeneity that exists amongst households. This study would utilize the agricultural household model as in Holloway (2012) to determine livestock loss among transhumant pastoralists and livelihood activity choices among their households as a result of the losses they encounter in the event of an exogenous shock.

II. METHODS AND MATERIALS

Located between 09°02'N and 38°42'E in the horn of Africa, Ethiopia is bordered by Djibouti and Eritrea to the north-east, Kenya to the south, Sudan to the west and Somalia to the east (figure 3). In 1997, the population of Ethiopia was estimated at 58,732,577 and has increased to 90,873,739 in 2011 with a total area of 1,104,300 sq km. It also has a large population of livestock providing income for over 15 million pastoralists whose livestock products' sales and processing are channeled through various outlets. Owing to this, the Ethiopian Ministry of Agriculture's smallholders Dairy Development Project (SDDP) in collaboration with the Finnish International Development Association (FINNIDA) initiated the formation of four milk groups called weredas which were divided into different peasant associations that foster milk sales for both those participating in such groups and those that are not. An initial survey of four peasant associations Mirti and Ashebaka and then Ilu-kura and Archo from Arsi and Shewa regions respectively was carried out in 1995.36 households were selected from each peasant association to form a sampling frame for data collection based on how active the members were in the groups, adoption and ownership of improved (crossbred) cows and the time it takes for them to get to the market or groups. However for the purpose of this study, 68 households from the Mirti and Ilu-kura associations with 33 households in the former and 35 households in the latter were focused on. Information on the household demography, livelihood options, milk surplus for market, animate inputs and milk production was collected during the survey of the households. The households were visited three times every four months over a period of one year to yield a panel of 68 × 3 households. Information of weekly activities was collected to yield a total of 1428 records on their household transactions (Holloway and Ehui, 2002).

a. Theoretical Framework

Based on the conceptualization that the way and manner in which time is apportioned to production and recreation is paramount to households, the type of animal resource that pastoralist's households put into the production of their livestock is of great importance when it comes to valuing the livestock among such households (Holloway, 2012b). The linear agricultural household model takes into account the interactions between household sales, consumption and production decisions since it incorporates the dynamics of how rural households respond to the impact of any shock or policy change. A shock such as drought in pastoral setting that leads to livestock loss among households could reduce the welfare level of such households. For the pastoralist households it is assumed that consumption and sales depend on the level of production such that what is produced is either sold or consumed. A combination of the agricultural household model with linear quadratic constraints which shows that households tend to maximize the indirect utility $\mathcal{U}$ of the profit π they get from production of milk in an imperfect market or missing market situation as suggested by (Holloway, 2012b) is expressed mathematically as;

(1)Max $(\mathcal{Y})$ $\quad \mathcal{U}(\mathcal{Y}_c) + \pi(\mathcal{Y}_s, \mathcal{Y}_p)$

Subject to

(2) $\quad \mathcal{Y}_p - \mathcal{Y}_s - \mathcal{Y}_c = 0$

Where

(3) $\quad \mathcal{U}(\mathcal{Y}_c) \equiv \alpha + \beta\mathcal{Y}_c - \frac{1}{2}\delta\mathcal{Y}_c^2$

(4) $\quad \pi(\mathcal{Y}_s, \mathcal{Y}_p) \equiv P\mathcal{Y}_s - \mathcal{C}(\mathcal{Y}_p)$

(5) $\quad \mathcal{C}(\mathcal{Y}_p) \equiv \delta + \varepsilon\mathcal{Y}_p + \frac{1}{2}\phi\mathcal{Y}_p^2$

$\boldsymbol{\mathcal{U}}$ is continuous, non-negative and quasi-concave utility function, $\boldsymbol{\mathcal{Y}_c}$ represents level of consumption, $\boldsymbol{\mathcal{Y}_s}$ represents level of household sales and $\boldsymbol{\mathcal{Y}_p}$ represents the level of household production, $\boldsymbol{\alpha}, \boldsymbol{\beta}, \boldsymbol{\delta}, \boldsymbol{\varepsilon}$ *and* $\boldsymbol{\phi}$ represent quadratic utility dependence on consumption and production respectively, $\boldsymbol{P}$ represents the price of livestock products in this case milk output that is sold, $\boldsymbol{C}$ represents cost of production in this case animal inputs that pastoralists put into production of milk output and households minimize this cost of production in order to maximize the profit that accrues to them from such production.

The solution in general form for the utility function is gotten by substituting into equation (1) and then solving using the Lagrange multiplier given as;

(6) Max $(\mathcal{Y})$ $\quad \mathcal{U}(\mathcal{Y}_c) + P\mathcal{Y}_s - \mathcal{C}(\mathcal{Y}_p)$

Subject to

(7) $\quad \mathcal{Y}_p = \mathcal{Y}_s + \mathcal{Y}_c$

Introducing the Lagrange gives;

(8) $\quad \mathcal{L}(\mathcal{Y}, \lambda) \equiv \mathcal{U}(\mathcal{Y}_c) + P\mathcal{Y}_s - \mathcal{C}(\mathcal{Y}_p) + \lambda(\mathcal{Y}_p - \mathcal{Y}_s - \mathcal{Y}_c)$

The first order Kuhn-Tucker condition gives;

(9) $\quad \mathcal{L}_c^{'} \equiv \mathcal{U}_{yc}^{'} - \lambda = 0$

(10) $\quad \mathcal{L}_s^{'} \equiv \mathcal{U}_{yS}^{'} - \lambda = 0$

(11) $\quad \mathcal{L}_p^{'} \equiv -\mathcal{C}_{y\mathcal{P}}^{'} + \lambda = 0$

(12) $\quad \mathcal{L}_\lambda^{'} \equiv \mathcal{Y}_p - \mathcal{Y}_c - \mathcal{Y}_s = 0$

By substitution, the differentiation yields;

(13) $\quad \mathcal{L}_c^{'} \equiv \beta - \delta\mathcal{Y}_c - \lambda = 0$

(14) $\quad \mathcal{L}_s^{'} \equiv \mathcal{P} - \lambda = 0$

(15) $\quad \mathcal{L}_p^{'} \equiv -(\varepsilon + \phi\mathcal{Y}_p) + \lambda = 0$

(16) $\quad \mathcal{L}_\lambda^{'} \equiv \mathcal{Y}_p - \mathcal{Y}_c - \mathcal{Y}_s = 0$

i. Bayesian Method

With deep roots in the usage of Bayes' probability theory, Bayesian methods of econometric analysis are now widely used to make inference about the outcome of events that occur. It starts with a prior distribution of the observations in questions and then the likelihood function of the event that is being observed(Zellner, 1971 and Lancaster 2004). This prior distribution following Bayes' rule is given conventionally as;

(17) $$p(\theta|y) = \frac{p(y|\theta) \cdot p(\theta)}{p(y)}$$

which involves a three stage procedure which begins with setting the prior probability distribution $\boldsymbol{p(\theta)}$ of the parameter of interest $\boldsymbol{\theta}$which shows prior information about it even before the data is inspected and so does not depend on the data. The second stage involves selecting $\boldsymbol{p(\theta|y)}$ which is conditional on the data and the prior information followed by updating new beliefs about the parameter$\boldsymbol{\theta}$.

Since the parameter of interest is$\boldsymbol{\theta}$, $\boldsymbol{p(y)}$ which represents the marginal distribution of the data is disregarded (Zellner, 1971 and Lancaster 2004) to give;

(18) $$p(\theta|y) \propto p(y|\theta)p(\theta)$$

Where∝ represents proportionality, $\boldsymbol{p(\theta|y)}$ represents the posterior *pdf* given the sample information y of the parameter$\boldsymbol{\theta}$, $\boldsymbol{p(y|\theta)}$ represents its likelihood function and then $\boldsymbol{p(\theta)}$reresents its prior *pdf*. With this, inference about the parameter of interest can be made. However, as simple as this sound, it becomes difficult to analytically integrate the posterior distributions which are mostly impossible to arrive at. This necessitates the use of Markov chain Monte Carlo (MCMC) methods like Metropolis-Hastings or Gibbs sampling algorithm for such simulations which basically involves random draws from the posterior distribution (Chib 1995). Detailed review of the Gibbs sampling algorithm is presented in Casella and George, (1992).For the purpose of this study, Gibbs sampling algorithm was used since it is easy to execute using random numbers generation with Gibbs set at 100,000 iterations.

ii. Empirical Specification of the Bayesian Method

Of particular interest in this valuation exercise for milk producing households is the marginal productivity of the inputs that is used in production. Empirical estimation with a normal linear model becomes necessary since is provide the marginal productivity values from both breeds of livestock that the households keep and values are crucial for the valuation procedure that this study follows. A normal linear model as presented in(Lindley and Smith, 1972; Smith, 1973; Raftery, *et al.*, 1997; Koop, G. 2003; Koop and Poirier,2004) using Bayesian methods shows the relationship between the dependent variable y and the independent variables x with an equation given as;

Eq. (C.1) $$Y_i = X_i\beta + \varepsilon_i$$
$$\varepsilon \sim MVN(0, \sigma^2 I_n)$$

and can be written in matrix notation as;

$$\begin{bmatrix} y_1 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} x_{11} & \cdots & x_{1k} \\ \vdots & \ddots & \vdots \\ x_{n1} & \cdots & x_{nk} \end{bmatrix} \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_n \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_n \end{bmatrix}$$

where Y is an $n \times 1$ dimensional matrix of the total daily milk produced , X_i is an $(n \times k)$ matrix of the covariates of interest, β is a $(k \times 1)$ vector of coefficient estimates, ε_i is an $n \times 1$ vector of random errors with ε_i being iid and distributed as $N(\mu_i, \sigma_i^2)$ and *MVN* represents multivariate normal. For this regression, total milk output is a function of several covariates given as;

$$TOTMILK = f(avmilk, pricemilk, numcbown, distmarket, ilkura, mirti, pastland, numcb, numlb)$$

and specified empirically as;

$$TOTMILK = \beta_1 avmilk + \beta_2 pricemilk + \beta_3 numcbown + \beta_4 distmarket + \beta_5 ilkura + \beta_6 mirti + \beta_7 pastland + \beta_8 numcb + \beta_9 numlb + \varepsilon_i$$

Table 1: Definition of Variables for Bayesian normal linear model

Variables	Description
Totmilky	Total daily milk yield -litres
Avmilkx_1	Average daily milk sales over the seven consecutive days
Pricemilkx_2	Price of milk sold-Eth. Birr/litre
Numcbownx_3	Number of crossbred cows owned
Distmarketx_4	Distance to nearest local market,
Mirtix_5	Ilkura Peasant Association - group site (=1,Else=0)
Ilkurax_6	Mirti Peasant Association - group site (=1,Else=0)
Pastureland x_7	Pasture land used in hectares
Numcbx_8	Number of crossbred cows milked
Numlbx_9	Number of local bred cows milked

Both the regression and valuation exercise were carried out in MATLAB using codes provided by Holloway (2012). Different explanatory variables were used regression trials for both cases to get a model that fit the variables of interest with the highest log-marginal likelihood in both cases.

iii. Holloway's Model of Valuing Livestock Loss

Holloway's model of valuing livestock loss was developed recently based on the theory of household production and modern duality theory with "back-of-the-envelope calculations" to provide robust estimates of how much households are willing to relinquish for livestock loss. The procedure used to derive the valuation estimates explores the household's willingness to pay to prevent loss of their livestock should any shock occur.

It takes into account the estimates of the marginal productivity of cattle breeds that households own and informed the use of the normal linear model to derive such estimates. The formula for valuing livestock as derived in Holloway (2012) is given as:

Eq. (C.1) $$\theta \equiv \left(P_i \times \left(\frac{N_i}{N}\right) + P_m \times \left(\frac{N_m}{N}\right)\right) \times \left(\theta_l \times \left(\frac{N_1}{N_\iota}\right)\right) \times \left(\theta_C \times \left(\frac{N_C}{N_\iota}\right)\right) \times \sigma_{S:Pa} \times \sigma_{Pa:W} \times \sigma_{w:e} \times \sigma_{eb:us} \times \sigma_{d:y}$$

Where θ represents the loss estimate in US dollars,P_i and P_m represent the price in Ethiopian birr for milk sold in the Ilu Kura and Mirti associations given as 1birr and 1.25birr respectively, N_i and N_m represent the household heads in the Ilu Kura and Mirti peasant associations given as 35 and 33 respectively, N_ι represents the number of livestock units in both associations in question given as 408,N_1represents the total number of local breed cows employed given as 122, $N_c$represents the total number of cross breed cows employed given as 286, N represents the total sample size of households in both peasant associations given as 68, θ_l and θ_C represents the marginal productivities of one local and cross breed cow each given as 0.97 and 2.06respectively, $\sigma_{S:Pa}$ represents the scale factor converting the sample to the peasant association, $\sigma_{Pa:W}$ represents the scale factor for converting peasant to wereda, $\sigma_{w:e}$ represents the scale factor for converting the weredas to the Ethiopian national aggregate, $\sigma_{eb:us}$ represents the scale factor for converting the Ethiopian birr to US dollars and then $\sigma_{d:y}$represents the scale factor for converting days into years.

III. RESULTS AND DISCUSSION

i. Descriptive Statistics

This section briefly describes the data underlying the analysis of the Ethiopian highland households. Majority of the households were headed by male with 22.1% being headed by female. About 70% of the household members have no formal education and the small proportion (2.9%) of household members who are educated have only a maximum of 12 years education. Majority of the households (with the exception of 1 household head who was visited 54 times) have not been visited by extension agents and so they rely on experience when it comes to farming and livestock keeping. Of the 68 households investigated, 33 household heads were members of the Ilu-Kura association while the remaining 35 were members of the Mirti association. Multiplying these membership values by the 3 times the data was collected gives the sample size for each association's visitation as 99 and 105 respectively. The maximum number of crossbreed cows owned by a relatively small proportion of the households is 4 with a large proportion of households without any crossbreed cows. Although a high proportion of the households depend on the sales of livestock units and their products for their income, they still diversify into other livelihood activities where the highest proportion if income earned from non-livestock income is gotten from grain sales. This explains the reason why even with the pasture land they use,they still need cropland for cultivation with average cropland usage of 2.12 slightly below the average amount of land used for pasture.With this ability to cultivate their own food, they can get still get income from grains.

Table 2: Summary Descriptive Statistics

Household Characteristics	Min	Max	Sum	Mean	Std. Deviation	Variance
Gender of household head (male=1, female=0)	**0**	**1.00**	**159.00**	**0.78**	**0.42**	**0.17**
Farming experience-years	**0**	**62.00**	**5019.00**	**24.60**	**15.87**	**251.77**
Age of Household members						
21-30	**0**	**2.00**	**159.00**	**0.78**	**0.80**	**0.65**
31-40	**0**	**2.00**	**96.00**	**0.47**	**0.56**	**0.31**
41-50	**0**	**2.00**	**81.00**	**0.40**	**0.55**	**0.30**
51-60	**0**	**1.00**	**48.00**	**0.24**	**0.42**	**0.18**
61-70	**0**	**2.00**	**39.00**	**0.19**	**0.46**	**0.22**
71-80	**0**	**1.00**	**21.00**	**0.10**	**0.30**	**0.09**
81 and above	**0**	**1.00**	**3.00**	**0.01**	**0.12**	**0.02**
Formal schooling-years	**0**	**12.00**	**390.00**	**1.91**	**3.34**	**11.17**
Crop land used (hectares)	**0**	**9.00**	**446.99**	**2.19**	**1.63**	**2.65**
Pasture land used (hectares)	**0**	**13.00**	**434.06**	**2.13**	**2.02**	**4.08**
Crossbred cows owned	**0**	**4.00**	**153.00**	**0.75**	**1.07**	**1.13**
Herd size in TLU	**0**	**26.64**	**2002.59**	**9.82**	**5.76**	**33.21**

ii. Results for Bayesian normal linear model and valuation exercise

The results of the normal linear model applied to the panel data collected in Ethiopia are presented in table 5. These estimates are obtained by using a Gibbs sampler algorithm running for 100,000 iterations and executed in ©MATLAB using code provided by Holloway (2012b). The 2.5 percentile 50 percentile and 97.5 percentile intervals were calculated giving a 95% credible interval for the regression coefficients. With this calculation, intervals without zeros are significant and explain the variation in the dependent variables and this implies that only those betas with the same signs are significant. The signs of the values also show whether the relationship between the dependent variable and the covariates is positive or negative. For plots of the sigma and posterior distribution of the betas see figure 1 in the appendix.

Table 3: Estimates of the Normal Linear Model

Variables	2.5 percentile	50 percentile	97.5 percentile
Sigma	1.68	2.02	2.47
avmilk	0.78	0.98*	1.18
pricemilk	-1.43	-0.58	0.28
numcbown	-0.13	0.14	0.40
distmarket	-0.02	-0.01*	-0.00
Ilu kura	0.56	1.42*	2.27
mirti	-0.13	0.36	0.86
Pastureland	-0.23	-0.12*	-0.00
numcb	1.68	2.06*	2.44
numlb	0.77	0.97*	1.17

Rsquared= 0.79 *** = Significant at 95% level of Bayesian confidence interval**
Log-Marginal Likelihood= -389.95 **Standard Errormarginallikelihood =0.00**

As expected, the predictions for the dependent variables are centered around the true value (See figure 1) with a relatively high R-squared of 0.79 which implies that the explanatory variables in the model explains 79% of the independent variable in this case, the total milk output. With the high R-squared and highest log-marginal likelihood value derived from this model, it was chosen as the best fit. The average amount of daily milk sales has a positive relationship with the total daily milk yield and is statistically significant from zero. As the amount of milk sold daily increases by 1 litre, the expected total milk output will increase averagely by 0.98 litres with 2.5 and 97.5 percentiles of [0.78, 1.18]. The price at which milk is sold is not statistically significant from 0 and has no influence on the total amount of milk produced. This makes logical sense since irrespective of the amount of milk produced, the price at which milk is sold in each group does not change. Also, even if there is an incentive to produce more by increasing the price at which milk is sold, each livestock unit would still only produce the optimum amount of milk that it can produce daily. The main reason why crossbreed cows were introduced to households in the first place is to increase the milk output that household get from cows and as such, it is expected that as the number of number of crossbreed cows that is adopted increases, the total output of milk produced would increase too. However, it is surprising that the amount of cross breed cows owned is not statistically significantly different from 0. This could be because majority of the households do not even have any crossbreed cow to start with. Distance to market is statistically significant from 0 and would increase the total amount milk produced averagely by 0.01 litres with 2.5 and 97.5 percentiles of [-0.02, -0.00] as the distance to market decreases by 1 minute. Association with the Ilu kura group shows a positively significant relationship with the total amount of milk produced daily while association with Mirti group is not significantly different from 0. This could be as a result of differences in both groups and how the groups are been administered.It could also be a result of the different times required to wait in groups as observed from the data. The amount of pasture land that households use has a negatively significant difference from zero with the total amount of milk produced daily. As usage of pasture land increases by 1 hectare, the amount of milk produced daily produced decreases averagely by 0.12 litres with a 2.5 and 97.5 percentile of [-0.23, -0.00]. This result is not surprising as pastoralists usually prefer to move their livestock from one pasture point to another and if this is the case, as the amount of pasture lands available for use increases, their livestock may be subjected to long daily treks that could reduce the amount of milk that is produced daily. However, if the number of pasture lands at the disposal of pastoralist households is limited, they would have the incentive to keep their livestock confined to a particular place where feed and water can be brought to them regularly by household members, thereby conserving livestock energy and invariably increasing yields from such livestock.

The values of interest in the study namely; the daily marginal productivity of cross and local breed cows both show positive and statistically significant estimates as in Holloway (2012). The marginal productivity value for crossbred cows is higher than those from the local breed cows. This result is however, contrary to the findings of Ayalew, *et al.* (2003) where local breeds performed better.As the number of cross breed cows milked increases by 1 unit, the total daily milk produced increases marginally by 2.06 litres with 2.5 and 97.5 percentiles of [1.68, 2.44] while the total daily milk produced increases marginally by 0.96 litres with 2.5 and 97.5 percentiles of [0.77, 1.17] respectively as seen in figures 3 and 4.

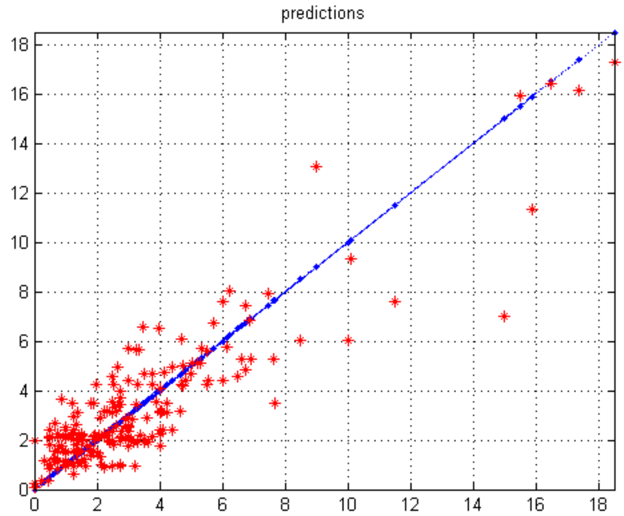

Figure 1: Predictions from the normal linear model

1.

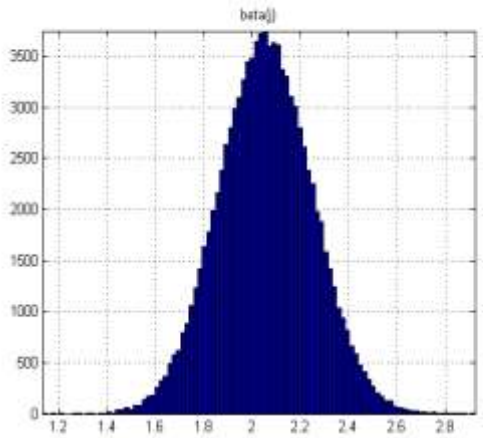

Figure 3: Posterior distribution of the marginal productivity of a cross breed cow

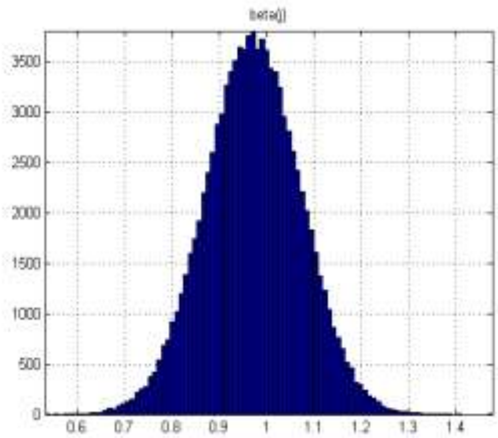

Figure 4: Posterior distribution of the marginal productivity of a local breed cow

iii. Economic Value of Livestock Loss

Following the valuation procedure developed by Holloway (2012) the livestock loss from both local and cross breed cows was derived and is depicted graphically in figure 5. To understand this plot, the reader should look at the plot like a mountain viewed from above with thedark red dot at the centre that the arrow points atas the peak of the mountain and also the modal values of loss across the two genetic breeds considered. The value of loss from both the cross and local breed cows was calculated as \$34,332,395,932.65 and \$38,720,845,644.67 in 2012 respectively.These valuesare slightly higher that the value estimated in (Holloway, 2012) whose values where approximately\$3.37 $\times 10^{10}$ and \$3.84 $\times 10^{10}$for cross breed and local breed cows respectively. This different in values could be a as result of the simple normal linear model that was used to calculate the marginal productivity for both breeds of cow for this study. Considering the amount of loss in absolute terms that was calculated, should any disaster occur, the impact would have a ripple effect on every aspect of the economy in Ethiopia with the households as the center of the ripple that spreads to the national level. Although, managing crossbreed cows can be challenging due to the risks that they stand to face if they are not properly taken care of, it can be seen that it would pay households more to own crossbreed cows since their marginal productivity is higher and the losses incurred on crossbreed cows are lower than that incurred on local breeds.

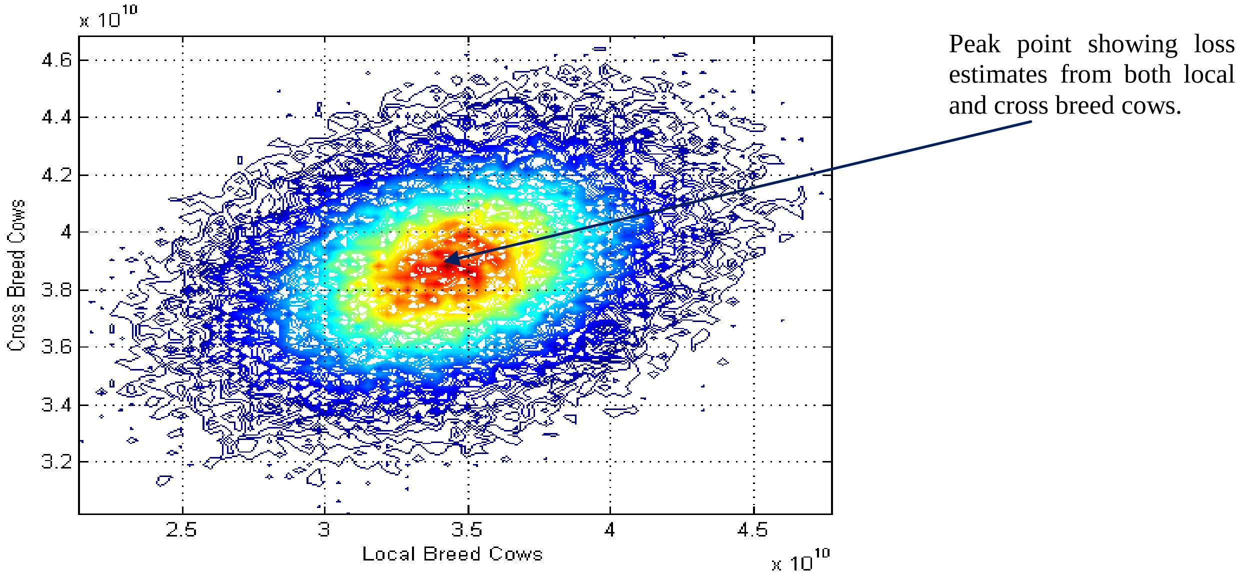

Figure 5: Value of Losses across the Local and Cross Breed Cows

b. Summary and Recommendations

The world of pastoralism is one filled with risks and uncertainties despite itsimmerse contributions to the livelihoods of many households and countries especially those in the developing world. Disasters are natural events like drought, flood and Dzuds that occur everywhere in the world but most developing countries are not well prepared to mitigate their effects of such disasters. So when such disasters occur, pastoralists are faced with the loss of their livestock which is the main source of their livelihood forcing many to diversify. This study is justified by the need to value such losses that households face when disaster occur.

The methodology for the study is based on a linear household model. Normal linear model using Bayesian methodology and Gibbs sampling algorithm in particular was used to get estimates marginal productivity from both genetic breeds using pastoralist households' dataset from two peasant associations collected in 1997 in the Arsi and Shewaregions of the Ethiopian highlands. It also presents the valuation method that was used to get the value of loss in pastoralist households and empirical specification for the multiple regression for the determinants of cross breed cows adoption. The key findings from the results shows that the total amount of milk produced had positive relationship and is statistically significant from zero for the average daily milk sales, association with Ilu-Kura and the number of local and cross breed cows milked. Total milk produced also had negative relationship and is statistically significant from zero for pastureland used and distance taken by households to reach market for sales of livestock products while price of milk sold, number of crossbreed cows owned and association with Mirti group were not significant. The values of loss calculated using Holloway's methodology for crossbred and local cows were $34,332,395,932.65 and $38,720,845,644.67 respectively.

While the valuation procedure gives robust estimates of the value of livestock loss with particular focus on the breeds that pastoralist keep, it could be expanded to involve other aspects of livestock assets that households keep that could be loss should any disaster occur.As the theoretical model explains briefly, information about how much households consume is necessary and should be incorporated in the valuation procedure so as to reduce bias in the results derived. Physical livestock units that households loose can also be incorporated and accounted for in the valuation exercise and this means that when data is collected, information about such losses should also be collected. Also in order to get good estimates at the national level, adequate information about the country, herd size and types of livestock breed kept is important. With this data, no such problem arises since it was used for developing the valuation procedure for this study and in this case, prior knowledge about the heterogeneity of the households in each peasant associations was made available. This calls for regular data collection and the need to use extension agents and keep records properly. With a good knowledge of what households produce, when catastrophic incidents occur as they frequently do in most countries in Africa-east Africa in particular, this valuation procedure becomes important as it can be used to simulate with high degree of accuracy the amount that households can be compensated with. It also has a very important role to play when it comes to index-based livestock insurance that has been recently introduced in East Africa (Mcpeak *et al*., 2010). It could be extended to calculate losses incurred at household level and not just national level. This is because the value given to livestock is paramount when it comes to the insurance that covers households should any catastrophic shock occur. This valuation procedure can also be extended for several purposes and different types of livestock that households keep. The dynamic nature of this valuation procedure is that it is simple and can be move back and forth in time for getting information on value of livestock loss in the past and for future forecast. In addition to this valuation of other products that households get from livestock can also be taken up for future studies.

It can be concluded that households experience substantial amount of livestock losses which if not prevented would continue to lead to decrease in the contributions that livestock make to both the households themselves and their countries too. Considering the productivity of the genetic breeds that households adopt incorporates the non-trades value of livestock and reduces the biases that may occur when valuing livestock. Knowledge about the differences in each pastoral community is important if accurate valuations are to be made.

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