Micro-Economics of Forest – Food Security Linkages in Northern Ethiopia: Safety Nets or Poverty Traps?

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Abstract

In this paper, we investigate the differences in food security outcomes (total expenditure per adult equivalent., distress sale of assets for immediate consumption and number of months that the household had enough food stock available in a year) between households that participate in forest environmental resource extraction and those who do not, using 251 sample farm households from ten Peasant association (tabias) living in Tigray Regional State Ethiopia. We use a propensity score matching methods to account for a selection bias that normally occurs when unobservable factors that influence both participation in forest environmental resources extraction and food security outcomes. The paper also addresses household heterogeneity by explicitly providing separate estimates of the average treatment effect (ATT) for poor and non poor households.

Our analysis leads to several interesting results. First we find that households that are education, age and sex of household head, access to off –farm employment, shocks related to death or illness of a household member and awareness of climate change significantly affects participation in forest environmental resources. Second, we find that participation in forest environmental resource extraction in rural Tigray has significantly lower food security outcomes. Third , we find that the poor and non poor households that are participating in forest extraction had lower distress sale of assets for immediate consumption than non participants in the same sample enforcing the widely held view that forests are important as economic buffer in hard times. Fourth households' in rural Tigray are not driven into forest extraction by risks in farm output only but also by diversification strategy, suggesting that , the problem for local communities has both the characteristics of portfolio analysis and economics of insurance

Finally our findings supports the widely held view that the poor appear to be linked with nature based resource use, but these may serve to perpetuate poverty and food insecurity. This of course, is an important issue for discussion, since it has been widely believed that forests provide an essential safety net for the poor, preventing from destitution. However, if this dependence is reproducing the patterns of poverty and food insecurity, it may be important to examining alternative livelihood strategies in order to benefit these economically marginalized groups.

Key Words: Forest, food security, Matching, Tigray

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1. Introduction

Importance of NTFP (non-timber forest products) captured the imagination of conservationists around the world, when an article by Peter et al (1989) published in the 'Nature' claimed that more money could be earned from tropical forests by collecting these products than from logging (Kaimowitz, 2004). The perception, that NTFPs are more accessible to rural populations, especially to the rural poor (Saxena 2003) and that their exploitation is more benign than timber harvesting (Myers 1988) favoured NTFP becoming economically acceptable ecological option of development. There was also an assumption, often implicit, that making forests more valuable to local users can encourage forest conservation (Plotkin and Famolare 1992). NTFP-based development was born as a new development paradigm capable of accommodating many conflicting needs - of local livelihoods and of global markets; of balancing regional developmental aspirations with that of national growth and above all that of environment and of development.

These developments quite obviously kick-started cascade of research investigations and publications on different aspects of NTFP and in the process buttressed the global NTFP discourses leading to policy changes in many countries. NTFP's perceived role in poverty alleviation was instrumental in its acceptance as a new development paradigm; but reality seems to differ. The resulting NTFP discourses and policy shifts seem to have benefited others more than the poor. The NTFP statistics in form of macro and micro-economic indicators, portrayed in these discourses with varied degrees of claims on pro-poor benefits also translates to very poor economic returns to the poorest. Neumann and Hirch(2000) present evidence from an array of studies that show NTFP extraction is an activity of the poor , and Wunder (2001) and Angesen and Wunder(2003) argue that optimism about- a win – win development and conservation is unwarranted , and that NTFP extraction is generally a low- income activity that may even result in a poverty trap. Here poverty is endogenous, in the sense that biodiversity resource dependence is a symptom of poverty, and it is only by "leaving the forest" that the poor can hope to escape poverty (Lavange et al.,2005). In these cases, a more effective pro- poor (and pro –environment) strategy would assist families to rely less on natural resources and move into other kinds of employment. Conversely, where natural resources are crucial to weathering income variability and show potential for assisting in building up stocks of physical and human capital, resource based strategies combining with complementary policies may prove useful for improving household welfare (Angelsen et al., 2008). Yet, the actual and potential contribution of forests and trees to food security and sustainable livelihoods tends to be overlooked by decision and policy makers. This situation is due to the predominance of information on crops and livestock in the agriculture sector and/or a narrow vision on the role of forestry sector (FAO 2003)

In fact several studies have examined the nature and determinants of forest environmental resource extraction[2] in rural developing countries **(**Angelsen and Wunder, 2003, Adhikari et al., 2004; Babulo et al., 2008; Campbell et al., 2002 Cavendish, 2000; Mamo et al., 2007). A substantial amount of the existing literature examines the dependency of the poor on biodiversity reflected in the proportion of income that is derived from forests (Vira B. Kontoleon A.2010) ,

[2] The term " environmental resource" encompasses all biological materials other than timber which are extracted from forests for human use.

on income equity effects (e.g. Adhikari et al., 2004 Babulo et al., 2008) and on correlations rather than causal effects of income from forest environmental resources on household welfare(Pattnayak and Sills 2001).
In a wide ranging review, Angelson and Wunder (2003) address the links between poverty and forests, and engage with the emergent, more sophisticated approaches to conceptualizing poverty and their implications for our understanding of the livelihoods of forest dependent people. They suggest that it may be useful to distinguish between the way we "think about" poverty , which can be multi-dimensional and complex, and the way we " measure " it, which needs robust and reliable techniques that lend themselves to replication and comparison. Vira B. Kontoleon A. (2010) also argued that if nature's resources help to temporarily smooth consumption and incomes, their poverty impacts may be better captured through an explicit focus on this temporality as part of our poverty measure, instead of restricting to annualized income or consumption (in which these temporary contributions do not always feature as significant).. This suggests that there is still a need to increase our understanding about the specific roles of forests for different strategies in different contexts (Tesfaye et al., 2011). Interestingly, there is no study to our knowledge that subjects these issues to critical empirical scrutiny.

By explicitly focusing on other food security indicators along with the annualized income and consumption indicators, this study contributes to the existing literature by empirically examining whether dependence on forest environmental resource extraction is really safety net or a poverty trap[3] using sample farm households from Northern Ethiopia.. We employ propensity score matching method to control for self- selection that normally arises when participation in forest environmental resource collection is not randomly assigned and self- selection into participation occurs. By explicitly considering the causal relationship between participation in forest environmental resource collection and food security indicators, the paper seeks to address counterfactual questions that may be significant in predicting the impacts of policy changes and framing our understanding of the potential for resource based interventions to offer potential pathways out of poverty.

The remainder of the paper is organized as follows: section 2 provides review of related literature on forest - food security linkage. Section 3 discusses an over –view of food security in situation Ethiopia. Section 4 presents the data used in the empirical analysis. Section 5 outlines the conceptual framework and empirical procedure. Section 6 discusses the empirical results, while the final section provides concluding remarks.

2. Literature Review on Safety net and Insurance role of Forest

Although the empirical literature on the impact of forests on food security is considerably smaller than that on biodiversity as a sources of livelihood, a few more informative studies assess

[3] Delacote (2007) define a poverty trap as a situation in which households do not get more than their subsistence requirement, while more lucrative, but riskier opportunities are available. This definition therefore differ from the usual poverty trap applications , which involve dynamics and multiple equilibria.

the role of tropical forests (and hence biodiversity rich ecosystems) as an insurance against food security (and income) variability**.**

Pattanayak and Sills (2001) found that time spent collecting forest products was correlated with agricultural yield risks (an income smoothing response) and unforeseen production shocks (a consumption smoothing response). One of the main findings of Takasaki et al. (2002) was that the insurance value of forests (as a source of NTFPs during unforeseen shocks) was much more significant for the poorest segments of their sample. According to Bromley and Chavas(1989), non exclusive property rights can be seen as an integral part of risk sharing . Dasgupta and Maler (1993) argue that local commons provide the rural poor with partial protection in time of unusual economic stress. A study of tribal groups in rural Bahir qualifies communally held forests as the only means of survival for poor members in lean seasons (Agrawal, 1991). The micro – econometric study of Fisher and Shively (2005) on communities living at the margins of tropical forest of Malawi find that rural households rely on tropical forests (for wild foods) for coping with income and consumption shocks and that asset –poor households are even more dependent on forests dealing with such shocks. Similar findings are reported in Akinnifesi et al.2006; World Bank 2007; McSweeney 2003; and Sunderlin et al .2000). The importance of resource extraction is amplified in the presence of risks, and such risk is expected to intensify as future climate change precipitates more extreme weather events, especially in the marginal agricultural areas (Sivakumar et al.2005). Hence at least for the case of poor communities living close to tropical forests, there appears to be support for conjecture that forests act as a safety net against food insecurity (and income) variability.

However, even if the above papers studied the insurance role of common property resources, many other researchers argued that resource reliance represents a strategy that prevents the poor from participating fruitfully in other activities and escaping their poverty. Indeed existing overviews (Byron and Arnold 1999; Neumann and Hirsch 2000) suggest that most NTFPs produce low returns (particularly) in terms of return per ha and often, also per labour unit), are primarily used for subsistence and often fill income gaps. They are accessible to the poor people precisely because no one else wants them. In economic terms, many are inferior goods which are substituted by superior products when income rise (Arnold and Perez 2001), and /or domesticated (Homma 1996, Ruiz-Perez et al. 2003).

There is also a strong correlation between NTFP dependence and poverty. At the household level, resource reliance is often viewed as both a consequence and cause of poverty. Income from easy – entry, low – returns environmental enterprises acts as an "employment of last resort "(Angelsen and Wunder 2003). And resource reliance represents a strategy that prevents the poor from participating fruitfully in other activities and escaping their poverty. At a more aggregate level, the poor are both agents and victims of environmental degradation; their dependence on natural resource results in environmental degradation, a shrinking resource base, and increased poverty (Duraiappah 1998; Zimmerman and Carter 2003). In fact Delacote (2007) analyses using commons as insurance whether it is a safety net or poverty trap. But his research work is only applied theoretic, and would benefit a lot of being tested empirically.

The general conclusion is that the safety net and poverty –trap aspects of NTFPs are linked, in as much as features that make them attractive to the poor also limit their potential for generating increase income. The key issue is therefore to present the role of forests as safety nets in

locations where they are more than dead –end poverty traps and where other forms of social insurance cannot take their place. With the exception of Delacote (2007), most of the studies ignore the reverse link when this safety net/insurance role of resource extraction may turn to be poverty trap. They therefore, shed no light on the nature and extent of linkages between bio-diversity conservation and poverty and hence missed opportunities for identifying common causes and common solutions to the two issues.

3. Food Security, Heterogeneity and Common Pool Resources use in Ethiopia

Chronic food insecurity has been a defining feature of the poverty that has been affected millions of Ethiopians for decades. The vast majority of these extraordinarily poor households live in rural areas that are heavily reliant on rain fed agriculture and thus, in years of poor rainfall , the threat of widespread starvation is high(Hoddinott et al., 2009). For decades it has been known that famine and hunger are not inevitable consequences of drought, and the Ethiopian Government, national and international development agencies, and NGOs have been attempting to understand and address the factors that come together to generate the drought-hunger-poverty nexus(FAO 2006). Another of the most important and tenacious problems that is argued to either cause or seriously aggravate the drought-poverty-famine nexus in the plough-based cereal farming system of the highlands is severe natural resource degradation, particularly manifest in soil erosion, deforestation, and devegetation. These factors often interact with one another resulting in a reinforcing cycle of the "poverty, food insecurity and natural resources degradation trap". This problem is most acute in the Ethiopian highlands (where over 85 percent of the country's population lives), which is affected by recurrent drought and famine affecting millions of people (FAO 2003).

Government and international efforts to understand processes contributing to this degradation and to reverse it have been massive and certainly predate the renowned 1984-85 drought and famine. Successes in reforestation efforts, in protecting other resources such as grazing lands, and in implementing soils and water conservation measures on private holdings, have been significant and some of the degradation appears to have been reversed. However, thus far it appears that little success has been achieved in regenerating people's capacities to earn their livelihoods without foreign aid, widespread malnutrition and misery, and continued degradation of resources especially on common lands that are not protected through enclosure (FAO 2006). Natural resource degradation also appears as to be structural feature of the development dynamics of the highlands.

Another phenomenon, which is certainly not new but which is also likely to be much more common and consequential now than in the past, is the high incidence of dependency in forest environmental resources and the striking correlation between extreme poverty and forest dependent households. Income from forest products contribute as high as 27% and 39%, for rural households living close to natural forests in Northern and Central Ethiopia, respectively (Babulo et al., 2008; Mamo et al., 2007). Studies have have also shown that forest dependent people are poorer, live close to the forest, are younger, and have lower livestock and crop income (Illukpitiya and Yanagida, 2008; McElwee, 2008; Mamo et al., 2007) . In this regard, common land is an essential constituent of livelihoods in an area where the plough based farming system is dependent on feed resources from communal grazing lands; where house construction, fuel,

agricultural and household implements are all mainly derived from trees and other plant species that are found in only miniscule quantities , if at all, on private holdings; where medicines as well as fruits, vegetables and other essential nutrients are also generally not supplied by the cereal and legume-based production system; and where cultural associations with indigenous and wild botanicals have such strong religious foundations that these continue to thrive in local churchyards that are so rich in species diversity and density that other communally protected forested areas pale in comparison. The institutional reforms of the past thirty years, and the massive campaigns to halt degradation and reforest the highlands, have had a major impact on those common land areas that have remained.

Laws governing the management of such areas have changed repeatedly and have also often failed to define many user rights. Those areas that are protected ("enclosures") have generated considerable environmental benefits, but policies have largely neglected to consider the population's needs for botanical resources other than grass and timber. Enclosures have largely failed to contribute to the livelihoods of the very poor who, lacking livestock and cash, cannot use many of the livelihood resources that they do provide. As a result, local people have encountered losses of economic benefits and welfare. These have led many local residents to view such a land use policy change as a less favoured land use option (Babluo et al, 2007). In addition common land areas that are not protected have been largely left out of conservation policy: large tracts of land have become de facto open access, and it is upon these lands that the majority of the highland populations rely to meet these multiple material and cultural needs. It is only realistic to expect that continued degradation of this "third" of all livelihood resources will result (FAO 2006)

4. Data Description

A household survey was conducted in 2010/11 on 254 households in Tigray region of northern Ethiopia. A two stage sampling design was made in the study. The primary sampling units (PSUs) were tabias. Sample tabias were selected on the basis of secondary information collected from all the Woredas. In selecting the sample tabias, a number of factors that affect socio economic condition such as nearness to market, geographical location, the availability of both rain fed agriculture and irrigation, size of tabias based on population etc were considered so as to make the sampled tabias representative. In this category, a total of ten tabias namely Arato, Derga _ajen, Hugumrda, Meswaeti, Kara_adishawo, Worebayu Kal_amin, Kelisha_emni,and Felege_woini were selected for the survey. The tabias selected are representative of the three different agro-ecological zones of the region identified on the basis of altitude. Areas with altitude ranging from 1500- 2300 m.a.s.l. are locally termed as *woina douga* i.e midland areas, areas above 2300 m.a.s.l. are locally known as *douga* i.e highland areas and areas with altitude less than 1500 m.a.s.l. are termed as *kola* i.e., lowland. Two of the tabias are in *woina douga*, one is in *douga* and the fourth in *kola.* A multi-purpose questionnaire was used to gather information on household income, expenditure, off-farm income, household assets and local institutions along side a host of other information related to production and sales.

<<< Figure 1 >>>

The dependent variable used in the study is a dummy variable that takes the value of one, if the household participated in forest environmental resource extraction, and a value zero, if no participation was recorded. The outcome variables used in this study are log transformed total per capita expenditure per adult equivalent (Log_tot_expend), distress sale of assets (distress_sale) for current consumption, the number of months in a year that the household had enough food stock available and one binary indicator that takes one, if the household mortgage its assets (distress_sale) for current consumption during the farming season, zero otherwise. These food security indicators were chosen to be in line with those suggested in the literature (Devereux, 2008, Owusu and Abdulai, 2011)

<<<< Table 1 >>> and <<<< Table 2 >>>

Tables 1 and 2 present the definitions and sample statistics of the variables used in the analysis. Also presented in the Tables are differences in means of the variables used in the matching analyses along with their significance levels. The significance levels suggest that there are some differences between participants and non-participants with respect to household and outcome variables. With regards to the outcome variables, there appear to be statistically significant differences in household total per capita expenditure per adult equivalent, distress sale and in the number of months in a year that the household had enough food stock available between participants and non participants. There are also significant differences in sex and education of household head, household size, and awareness of climate change, net financial assets, and total asset, off farm income as well as in total farm income.

Quite interesting is the significant difference between participants and non participants regarding awareness of the climate change. 31% of the participants have awareness of climate change while the corresponding figure for non participants is 58% revealing how awareness to climate change might reduce participation in extractive activities. There are also significant differences between participants and non participants in terms of education. On average, participants tend to have a lower number of years of formal education than non-participants. With more education, households may access a broad variety of livelihood activities, have higher opportunity cost of time (Adhikari et al., 2004) and may disregard the collection of forest resources. In addition participants have lower value of total assets, net financial assets and durable assets compared to their participant counterparts. As argued by (Angelsen and Wunder, 2003) households with more assets may easily access more profitable livelihood activities and may give less priority to environmental and park resource incomes which are often considered "employment of the last resort".

Many researchers argued that female-headed households may exhibit greater dependence on forest resources (Cavendish, 2000; Shackleton and Shackleton, 2006a,b), possibly because they often are poorer, have less access to adult labor (Vedeld et al., 2004), and may lack the means to seek employment away from their families (Shackleton and Shackleton, 2004). In contrast to this traditional view our survey indicated that male headed households participate more in forest environmental resource collection. Our finding is similar (Adhikari, 2005). In addition to there is significant difference between participants and non participants in terms of family size. Participants have higher family size than the corresponding figure of the non participant

counterparts. Larger households may collect forest resources for two reasons: they have more labour to allocate to this activity, but may also be forced to do so by greater dependence and consumer burdens (Godoy et al., 1997).

The findings from the previous section that simply compare mean differences in the outcome variables and other household variables between participants and non-participants suggest that non participants are generally better off than participants. Given that the comparisons of mean differences do not account for the effect of other characteristics of farm households, they may confound the impact of participation in in forest environmental resource extraction on food security status with the influence of other characteristics. Multivariate approaches that account for selection bias arising from the fact that participants and non-participants may be systematically different are essential in providing sound estimates of the impact of participation on household income and food security. The independent variables used in the probit regression models to predict the propensity scores were based on past research on determinants of participation in forest environmental resource extraction (Cavendish, 2000; Shackleton and Shackleton, 2006a,b Vedeld et al., 2004 Adhikari et al., 2004 Adhikari, 2005, Babluo et al, 2007)

5. Conceptual Framework and Empirical Procedure

The model employed is essentially the one suggested by Huffman (1991), where farm households allocate their time to individual activities including non-farm employment. A farm household is assumed to maximize a utility function defined over consumption of goods *Q* and leisure, *H*, i.e., *U* =*U* (*Q*, *H*). Utility is maximized subject to time, budget, production, and non-negativity constraints. The time constraint is $T = L_1 + L_2 + H$, where *T* is total time endowment, L_1 and L_2 are respectively time allocated to farm work and forest extraction , and *H* is leisure as defined above. The budget constraint on household cash income can be expressed as:

$$PQ = p_1 y_1 - w_1 L_1 + w_2 L_2 + R \qquad (1)$$

Where *P* is the price for the consumption good purchased in the market, w_1 and w_2 denotes returns to labor from farm work and forest extraction, respectively,y_1 and p_1 are annual quantity of farm output produced and sold and price for farm output, respectively and *R* represent non-labor income.

The first order condition for optimal time allocation for farm work, non-farm work and leisure is given as $\alpha U/\alpha L_i = w_i \alpha U/\alpha\, Q - \alpha U/\alpha = 0$. This first order condition can be rearranged to obtain the returns to labor from farm work and forest extraction:
$w_i = (\alpha U/\alpha L)\ /(\alpha U/\alpha Q)$. when farm households allocate their time to the three activities, the labor supply functions for farm work and forest extraction can be derived as

$$L_1 = L_1(w_1, w_2, p_1, p_2; Z) \qquad (2)$$
$$L_2 = L_2\,(w_1, w_2, p_1, p_2\,, R; Z) \qquad (3)$$

As noted by Huffman (1991), a positive number of labor hours for extractive activities will be observed for an individual *i*, if the potential shadow wage $(w_i^m)$is greater than the reservation

wage(w_i^r). Thus L_i = 1 if $w_i^m > w_i^r$ and L_i = 0 if $w_i^m \leq w_i^r$, However, these differential wages are not observable. What is observed is the decision to participate, or not to participate in forest environmental resource extraction. This decision can be specified as an index function, with unobserved variable,

$$L_i^* = \beta Z_i' + \mu_i$$
$$L_i = 1 \text{ if } L_i^* > 0 \qquad \textbf{(4)}$$
$$L_i = 0 \text{ if } L_i^* \leq 0$$

Where Z_i' denotes a vector of variables such as household and location characteristics that influence the individual's reservation and shadow wages , and μ_i is the random disturbance term.

To analyze the relationship between participation in forest environmental resource extraction and outcomes such as household income and food security status, we start from the linear function

$$Y_i = \lambda_i + \alpha_i X_i' + \delta_i L_i + \varepsilon_i \qquad \textbf{(5)}$$

Where $Y_i$household income or food security status, L is denotes a dummy variable representing one, if the household participates in forest related activity and zero otherwise; X_i' is a vector of household characteristics, λ_i is a vector of unknown parameters, and ε_i is random error term. The specification in the above equation treats participation in forest related activity as an exogenous variable on the promise that households participate in forest related activity to increase their income or improve their food security status. However, since the assignment of households into forest environmental resource extraction may not be random, with the group of participants being systematically different, the measured return to participating in the forest environmental resource collection may be biased.

This well known evaluation problem can happen in two ways. First , we do not observe pre-participation earnings of the participant .If both pre – and post participation earnings were observable, the benefits of participating in forest environmental resources for each households who participates can be determined by averaging the difference of the pre- and post participation earnings. Second, missing data also arise because of self selection. Because those who participate may be very different from those who do not, a simple difference between participants and non participants will be biased estimate of returns to participation in forest environmental resource collection. Specifically selection bias occurs if unobservable factors influence both the error term (μ) of the participation equation (4), and the error term (ε) of the income equation (5) , thus resulting in correlation of the error terms.

When correlation between the error terms occurs, estimating equation (5) with ordinary least squares method results in biased estimates. Heckman two- step approach has been mostly employed to address this selection bias. However, the approach depends on the restrictive assumption of normally distributed errors. An alternative way of controlling for selection bias is to use instrumental variable (IV) method. A major limitation of the approach is the difficulty in defining instruments in the estimation. In addition to these limitations, both OLS and IV procedures tend to impose a linear functional form assumption, implying that the coefficients on

the control variables are similar for participants and non participants. However, this assumption may not hold, since the coefficients could differ (Jalan and Ravallion, 2003). We use the propensity score matching method to address this issue (Rosenbaum and Rubin, 1983). The idea is to create groups of participants and non – participants who are as similar as possible and then use the differences in their outcome (that is food security indicators) in order to obtain a credible estimate of the benefits of participation in forest environmental resources collection.

Specifically, suppose the earnings of a participant areY_{i1}, and the pre-participation earnings of the same household areY_{i0}, where i indexes the population of interest, and $L_i = \{1,0\}$ denotes participation status. Then the benefit of participation is,

$$\Delta_i = Y_{i1} - Y_{i0} \quad \textbf{(6)}$$

However, while the first of the terms on the right is observable, the second Y_{i0}, is not. One of the key goals is therefore to try and obtain an estimate of this missing data. As a starting point, we have to accept the impossibility of obtaining Δ_i, the benefit of participation for any participant, and focus instead on the average benefit in the population (Heckman et al.1999). This makes it possible to estimate the last term of the equation above from sub sample of non participants (the untreated) in the population, and thereby obtain an estimate of the average benefit of participating. That is ,

$$\Delta^e = \mathrm{E}(Y_{i1} | L_i = 1) - \mathrm{E}(Y_{i0} | L_i = 0) \quad \textbf{(7)}$$

While this difference can be estimated, it is potentially biased if participants and non – participants differ significantly in their characteristics, and we use the earnings of the non – participants to estimate the pre – participation of the participants (Dehejia and Wahba, 1999).

We can minimize this bias by obtaining the same observable characteristics (covariates) from participants and non participants and then match each participant with a non participant on the sameness/similarity of these covariates. Effectively, this implies assigning observations into cells defined by unique values of the covariates. If the number of characteristics used for matching is small, then it is easy to create the necessary comparable groups. For instance, with two binary variables, there would be four groups (cells). However, matching on the covariates can be daunting if they are multi- dimensional and one or more take continuous values. Therefore, a key argument for focusing on the propensity score matching is to reduce this high dimensionality.

First , we estimate the probability of participating in the forest environmental resource extraction conditional on the pre- treatment characteristics , Z, in order to obtain a single- index variable (the propensity Score) to make the matching feasible. Thus, the propensity score $p(Z_i)$ is defined as the conditional probability of participating in forest related work given pre-participation characteristics. That is

$$p(Z_i) \equiv Pr[L_i = |Z_i] = E[L_i|Z_i] \; ; \; p(Z_i) = F\{h(Z_i)\} \quad \textbf{(8)}$$

Where $L_i = (0,1)$ is the indicator whether the household participates in forest related activity or not and Z_i denotes a vector of pre- participation characteristics, and $F\{.\}$ can be a normal or

logistic cumulative distribution .The propensity score can be predicted with either the logit or probit model (Hujer et al., 2004; Sianesi, 2004; Faltermeier and Abdulai, 2009).

The propensity score matching methods use observable characteristics to reduce the bias that is attributable to unobservable factors. The extent to which the bias is reduced depends on the quality of the conditioning variables (Beker and Ichino, 2002). In addition previous studies have shown that matching methods provide reliable estimate of program impact provided that (1) the same data source is used for participants and non participants, (2) participants and non participants have access to the same markets, and (3) the data include meaningful X variables capable of identifying program participation and outcomes (Heckman, Ichimura ad Todd, 1997,). We believe that each of these criteria is satisfied in this study. All data come from 2010 household survey, with the samples of participants and non participants drown from the same tabia to assure comparability of markets and local context. In addition the diversity of variables we have chosen accomplishes this objective and that the assumption that, conditional on the observable factors, participation in forest environmental resource extraction is not correlated with an observable that predict future earnings is satisfied. Our observable characteristics include a rich set of household, community and village level characteristics. Household characteristics control for differences in endowments such as productive assets and serve as a proxy for household wealth, which is likely to influence household's decision to participate in forest environmental resource extraction. We also include community level variables to take account of differences in economic opportunities available to households living in different communities. We add village level dummies to control for natural, political, and economic differences across villages. This specification is consistent with previous empirical literature (see for example Angelsen and Wunder, 2003, Adhikari et al., 2004 Cavendish, 2000).

Our interest is to in the causal average effect of participation in forest environmental resource extraction on some outcome (food security indicators). Accordingly we calculate propensity scores using a standard probit (similar to the one described above) where the binary dependent variable represents the two alternatives that we want to compare. Next we match participants and non participants with the same or similar propensity score (see Becker and Ichino(2002) for more details on the assumption behind estimation.
The predicted propensity scores can then be used to estimate treatment effects . The most common treatment effects in the evaluation literature include Average Treatment Effect (ATE) which captures the treatment effect of the whole sample, Average Treatment Effect on the Treated (ATT) or the participation effect , and the Average Treatment Effect on the Untreated (ATU). Becker and Ichion(2002) indicate that the parameter of interest in the estimation of the propensity score is the Average Treatment Effect on the Treated (ATT).

Given the propensity score $p(Z_i)$, the average treatment effect is evaluated as:

$$\text{ATT} = E[E\{Y_i^1 | L_i = 1,\ p(Z_i)\} - E\{Y_i^0 | L_i = 0,\ p(Z_i)\} | L_i = 1] \quad \textbf{(9)}$$

Where Y_i^1 and Y_i^0 are the two counterfactual outcomes of participation and non participation in forest related activities.

A number of matching algorithms have been suggested in the literature to match participants and non participants of similar propensity scores. The most widely employed algorithms include the nearest neighbor matching, caliper matching, and the kernel matching methods. In the first , the nearest matching estimators with replacement , we compare a participant and non participant whose propensity scores are sufficiently close , by recognizing that it is impossible to obtain exact propensity scores for all pairings of participating and non participating households, and that a non –participating household can be a best match for more than one participating household. In the second, we try Kernel matching. Rather than much one participant with one non-participant, we can use several non- participants, to act as the matches for a participant. The idea is to calculate the average propensity score from a neighborhood of propensity of several comparison members (non participants), match this average propensity score to the propensity score of a participant and then proceed to obtain the average participation effect in equation (7). We use kernel to test the robustness of the results. Finally, we take the difference in food security indicators between the matched participants and non, participants, and sum over all the differences to obtain the Δ^e as in equation (7)

6. Empirical Results and Discussions

6.1. Determinants of Participation in forest Environmental Resources Collection

To construct the propensity score used to match participants and non participants in forest environmental resource extraction a probit regression model was estimated where, the dependent variable is binary variable indicating whether the household participates in forest environmental resource collection or not using a broad set of control variables. In the propensity score matching, it is important to condition the match on variables that are highly associated with the outcome variables (Heckman and Navarro-Lozano, 2004). However, Smith and Todd (2005) argued that there is little guidance on how to select the set of conditioning variables used to construct the propensity score. As stated in the empirical strategy section, we focused on finding a set of conditioning variables that on theoretical grounds and information in the survey should be highly associated with the probability of participating in forest environmental resource extraction and with the outcomes of interest. In general the control variables were chosen based on empirical studies of rural household's reliance on forest environmental resources (Adhikari et al., 2004, Fisher and Shively, 2005, Cavendish, 2000 ; Babulo et al., 2008).

Thus table 3 presents the empirical results of participation in forest environmental resource extraction used to create propensity scores for the matching algorithm. The control variables chosen include household demographic variables (sex, age and education of the household head and the number of students in the household, number of male and female adult labor), whether the household is aware of climate change or not, whether the household experienced weather related shocks, death or illness of a household member , loss of livestock, whether the household earns off-farm income, whether the household has access to private forest , land holding in tsimdi, number of livestock owned in TLU and number of donkey owned , log distance to market and to forest in minutes and location dummies.

<<<< Table 3 >>>

Results of the econometric analysis in the table 3 confirm that education of household head is a significant determinant of participation in forest environmental resources extraction. Higher education levels of a household head are associated with lower probability of participating in forest environmental resource extraction. With more education, households may access a broad variety of livelihood activities, have higher opportunity cost of time (Adhikari et al., 2004) and may disregard the collection of forest resources. Second our result indicated that the probability of participating in forest environmental extraction is significantly higher for male headed households compared to female headed households. This result is different from those many other studies that have attributed to forest extraction as an activity of female headed households (Cavendish, 2000; Shackleton and Shackleton, 2006a,b), possibly because they often are poorer, have less access to adult labour (Vedeld et al., 2004), and may lack the means to seek employment away from their families (Shackleton and Shackleton, 2004). Our finding is similar to (Adhikari, 2005). In addition households affected by death or illness of a household member were more likely to extract forest products. This finding is consistent to Voker. M and Waibel (2010) in their study of Vietnam. Likewise households engaged in off farm employment are less likely to participate in forest extraction which is often considered "employment of the last resort". They usually have lower returns on labor effort and are typically strenuous to acquire (Angelsen and Wunder, 2003)

Quite interesting is the negative and significant impact of aweless of climate change. Farm households that are aware of climate change are less likely to participate in forest extraction at one percent significant level. This finding is quite interesting given the source of 20 % of the greenhouse gas emission is due to deforestation

6.2. Propensity Score Matching Results

Having looked at the determinants of the probability of participating in forest environment resource extraction in rural Tigray, we now examine the size of consumption expenditure per adult equivalent, distress sale and food availability during the critical periods between participants and non participant households. We then split the sub sample into two sub samples: The poor (households belonging to the first and second quintiles) and the non – poor (households belonging to the two upper quintiles), and we do the same comparisons. This split enables us to see the extent to which participation in forest environmental resource is pro- poor or otherwise.

Table 3 presents estimates of the average impact of participation in forest environmental resource extraction. The outcomes considered include total expenditure per adult equivalent, distress sale of assets for immediate consumption and the number of months in a year that the household had enough food available. Panel A of table 3 shows the average level of food security outcomes defined above along with the average differences and P-values for treated and

control variables, where treatment is defined by participation in forest environmental resource extraction for the whole sample, while panel B and C presents the same outcome for poor and non poor households respectively.

The results indicate that the difference in household expenditure per adult equivalent between treated (participants in forest environmental resource extraction) and untreated (non participants) households for the whole sample is substantial (-0.11) and (-0.18) when households are matched based on demographic, assets and other covariates and we use the nearest neighbor and kernel matching respectively. Participants in the matched sample have on average 1.5% and 2% lower per capita expenditure per adult equivalent than non participants in the same sample as shown by the nearest neighbor and kernel matching respectively. This suggests that participation in forest environmental resource extraction has a causal influence on total expenditure per adult equivalent when households are matched on relevant socio-demographic, assets and other covariates. Hence if we had two hypothetical households matched on those socio-demographic, assets and other variables in table 2 were to make one of them to participate in forest environmental resource extraction she/he would have total expenditure per adult equivalent on average 1.5% and 2 % lower than households not involved in the extraction of forests for nearest and kernel matching respectively.

For the number of months that the household had enough stock of food available (fooda_months), a similar trend is reflected. Treated households in the matched sample have lower months of enough food available during the year than non participants in the same sample. The participants have enough food stock available on average for 1.74 months (24%) lower than non participants and the difference is statistically significant at 5% levels of significance.

The third outcome estimated for participants and non participants is distress sale of assets for immediate consumption (distress sale). Again participants have higher level of distress sale than non participants in the same sample. Participants have a distress sale level that is on average 0.05 points (i.e 13%) higher than non participants and the difference is statistically significant at 1% level of significance.

To sum up, Panel A of table 3 indicated that treated have significantly lower food security outcomes than the untreated households in rural Tigray and the finding is robust to whether that we use different food security indicators or matching methods used.

In Panel B and C we split the sub sample into two sub samples: The poor (households belonging to the first and second quintiles) and the non – poor (households belonging to the two upper quintiles), and we do the same comparisons as panel A. This split enables us to see if the average impacts in panel (b) masks significant impacts of participation in forest environmental resource extraction for some participants and to see the extent to which participation in forest environmental resource is pro- poor or otherwise.

The results show that participants (treated) have lower total expenditure per adult equivalent for the poor and non poor households. However, we find that the poor and non poor households that are participating in forest extraction had lower distress sale of assets for immediate consumption than non participants in the same sample enforcing the widely held view that forests are

important as economic buffer in hard times. Finally while find that the non poor had higher number of months food stock available compared to non participants in the same sample we didn't find any significant different on the number of months that the household had enough food available for participants and non participants

Table 4: **Food Security outcomes of households that participate in forest environmental resource collection and non participants**

Outcome	Matching algorism	E(Y) Participants	E(Y) non participants	Differences in Average outcome (ATT)	P-value
PANEL A: All Households Treatment: Participation in forest Environmental resource extraction Impact: Mean Impact					
Log_t_exp_aue	Nearest _neighbor	7.45	7.56	-0.11	**0.000*** **
	Kernel Matching	7.45	7.63	-0.18	**0.000*** **
Distress Sale	Nearest _neighbor	0.75	0.70	0.05	**0.000*** **
	Kernel Matching	0.75	0.67	0.09	**0.000*** **
Fooda_months	Nearest _neighbor	5.51	6.37	-0.85	**0.046** **
	Kernel Matching	5.51	7.18	-1.67	**0.045** **
PANEL B: POOR Treatment: Participation in forest Environmental resource extraction Impact: Mean Impact					
Log_t_exp_aue	Nearest _neighbor	7.27	7.48	-0.21	**0.002*** **
	Kernel Matching	7.27	7.47	-0.20	**0.002*** **
Distress Sale	Nearest _neighbor	0.67	0.84	-0.17	**0.039*** **
	Kernel Matching	0.66	0.81	-0.15	**0.037** **
Fooda_months	Nearest _neighbor	5.15	6.73	-1.58	0.410
	Kernel Matching	5.16	6.90	-1.74	0.281
PANEL C: NON POOR Treatment: Participation in forest Environmental resource extraction Impact: Mean Impact					
Log_t_exp_aue	Nearest _neighbor	7.63	7.99	-0.36	**0.001*** **
	Kernel Matching	7.63	7.95	-0.32	**0.001*** **
Distress Sale	Nearest _neighbor	0.84	0.93	-0.83	**0.002*** **
	Kernel Matching	0.84	0.91	-0.07	**0.001*** **
Fooda_months	Nearest _neighbor	5.86	5.15	0.71	**0.036** **
	Kernel Matching	5.86	4.94	0.92	**0.046** **

***, **, * denotes significance level of 1, 5 and 10 percent respectively

6.3. Does Diversification or Coping Strategy explain households' choice of Participation?

It is now generally established that the safety net use of NTFPs extraction may take two forms, corresponding to two kinds of risk – management strategies. First, the diversification strategy which is equivalent to portfolio analysis, because the households use NTFP extraction as risk free asset (Alderman and Paxson, 1994). Second the coping strategy consists of extracting NTFP only when agricultural output is too low, working as a "natural" insurance mechanism. Therefore, the problem for local communities has both the characteristics of portfolio analysis and economics of insurance (Delacote 2007). In the latter case while NTFPs extraction insures against bad outcome (in case a household relied on just one risky activity) as shown in section 2 of the paper, it also , potentially excludes the household from engaging in high return activities that come from specialization.

We now explore more rigorously, the idea that participation into forest environmental resource collection is motivated by mitigation or reduction of the potentially high risk in agriculture. We measure the risks that households face in agriculture through predicted probability that the farm households have zero or negative profits from their agricultural activities. We compare this outcome across comparable groups of participant and non –participant households. Initially we obtained the probability of participation in forest environmental resource collection- the propensity score (being participant and non participant in forest environmental resource collection). Next we matched participant and non participants on the propensity score. Having obtained groups of comparable households, we calculate the average differences in the predicted probabilities of having positive profit from farming across the participant and non participants. These predicted probabilities are obtained through a probit model where having positive profit from farming is a function of sets of variables which normally influence farming profits (see annexed table 5).

Table 6. Differences in farming profit of participants and non – participants in forest environmental resource extraction

Outcome	Matching algorism	E(Y) Partic ipants	E(Y) non partici pants	Differences in Average outcome (ATT)	P-value
PANEL A: All Households Treatment: Dummy if the household positive agricultural profit equals 1, zero otherwise Impact: Mean Impact					
Forest Extraction	Nearest _neighbor	0.85	0.94	-0.087	0.408
	Kernel Matching	0.86	0.92	-0.06	0.425
PANEL B: POOR (1) (126) Treatment: Dummy if the household positive agricultural profit equals 1, zero otherwise Impact: Mean Impact					
Forest Extraction	Nearest _neighbor	0.86	0.91	-0.05	**0.071***
	Kernel Matching	0.85	1.00	-0.15	**0.009*****
PANEL C: NON POOR(2) Treatment: Dummy if the household positive agricultural profit equals 1, zero otherwise Impact: Mean Impact					
Forest Extraction	Nearest _neighbor	0.85	1.00	-0.15	**0.008*****
	Kernel Matching	0.85	1.00	-0.15	**0.009*****

***, **, * denotes significance level of 1, 5 and 10 percent respectively

Our results in Panel A suggest that households' in rural Tigray are not driven into NTFP extraction by risks in farm output. This finding is consistent with the diversification strategy usually observed in Latin American countries (Alderman and Paxson, 1994) that households' raises ex ante the number of its activities, choosing possible activities that have low covariance. However, the average pair wise differences for poor and non- poor (panel B and C) revealed that participants and non participants are significantly different in their predicted probabilities of farming profit. In this regard , our analysis suggest that the poor and non –poor farm households in Tigray also driven into forest environmental resource extraction by risks in farm output or more prone to volatile agricultural income. This finding is also consistent to the coping strategy which is observed in African countries (Alderman and Paxson, 1994) that agricultural risk mitigation explains participation in forest resource extraction (Delacote, 2007, Pattanayak and Sills, 2001).Overall, it appears that the decision to participant in forest environmental resource extraction in rural Tigray is motivated by both the diversification and Coping strategy

7. Conclusion and Policy Implication

In this paper, we investigate the differences in food security outcomes (total expenditure per adult equivalent., distress sale of assets for immediate consumption and number of months that the household had enough food stock available in a year) between households that participate in forest environmental resource extraction and those who do not, using 251 sample farm households from ten Peasant association (tabias) living in Tigray Regional State Ethiopia. We use a propensity score matching methods to account for a selection bias that normally occurs when unobservable factors that influence both participation in forest environmental resources extraction and food security outcomes. The paper also addresses household heterogeneity by explicitly providing separate estimates of the average treatment effect (ATT) for poor and non poor households.

Our analysis leads to several interesting results. First we find that households that are education, age and sex of household head, access to off –farm employment, shocks related to death or illness of a household member and awareness of climate change significantly affects participation in forest environmental resources. Second, we find that participation in forest environmental resource extraction in rural Tigray has significantly lower food security outcomes than farm households that are not participating. This finding is robust to weather the data are split into poor and non poor households and matching methods used. Third , we find that the poor and non poor households that are participating in forest extraction had lower distress sale of assets for immediate consumption than non participants in the same sample enforcing the widely held view that forests are important as economic buffer in hard times. Fourth households' in rural Tigray are not driven into forest extraction by risks in farm output only but also by diversification strategy, suggesting that , the problem for local communities has both the characteristics of portfolio analysis and economics of insurance (Delacote 2007).

.The implication of the above findings is that forests serve as a safety nets by mitigating distress sale of assets for immediate consumption at the same time households that are participating in forest resources are relatively poor in the sense that they have lower food security outcome(such as lower per capita expenditure per adult equivalent, higher distress sale of assets for immediate consumption and lower number of months in a year that they have enough food available), supporting the widely held view that the poor appear to be linked with nature based resource use, but these may serve to perpetuate poverty and food insecurity. This of course, is an important issue for discussion, since it has been widely believed that forests provide an essential safety net for the poor, preventing from destitution. However, if this dependence is reproducing the patterns of poverty and food insecurity, it may be important to examining alternative livelihood strategies in order to benefit these economically marginalized groups.

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Table 1. . **Variables and summary statistics of the sample households**

Variables	Descriptions and measurements	Mean	Std.Dev.
Treatment Variable:			
Forest _extraction	1if the household participates in forest environmental resource extraction , 0 otherwise	0.85	0.36
Outcome Variables			
Log_tot_exp	Log transformed total expenditure per adult equivalent in Ethiopian Birr	7.51	0.48
Distress_sale	Food insecurity (1 if the household sale its assets for current consumption, 0 otherwise)	0.71	0.46
Fooda_months	Food security (number of months in a year that the household have enough food stock)	5.70	3.43
Independent Variables			
HH characteristics			
Hhh_sex	Sex of the household head (1 if male ,0 otherwise)	0.85	0.36
Age_hh_1	Age of the household head in years	46.8	12.5
Edu_hhh	Education of the household head in years	1.17	2.18
Stu_number	Number of students in the household	1.51	1.43
Aware_cc	Awareness of Climate change in the household(1 if the household head is aware of climate change, 0 otherwise)	0.35	0.48
Asset Holdings			
Male_adults	Number of male adult labor in the household	1.37	0.91
Female_adults	Number of female adult labor in the household	1.49	0.87
P_size _tsimdi	Plot size of land owned by the household in Tsimdi	4.36	2.93
Tlu	Number of livestock owned by the household in TLU	3.11	2.59
N_donkey	Number of donkey owned by the household	0.75	0.84
Private_forest	Access to private forest (1 if the household owns private forest,0 otherwise)	0.45	0.50
Shock dummies			
S_death_ill	Household experienced any shock due to death or illness of a person (1 = yes; 0 otherwise).	0.23	0.42
S_weather	Household experienced any weather-related shock: drought, flood, erosion, frost (1 = yes; 0 otherwise).	0.80	0.40
Lives_loss	Household experienced any shock due to loss of livestock (1 = yes; 0 otherwise).	0.45	0.50
Access to factor market and inputs			
Off_farm	Household have access to off-farm employment (1 = yes; 0 otherwise	0.32	0.47
Log_dis_forests	Log transformed distance to forests in Minutes	1.24	1.33
Log_dis_market	Log distance to woreda market in minutes	1.71	0.82
Location Dummies			
Southern Zone	1 if the household lives in southern zone, 0 otherwise	0.41	0.49
South_Eastern	1 if the household lives in southern eastern zone, 0 otherwise	0.20	0.40
Eastern Zone	1 if the household lives in Eastern zone, 0 otherwise	0.39	0.49

Table 2. Mean separation tests of participants and non participants in forest environmental resource extraction

Variable name	Non-Participant (n= 38)	Participant (n= 213)	p-value*
	Mean (SE)	Mean (SE)	
Log per capita expenditure per adult equivalent	7.84 (0.09)	7.45(0.03)	0.0000***
Distress Sale	0.45(0.82)	0.76(0.03)	0.0001***
Number of months with enough stock of food	6.77(0.56)	5.51(0.23)	0.0378**
Sex of household head	0.68(0.76)	0.88(0.22)	0.0020***
Ag e of household head	47.3(2.26)	46.7(0.84)	0.7584
Education of household head	2.42(0.48)	0.944(0.13)	0.0001***
Family Size	4.60(0.33)	5.95(0.14)	0.0003***
Awareness of Climate Change	0.58(0.08)	0.31(0.03)	0.0016**
Number of livestock in TLU	2.65(0.47)	3.29(0.16)	0.2341
Number of adult household member	2.53(0.20)	2.92(0.08)	0.0784*
Land holding in tsimdi	3.76(0.38)	4.46(0.21)	
Non-farm income	3352(1647)	733.92(137)	0.0007***
Food consumption expenditure per adult equivalent	7.55(0.08)	7.20(0.03)	0.0000***
Access to irrigation	0.21(0.07)	0.12(0.02)	0.1433
Off farm employment	0.55(0.08)	0.28(0.03)	0.0009***
Frequency of shocks (2005-2010)	1.82(0.21)	2.18(0.08)	0.0770*
Total Asset Value	2182(645)	1160(103)	0.0055***
Durable Asset Value	1882(617)	808.5(97)	0.0021***
Net financial asset	87.14(97.3)	-18.2(10.3)	0.0000**

***, **, * denotes significance level of 1, 5 and 10 percent respectively

Table 3: Determinants of Participation in forest Environmental Resources Collection

Dependent variable: Participation in forest Environmental resource Collection			
Variable name	**Coefficient**	**Standard error**	**Z-value**
Household characteristics			
sex of head (Male-headed)	1.023	0.360	**0.004*** **
Age of head	-0.029	0.011	**0.006*** **
Education of household head	-0.203	0.056	**0.000*** **
Number of students in the household	0.117	0.978	0.230
Awareness of Climate Change	-0.768	0.256	**0.003*** **
Asset Holding			
Number of male Adult labor	-0.035	0.143	0.808
Number of female Adult labor	0.206	0.172	0.233
Land holding in Tsimdi	0.025	0.052	0.633
Number of Livestock owned in TLU	-0.021	0.067	0.752
Number of Donkey owned	0.023	0.175	0.896
Access to Private Forest			0.613
Shocks			
Death or illness of a Household Member	0.561	0.332	**0.091***
Weather related Shocks	-0.106	0.397	0.790
Loss of Livestock	0.388	0.259	0.133
Access to Factor Market and Inputs			
Off-farm employment	-0.548	0.285	**0.055***
Log transformed distance to forest	0.015	0.157	0.923
Log distance to Market	-0.044	0.103	0.671
Location Dummies (Reference Southern Zone)			
South_Eastern	-0.278	0.375	0.459
Eastern	0.042	0.305	0.890
_cons	1.827	0.784	**0.020** **
Number of obs = 251			
Pseudo R^2 = 0.2685			
Log likelihood = -78.057317			

*, **, *** significant at 10, 5 and 1 percent level of significance.

Table 5: Determinants of Predicted probabilities of farming profit

Dependent variable: Dummy equals 1 if the profit from agriculture is positive, 0 otherwise			
Variable name	**Coefficient**	**Standard error**	**Z-value**
Age of head	-0.004	0.013	0.744
Education of household head	-0.072	0.073	0.325
Number of male adults in the household	0.040	0.182	0.828
Dummy equals 1 if the household has his/her own business, 0 otherwise	-0.102	0.354	0.772
Value of Seed in Birr	-0.001	0.000	**0.007*** **
Land holding in Tsimdi	0.081	0.083	0.327
Number of TLU per adult equivalent	1.517	0.462	**0.001*** **
Value of fertilizer in Birr	-0.001	0.001	0.327
Number of crops grown	0.462	0.175	**0.008*** **
Death or illness of a Household Member	0.081	0.405	0.842
Loss of Livestock	-0.755	0.326	**0.020** **
Access to credit 2010	0.314	0.341	0.358
Number of extension visit	0.002	0.027	0.913
Log distance to Market	-0.134	0.142	0.345
Distance to DA office in minutes	-0.011	0.005	**0.021** **
South_Eastern	-0.798	0.397	**0.044** **
_cons	1.253	0.831	0.132
Number of obs = 251			
Pseudo R^2 = 0.3230			
Log likelihood = -52.047128			

*, **, *** significant at 10, 5 and 1 percent level of significance.

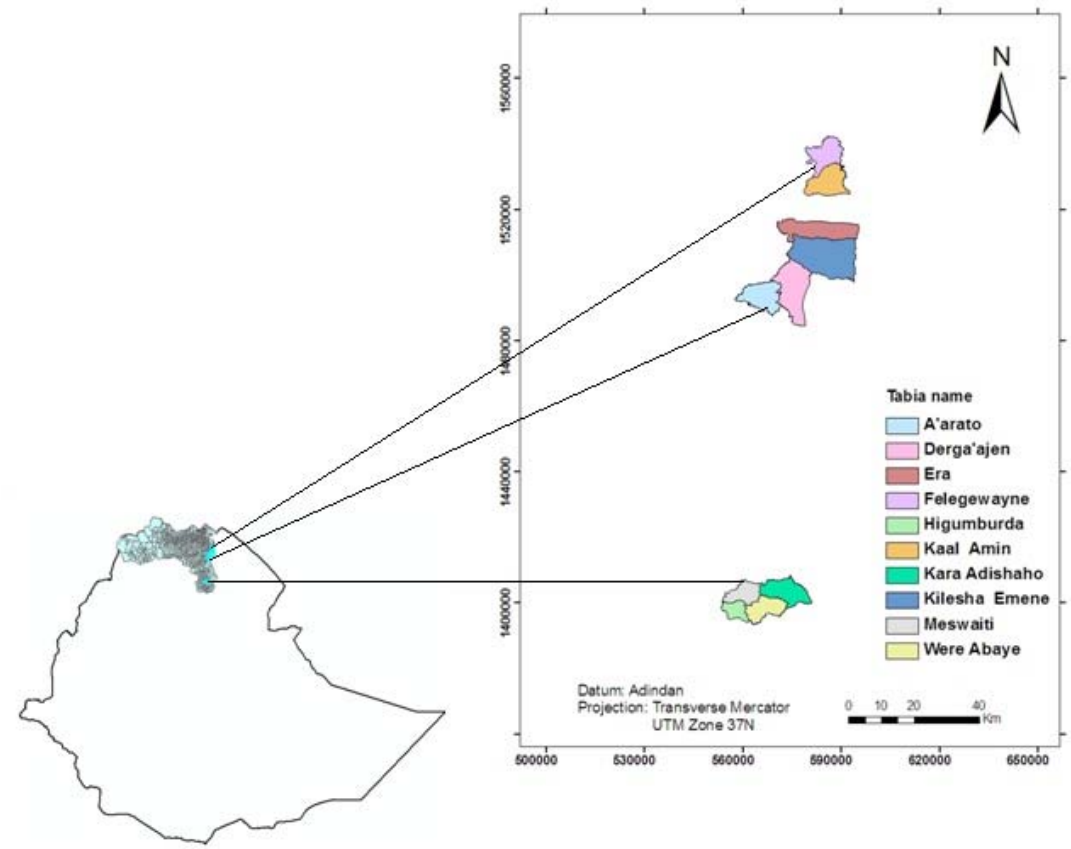

Figure 1 : Map of the Study area