Tenure, Forest Use and Policies for Reducing Emissions from Deforestation and Forest Degradation (REDD+)

Eiendomsrettigheter, bruk av skogressurser og skogvern som klimatiltak i utviklingsland (REDD+)

Philosophiae Doctor (PhD) Thesis

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Paper 2: Tenure issues in REDD+ pilot project sites in Tanzania

(Therese Dokken, Susan Caplow, Arild Angelsen, William D. Sunderlin)

Paper 3: Forest reliance across poverty groups in Tanzania

(Therese Dokken and Arild Angelsen)

Paper 4: Forest as an employer of last resort and potential impacts of REDD+ in Tanzania

(Therese Dokken)

Summary

The objectives of the thesis is to improve our understanding of what determine differences in access to and use of land and forest resources across households, introduce new methods to analyze this, and identify policy measures that can improve management of forest resources.

The decomposition method used in paper 1 is widely used in the labor market literature to explain wage differences, but it can also provide insight into why access to land differs across groups. The smaller landholdings by female-headed households' cannot be explained by differences in household endowments and characteristics alone, but also returns to these endowments and characteristics. Such differences in indicate discrimination gender bias in access to land.

In paper 2, we identify a mismatch between statutory and customary rights. Forests within village boundaries are not necessarily recognized as village lands by the state, while the village claims communal rights and also perceive their rights as secure. We find that factors internal to the village, such as low rule compliance and enforcement among households, are challenges to achieve collective action and reduce deforestation and forest degradation.

In paper 3 and 4 we look at which households are more dependent on forest and why some households are more dependent than others. In paper 3 we propose a new method to classify households when studying the forest-poverty nexus. We argue that the stock of productive, human and liquid assets should be considered when assessing households' poverty status, and that predicted income is a better measure of long-term income than the observed one-year income. We apply a two dimensional categorization of households, based on both observed and predicted incomes. The new classification changes a major conclusion in the forest-poverty literature for our case. One group stands out in terms of having both the highest forest reliance and absolute forest income, namely the stochastically rich. These asset-poor households have enjoyed a high income in the survey year, and have significantly higher forest income. These high forest-users are not classified as poor when using observed income, but are when using predicted income. While we fully realize that nothing can replace observing the same households over time, we believe a method combining observed and predicted income can be used to discuss some aspects of poverty, normally confined to analysis of poverty dynamics with long-running panel data.

In paper 4, I go more into depth to look at why some households are more forest reliant. I estimate the household specific shadow wages and find a negative correlation between forest reliance and the estimated shadow wage, indicating that forests at least to some groups serve as an employer of last

resort. Although forest activities are characterized by low returns, poor households have few other options for income generating activities.

INTRODUCTION

1 Introduction

The tenure system has welfare implications both at the macro and micro levels. At the macro level, the performance of the economy depends on how rights are defined and enforced by structuring the incentives for economic behavior within the society and determining who the actors in the economic system are (North and Thomas 1973; Libecap 1989; Rodrik 2000). At the micro level, lack of access to land is a cause of poverty for rural households in developing countries (de Janvry et al. 2001). In addition to the direct benefits derived from land, tenure rights to land can also have positive impacts on other factors that can further improve livelihoods, such as access to credit, bargaining power and social status of rural households (Agarwal 1994a). Further, secure rights for the users of natural resources provide incentives to invest in conservation (Feder and Feeny 1991) and more effective natural resource management in general (Demsetz 1967).

Access to agricultural land and the use of other natural resources are closely linked. A diversified income portfolio is a key characteristic of rural households in developing countries (Banerjee and Duflo 2007), and the initial access to land is often argued to be the asset that shapes the production decisions made by rural households (Ellis 2000). In their global comparative study of environmental income, Angelsen et al. (2014) found that households in more land scarce communities earn a higher share of their income from forest resources. These forest reliant households are more vulnerable to deforestation and forest degradation. At the same time, they may also be more vulnerable to initiatives to conserve the forest if this restricts the access to the forest, as they have fewer other income earning opportunities.

The global initiative of Reducing Emissions from Deforestation and forest Degradation, and enhancing forest carbon stocks in developing countries (REDD+) has been recognized as a viable option for addressing climate change early and at relatively low cost (Stern 2006). REDD+ can potentially facilitate large reductions in greenhouse gas emissions by compensating forest owners and users for lost forest income and livelihood opportunities (Angelsen et al. 2009). Tenure rights tend to be insecure for communities living in forested areas in the countries where REDD+ is being implemented (Sunderlin et al. 2008). In the context of REDD+, this is a concern, as more powerful actors can gain rights to the land while forest dependent communities not only lose future REDD+ benefits but also their livelihood opportunities (Larson et al. 2013).

The objective of this thesis is threefold. First, I aim to improve the understanding of what determine differences in access to and use of land and forest resources across households. Second,

and related to the first objective, I aim to introduce new methods to analyze these links. Third, based on the results, I aim to identify policy measures that can improve management of forest resources, with a particular emphasis on REDD+ initiatives. The first and second objective is covered in paper 1, 3 and 4 while the second objective is covered in paper 2 and 4. In paper 1, I identify a gender bias in access to land in Tigray, Ethiopia, by decomposing differences in returns to household characteristics between male- and female-headed households. In paper 3, we combine measures of observed and predicted income to identify differences in forest reliance across different categories of households. In paper 4, I go more into depth on why some households derive a larger share of their total income from the forest compared to others, to identify what actions can be made to reduce their forest reliance and contribute to the success of REDD+. In paper 2, we assess whether the existing institutional arrangements in REDD+ villages are sufficient to overcome collective action challenges and contribute to reductions in deforestation and forest degradation.

2 A brief history of tenure rights and livelihoods

2.1 Tenure and efficient management of resources

The tenure rights system is a set of rules and norms that determine who can use what resource, under what conditions and for how long (FAO 2009). Both *property rights* and *tenure rights* are terms commonly used in the literature, but the distinction between the two terms is not necessarily clear. In this section I use the terms interchangeably depending on which term is used in the original work[1].

Schlager and Ostrom (1992) distinguish among different bundles of rights, namely those of access and withdrawal rights, management, exclusion and alienation rights. These rights are independent of each other, and groups or individuals may hold only some of the rights. As an example, Schlager and Ostrom (1992) identify the *owner*, who holds all four bundles of rights, the *proprietor* who holds all but the right to alienate, the *claimant*, who has the right of management, access and withdrawal and the *user* who has access and withdrawal rights only. The incentives individuals face, the actions they take and the outcomes they achieve is affected by the different bundles of property rights they hold (Schlager and Ostrom 1992).

[1] In my papers, property rights refer to the resource itself and the right to benefit from this resource while tenure rights is a broader term that covers the relationships between people, and refers to the formal or informal rules and institutions which determine the property rights.

Demsetz (1967) identifies incentives and ensuring internalization of externalities as the primary functions of property rights. An externality is an effect of a decision made by one party on another party, whose interests are not taken into account (Coase 1960). An example of a negative externality is that of harvesting forest resources without taking into account the harmful effects for other users of the forest, on the ecosystem, biodiversity and carbon emissions. Demsetz (1967) argue that property rights develop when gains from internalizing externalities become larger than the costs of internalization, and thus changes in property rights is a response to changes in economic values of harmful or beneficial effects.

The term "the tragedy of the commons" has been widely used to explain resource degradation since Hardin published his paper with that title in 1968. It means that whenever an unlimited number of individuals use a scarce resource, we can expect that the resource will be degraded. The underlying logic is the divergence between individual and collective rationality. While each herder receives the full benefit of adding an extra animal to the pasture, he bears only a share of the costs of the overgrazing this animal contribute to. Each herder using this area will try to maximize his gains by adding more animals, resulting in a degraded pasture and lower returns to each animal.

This is closely linked to what kind of good a pasture is. Any good can be characterized by two attributes; the cost of exclusion and the rivalry of consumption (Table 1). A pasture is a common-pool good. It is costly to exclude others from using the pasture, but at the same time consumption by one decrease the amount of pasture available to others and the pasture is depletable. The problem of provision is closely linked to the free-rider problem. When an individual cannot be excluded from the benefits of a good provided by others, the individual may have no incentives to contribute to the provision of the good.

Table 1 Type of goods, classified by physical characteristics

	Exclusion cheap	Exclusion costly
Rivalrous consumption	Private (cattle, trees, fish, garden)	Common-pool (pasture, forest, fishery)
Non-rivalrous consumption	Club/toll (subscription-based streaming services)	Public (pollution-control, disease-control)

Source: Adapted from McKean (2000)

Many have suggested that the best way to avoid "the tragedy of the commons" is to create a system of private property rights (e.g., Smith 1981). There may, however, entail high transaction

costs of excluding potential users from certain natural and environmental resources like forests and fisheries. These resources may therefore be better managed jointly by a group of individuals. Ostrom (1990) (and others) argue that the problem of free-riding can be solved and collective action achieved when a group of individuals govern a resource under a common property regime. In addition to the physical characteristics of a resource, the attributes of the group enhance the performance of the communal property regime and increase the likelihood of achieving collective action (Ostrom 2003). This includes information about flows of benefits and costs, that the group is stable and develops low cost monitoring and sanctioning systems and that the participants in the group share norms of reciprocity and trust.

2.2 Distributional impacts of tenure

Property rights are important because they protect the rights of natural resource users to both use the resources and benefit from their sale (Bromley 1991). They define to what extent a household or an individual can gain access to the benefit streams generated and provide a set of benefits that have positive impacts on livelihood outcomes as well as other factors that can further improve livelihood, such as access to credit, bargaining power and social status of rural households (Agarwal 1994b).

While individuals and rural households are mainly farmers and derive a large share of their income from agriculture, they engage in a range of other economic activities and pursue diversified livelihood strategies (Ellis 2000). Environmental income is income from goods produced by resources that are not cultivated, such as natural forests and rivers, and there is a growing evidence of the importance of environmental income for rural households (e.g., Angelsen et al. 2014). In addition to supporting current consumption, environmental incomes, and particularly incomes from forested areas, can be important as safety nets in case of shocks and as gap fillers during income slack periods for the rural poor (Wunder et al. 2014). This literature also suggests that poorer households obtain a higher share of their income from environmental resources, and restrictions in the access to these therefore have significant distributional implications (e.g., Cavendish 2000, Angelsen et al. 2014).

Extraction of resources can lead to degradation of the resource stock, and have negative impacts on livelihoods, biodiversity and the environmental services provided by the resource. Secure tenure rights for the users of natural resources can provide incentives to invest in conservation and sustainable management (Feder and Feeny 1991), and this, in addition to improving rural dwellers livelihoods, has been the rationale behind various land reforms and conservation policies. Although

access to land through community membership remains important, privatization of all or some rights to agricultural land has been widespread. There is a strong, positive relationship between access to land and household income (de Janvry et al. 2001; Jayne et al. 2003). This makes the allocation of rights critical for households' livelihoods. In a study from India, Jodha (1986) found that the households who had relatively more land to begin with, also received more land upon privatization of the common property lands.

While the state remains the owner of all arable land in Ethiopia, peasants are allocated user rights. To reduce the number of administrative re-allocations resulting from population pressure, a land reform was implemented in the 1990's, issuing certificates to land users to increase their tenure security (Deininger et al. 2008). While the reform aimed to secure access to arable land for peasants without differentiation between genders, female-headed households perceive their tenure rights as less secure (Holden and Bezabih 2009), and in paper 1 in this thesis I find that female-headed households have less access to land.

2.3 Tenure and REDD+

In the context of REDD+, it is important to consider forest tenure because tenure rights tend to be insecure for communities living in forested areas in countries where REDD+ is being implemented (Sunderlin et al. 2008). Powerful actors can get rights to the areas at the expense of forest dependent communities who may lose not only potential future REDD+ benefits but also their current livelihood opportunities (Larson et al. 2013).

The source of tenure rights varies: statutory rights are based on state laws and enforced by governments and recognized by legal, formal institutions, while customary rights are have emerged over time and are embedded in local norms and customs. In developing countries, customary regimes often exist alongside the formal legal tenure system (Elbow et al. 1998). The result can be both overlapping and contradicting rights to particular resources; the state claims ownership to most of the forested area in developing countries, while people living in the forest often reject state control and continue to claim customary rights (Sunderlin et al. 2008). They may also co-exist more harmoniously, if statutory rights acknowledge and validate customary claims , and the differences between the two classes of rights are not apparent unless the customary rights are challenged (Schlager and Ostrom 1992).

To what extent REDD+ will benefit or marginalize forest communities depends on both the initial tenure arrangements (Cotula and Mayers 2009) and the design of the incentive schemes.

Customary claims to forest tenure are often unrecognized, leaving people living in forest adjacent communities vulnerable to exploitation (Larson et al. 2010, Larson et al. 2013). As REDD+ proceeds, and if the value of the standing forest increases, REDD+ can threaten the rights of the village as the *claimant* of the forest and the households in the village as the *users*. To a certain extent, this is what we find in paper 2; there is a discrepancy between the village's own perception of tenure rights and the statutory tenure rights. On the other hand, tenure rights also have implications for the success of REDD+. A core idea of REDD+ is conditional incentives to forest carbon rights holders. This requires that (1) the right holders to be rewarded for maintaining or enhancing the carbon sequestration are identified, and (2) that the right holders can be held accountable, in case they fail to fulfill their obligations. Further, forest dependent communities' rights and livelihoods must be protected, in line with the criteria to evaluate REDD+ projects suggested by Stern (2008). REDD+ gives value to a new commodity, forest carbon, and the goal is to discourage harmful forest use. This requires that (3) a land rush is avoided, by making the rights and responsibilities (1 and 2 above) sufficiently legitimate and clear, and (4) that no unacceptable harm is done to pre-existing access and management rights to forest resources and livelihoods (Sunderlin et al. 2014).

To succeed in both reducing emissions from deforestation and forest degradation and to protect the rights and livelihoods of forest dependent communities, knowledge about whom the users are, and why they are dependent on the forest is of great importance. In paper 3 and 4, we contribute to this knowledge. In paper 3, we propose a method to identify the households most reliant on forest resources by taking into account both short- and longer-term income when only cross-sectional data is available for analysis, and in paper 4 I go more into depth as to why some households are more forest reliant than others. Both the "*who"* and the "*why"* are important considerations to take into account for proponents implementing REDD+ and for policy makers designing the national framework.

3 Data

The data for the papers included in the thesis are from two different sources. The data analyzed in paper 1 was collected in Tigray, Ethiopia in 2006. The fieldwork was organized as a joint fieldwork with fellow master students and a PhD student from UMB, and is part of a panel data set. The Tanzania data used in paper 2, 3 and 4 is part of an interdisciplinary ongoing research project that aims to provide policy and technical guidance to REDD+ stakeholders, called the Global Comparative Study on REDD+ (GCS-REDD) conducted by the Center for International Forestry Research (CIFOR) and its partners[2]. I was the field research supervisor for the data collected in Tanzania, and was responsible for organizing the fieldwork. Both datasets are described in detail in the following sub-sections.

3.1 The data set from Tigray

The household and individual response data used in paper 1 were collected in Tigray over the period June to August 2006 with the help of 27 local bilingual enumerators and are part of a panel data set started in 1997/1998. Despite the fact that the data set is part of a panel, some of the specific data used in this paper were collected in the 2006 round only, and thus the analysis is limited to cross-sectional analysis.

The sampling method for the data was administered at two levels. At the village level, there was stratified sampling, taking into account agricultural potential, population pressure, access to irrigation and access to the market. In the 2006 round, 17 villages were included in the sample. At the household level, 25 households were randomly sampled from each village. Due to attrition, the number of households from each village varied in the 2006 round, and the total number of households was reduced from 425 to 370. Due to missing information for some of the households, the number included in the analysis is further reduced to 357.

The additional questions added to the 2006 round were pilot tested before being included in the questionnaire, to make sure they were both relevant and sensitive to the cultural context. Asking a married person about a previous marriage was expected to be sensitive, but we were surprised how

[2] For detailed information about this study, please visit the project website http://www.cifor.org/gcs/global-comparative-study-on-redd.html (accessed 7 April 2014).

openly they were willing to discuss this issue. Nevertheless, to get as reliable answers as possible, we interviewed husband and wife separately.

3.2 The data set from Tanzania

The Tanzania data was collected during 2010[3]. The data utilized in this thesis is part of a component aiming to assess the performance of REDD+ projects (Jagger et al. 2010).

Study sites within each country were purposively selected and not necessarily representative of the forest conditions and management in their respective countries. One reason for this is that the project proponents (project implementers such as NGOs or government agencies) had their own criteria when choosing which areas to implement their projects in. Secondly, GCS-REDD project sites (geographical area) were chosen based on their own criteria; within the area, a proponent was about to implement a project that had defined boundaries at the beginning of our fieldwork period in 2010, but that had not yet introduced any conditional incentives (e.g. payments to communities and/or individual forest users), had a reasonable chance of lasting throughout 2013 to enable us to collect the 'after-data' and lastly, projects that intended to quantify their activities through monitoring, reporting and/or transacting reductions in carbon emissions or increase in carbon stock (Sunderlin et al. 2010). In each project site, four villages were selected from a sample frame of 16 villages. For each of the selected villages, approximately four potential control villages were identified. These villages are similar to the intervention villages, but not included as an intervention village by the proponents. The intervention and the pool of potential control villages were then statistically matched on a set of variables considered to be important for understanding the livelihood and conservation effects of REDD+ projects, such as tenure arrangements, access to markets, population pressure and forest cover. At the village level, a random sample of 30 households were drawn from a list of all the households (Sunderlin et al. 2010).

We pilot tested all instruments tested in each country a few months before the actual data collection started, to ensure we collected the information we needed and that the questions measure what it is supposed to measure, that the questions are understood by the respondents with the given instructions and clarifications, to identify response choices, and to estimate the time spent to complete the questionnaires. We made sure to conduct the pilot testing in villages that were close to

[3] Research instruments and technical guidelines are publicly available : http://www.cifor.org/online-library/browse/view-publication/publication/3286.html (accessed 12 May 2014)

our study sites, but not the same villages that were included in our project to make sure none of the respondents were interviewed twice within a time frame of a few months. Data at the project level was collected by formal survey interviews with technical staff from the proponent organizations, project documents publicly available and/or provided by the proponents and through grey literature. I was present in the field at all times, and supervised a team of eight research assistants (locally employed and bilingual) who conducted the interviews with the households. We interviewed key informants and arranged village focus group meetings with 10-15 participants, both with a mixed group and pure women's group, while interviews with household respondents were conducted privately in their homesteads. All interviews in Tanzania were conducted in Swahili.

4 A mixed methods approach

A mixed methods approach refers to the use of both quantitative and qualitative methods. The papers included in this thesis are all empirical, and with the exception of paper 2, the main methods of analysis are quantitative. The quantitative, econometric methods are explained in depths in the papers, and will not be discussed here. The focus of this section is to explain the overarching research approach, and I will discuss the purpose and aspects of a mixed methods approach in the three different phases of the research process distinguished by Brannen (2005); the *research design phase*, *the fieldwork phase* and the *interpretation and contextualization* of the data.

A useful typology of the purposes of mixing methods is developed by Greene et al. (1989). They distinguish between (i) triangulation, to increase the validity of a measure, (ii) complementarity, to enrich the understandings of the social world, and reveal different dimensions of a phenomenon, (iii) development, to increase the validity of research instruments, (iv) initiation, when contradictions or paradoxes that appear in one part of their study are explored in a subsequent part, and finally (v) expansion, whereby researchers use different methods for different components of their study to extend and broaden their analysis. The strategy of mixing methods serves different purposes in this thesis, including development, expansion and complementarity.

Alexander et al. (2008) emphasize three aspects: first is the sequencing of the methods, which refers to whether methods proceed sequentially (e.g. one method is used to prepare for another) or in parallel. The second aspect is whether each of the methods used are independent or whether there is an element of interdependence between them. The last aspect is the relative status of each method

compared to that of the others, whether they are given equal weights in contributing knowledge about a phenomenon or one is considered more important.

In the *design phase* of the study of REDD+ projects (GCS-REDD), we used qualitative data and methods to identify potential project sites to be included in our study. After the sites were identified, qualitative methods were used to identify a pool of potential control villages nearby these sites, while quantitative methods were used to match intervention and control villages. Further, each research instrument was pilot-tested using mainly qualitative methods and the results were used to develop the questionnaires of a more quantitative nature. This was also part of the design phase of paper 1 using data from Tigray. Within the framework of a mixed methods typology presented above, the mixed methods proceeded mainly sequentially in the sense that results from one method was analyzed before proceeding to the next method. The methods were dependent on each other, but more weight was given to qualitative methods compared to quantitative. The purpose of this approach is to use results from one method to inform the other method, including sampling of villages and in order to develop more accurate research instruments. Within the typology of mixed methods, this is referred to as development (Greene et al. 1989).

In the *fieldwork phase*, the data collected from key informants and focus group discussions was both qualitative and quantitative. For the most part, the qualitative data is gathered based on open-ended questions following closed-ended in order to get more knowledge of why the informants responded as they did. The household survey instrument was mainly developed for collecting quantitative data, and it included some of the same questions as the focus group instruments, such as questions regarding perceptions of tenure security, well-being and livelihoods. In the fieldwork phase, the different methods were implemented simultaneously, in the sense that the sampling methods and the collection of qualitative and quantitative data was implemented at the same time but independent of each other, whereby the results from the focus group interviews and key informant interviews did not affect the data or sampling of the households and vice versa. The purpose of using different methods to ask for the same information was complementarity. We wanted to enrich our understanding of different issues, such as asking the focus group about the perception of tenure security for the village, and asking the individual households about their perceptions of tenure security to get a deeper insight into tenure issues across different groups within a village. The second purpose is that of expansion; the different methods used in our study allow us to analyze different research questions, ranging from perceptions of tenure security to income diversification.

The last phase identified by Brannen (2005) is the *analysis and contextualization* of the data. I use both qualitative and quantitative methods for analysis. While qualitative analysis is used to identify tenure issues and potential hindrance for reducing deforestation and forest degradation at the village level in paper 2, quantitative analysis is utilized for identifying which households are harvesting more forest resources and are more dependent on forest income in paper 3 and why they are more dependent on forest income in paper 4. The purpose of mixing methods this way is expansion and the opportunity to explore a range of research questions by applying different data and methods of analysis. In paper 1, 3 and 4, quantitative methods of analysis are given more weight compared to the qualitative methods, but the qualitative data and methods of analysis is used to explain my quantitative findings and deepen the understanding of differences across households.

The quantitative methods used for analysis is econometrics, a method merging economic theory, math and statistics. In general, econometrics is used to test and provide empirical content to economic theory and evaluate public policy (Gujarati 1995). When testing economic theory and evaluating public policy, we are usually interested in testing the effect of a change in one variable on another variable. A key notion is *ceteris paribus*, which means "other (relevant) factors being equal". In an empirical analysis, there is usually a large number of variables that might have an effect on the variable of interest. Unless we are able to conduct an appropriate experiment, we will have to rely on available data, and the main question is whether enough variables have been kept fixed (Wooldridge 2009). In addition to economic theory, qualitative data and knowledge of the cultural context inform us which variables are crucial to include in an econometric model to be able to argue a *ceteris paribus* effect. Specific methodological issues are explained in more depth in the papers.

5 Summary of papers

The thesis consists of four papers. They are all empirically driven, and related to tenure rights and the use of natural resources. Paper 1 is concerned with access to land, while the three other papers are concerned with the use of forest resources.

Paper 1: Allocation of land tenure rights in Tigray: How large is the gender bias?

In this paper, I use household level data collected in Tigray in 2006 to study gender differences in land ownership and use in northern Ethiopia. The objective of this paper is to investigate whether there is a gender-based difference in landholdings in Tigray, and – if so – whether differences in landholdings across households can be explained by differences in household size and non-land resources or if it is due to a gender bias towards female-headed households.

When comparing means of household landholdings, I find that female-headed households have 23% smaller owned landholdings and 54% smaller operational landholdings. This is not uncommon, and most studies explain the gender differences in landholdings in Ethiopia by the fact that while almost all female-headed households are either divorced or widowed, this is only true for a share of the male-headed households. Given that land is split upon such household dissolution, we should expect female-headed households to have less land. Further, female-headed households consist of fewer members. The tenure system in Ethiopia aims at allocating land based on livelihood needs, and one can therefore argue that smaller households need smaller landholdings. Female-headed households also have less non-land resources, such as oxen and male labor, and thus they are less able to cultivate the land. To explore whether these factors can explain the differences, I use the Blinder-Oaxaca decomposition method to estimate the share of the difference that is due to observable household differences in endowments and characteristics and the share that is due to differences in returns to the endowments and characteristics. While this method is commonly used in the labor literature when explaining differences in wages between different groups, this is the first time it is applied to explore differences in access to land[4].

I find that household endowments of non-land productive inputs are important, but that differences in observable characteristics such as labor and oxen explain less than half of the differences in landholdings differences, whereas the remaining differences can be attributed to

[4] To the best of my knowledge.

differences in returns to these characteristics. The latter suggests a gender bias in the land allocation. The main policy recommendation is to strengthen women's opportunities to cultivate their land and continue the process of securing women's tenure rights.

Paper 2: Tenure issues in REDD+ pilot project sites in Tanzania

REDD+ has been proposed as a viable option for addressing climate change in the near term, and at relatively low cost. There is a broad consensus that clearly defined tenure rights are important for the implementation and success of REDD+, both to manage forests effectively and to protect local communities' livelihoods. Tenure security and enforceable rights of exclusion are important because REDD+ presumes local stakeholders are responsible for forest management and can protect forests without outside interference. In this paper, we use village and project level data collected in Tanzania in 2010 to address three research questions: (1) what are the drivers of deforestation and forest degradation in REDD+ pilot project villages; (2) what are the land tenure issues identified by the villagers; and (3) what are the land tenure issues identified by the proponents and how are they planning to address them?

We use primary data from 23 villages in six REDD+ pilot sites in Tanzania to identify perceived causes of deforestation and forest degradation, and tenure rights issues, at the village level prior to project implementation. Further, interviews with project proponents and examination of project documents yields insights into how the proponents plan to address tenure issues.

Our findings indicate that both external and internal tenure arrangements must be favorable to limit deforestation and forest degradation. All villages that experienced an increase in the forested area over the past two years perceive their rights as secure, that they have the right to decide who can and cannot access their forests and that they are able to exercise this right, and the same is true for all but one of the villages experiencing an increase in the quality of the forest. This supports the theory that favorable external tenure conditions are enabling factors for effective forest management at the local level in Tanzania. Whereas perceptions do not necessary reflect villages' formal, statutory rights, perceptions are important because they shape the actions of the villagers.

Although most villages perceive their tenure as secure and have exclusion rights, collective action challenges are prevalent in villages experiencing deforestation and forest degradation. These findings suggest that the main tenure issues are related to internal institutional arrangements. While we find that tenure is high on the agenda for all the project proponents, they are mainly focusing on

formalization and securing tenure rights from state to community level. Though we do find this to be a precondition for reducing deforestation and degradation, some of the proponents' focus should be shifted to strengthening village institutions and enhancing internal compliance.

Paper 3: Forest reliance across poverty groups in Tanzania

There is an emerging body of knowledge about the importance of forest income to rural households' livelihoods in developing countries. In this paper, we use household data collected in Tanzania in 2010. We address two research questions. First, we test the commonly observed relationship: are the poor households more forest reliant while the better-off households have higher absolute income from the forest? Secondly, is the answer to this question sensitive to the method used to categorize the households? The objective of our paper is to improve the methods of poverty-environment analysis when only cross-sectional data is available.

Several studies have highlighted the importance of asset holdings when studying poverty. Most forest-poverty studies are limited by access to cross-sectional data only, and use the observed one-year income to classify the households into poverty groups and calculate forest reliance. Cross-sectional studies typically do not take into account that incomes fluctuate greatly from year to year. Households identified as poor because they are in the lowest quintile in the survey year may not necessarily be structurally poor. They may have been unlucky that particular year, and experienced a negative temporary shock in income, such as a crop failure. Similarly, some of the households with high observed income might have been lucky in the year of the survey, and are likely to be among the low-income households next year. The snapshot provided by cross-sectional data might therefore be misleading. We therefore use an augmented asset approach, and predict household income, based on a broad range of assets as well as contextual variables. We argue that the resulting predicted income is a better measure for the long-term poverty status of a household compared to using the observed one-year income only, when the analysis is limited by cross-sectional data.

The key finding of this paper is the insight from separating between the structurally and stochastically poor/rich households. We confirm the commonly found pattern that the poor households are the most forest reliant, but we identify different households as poor. Forest reliance is high among households that are poor in both assets and observed income, but it is also high among the households that appear to be rich but that we do not expect to be able to sustain this high level of income due to low levels of productive and human capital assets. In fact, this last group, the

stochastically rich, are the ones expected to be the most forest reliant in the longer term, because they are not only forest reliant now, but also derive high absolute values of income from forest resources.

Going beyond the commonly used method of categorizing households based on observed income only, we are able to separate between the structurally poor and the stochastically poor. Thus we are able to identify the households that are poor because they are experiencing a temporary income shortfall, which we are expecting them to overcome in the future. This has policy implications for targeting for poverty alleviation in general, but also for how vulnerable the different groups are to changes and restrictions in access to forest resources. While the structurally poor can be characterized by high forest reliance, the stochastically poor households do not have different patterns of forest resource use compared to the structurally rich, neither when we compare forest reliance or absolute forest income. Thus, the households categorized as stochastically poor are likely to be less vulnerable than the structurally poor and also the stochastically rich.

Paper 4: Forest as an employer of last resort and potential impacts of REDD+ in Tanzania

Income diversification is a key characteristic of rural households in developing countries, and the initial access to land is often argued to be a key asset to influence the production decisions made by a household. In this paper I use the same household-level data as in the previous paper. The focus is to investigate income and activity diversification across households and to understand why some households earn a larger share of their income from forest.

A poverty-environment household model is used as a theoretical framework to discuss the role of shadow wages in shaping households' activity choices, and look at the linkages between shadow wages, the use of forests and potential impacts of REDD+ projects. Theory predicts that welfare maximizing households will allocate their labor so that the marginal returns are the same across different economic activities. When a household undertakes relatively less of a certain economic activity it is likely that this is because their shadow price exceeds the returns to this activity, and they can yield a higher return by undertaking other activities. Most forest activities have low entry costs, and they require few skills and little capital. They are, however, often labor intensive and of low value. Thus, we expect that the households involved in forest activities are the households with the lowest returns to labor.

The analyses show that the resource-poor households have lower shadow wages. Their share of forest income relative to their total income is high, and my findings support the hypothesis of the

forest as the employer of last resort. Without access to other income generating activities, resource-poor households rely on harvesting forest resources to cover their subsistence and/or cash needs. The implications for REDD+ implementation in this context is that one needs to take into account that households use the forest differently, and that this is driven mainly by access to productive assets, such as land, capital and skills for household business. Higher restrictions on access to forest resources are likely to harm the resource-poor households with few other livelihood opportunities more than the resource-rich households. While resource-rich households can allocate more time to agriculture and/or household business in the case of reduced access to harvest forest resources, resource-poor households have few other viable opportunities to compensate for the lost income.

6 Conclusions

The objectives of the thesis is to improve the understanding of what determine differences in access to and use of land and forest resources across households, introduce new methods to analyze this, and identify policy measures that can improve management of forest resources. I review some important contributions of the theses towards each of these three objectives.

6.1 Methodological contributions and limitations

Going beyond the commonly used methods to study access to and use of natural resources can provide new insight. The decomposition method used in paper 1 is widely used in the labor market literature to explain wage differences, but it can also provide insight into why access to land differs across groups. The smaller landholdings by female-headed households cannot be explained by differences in household endowments and characteristics alone, but also returns to these endowments and characteristics.

In paper 3 and 4 we look at which households are more dependent on forest and why some households are more dependent than others. In paper 3 we propose a new method to classify households when studying questions about forestry and poverty. Most poverty-environment studies typically categorize households in poverty categories based on observed income in cross-section data, presenting a snap-shot reflecting both inter-household and inter-annual income variation. There are, however, assets that are potentially important to define the long-term income of a household, such as land holdings, human capital assets and liquid assets. We argue that asset holdings should be

considered when assessing households' poverty status and that predicted income is a better measure of long-term income than the observed one-year income. While we fully realize that nothing can replace observing the same households over time, we believe a method combining observed and predicted income can be used to discuss some aspects of poverty, normally confined to analysis of poverty dynamics with long-running panel data. The approach used can therefore be highly valuable given that most surveys are only one shot, cross section data.

In paper 4 I estimate household shadow wage to identify why some households are more forest reliant than others. This provides a useful framework for discussing potential impacts of REDD+ and other livelihood interventions.

Although the thesis provides new insights, there are, of course, limitations in the papers. Some are caused by data limitations and others by time constraints. In paper 1, knowing the year of household dissolution and the amount of land rather than the share each spouse received would improve the analysis. Similarly, it would be useful to know why female-headed households rent out their land, especially when they have the resources to cultivate it themselves.

In paper 2 we identify a discrepancy between the village's perception and the proponent's perception of village tenure security. Formalization of tenure is part of REDD+ implementation, and it would be useful to know how this process affect perceptions of tenure security and further, their compliance and enforcement of forest user rules. More data on possible reasons why households have lower than predicted income in paper 3 would be very useful. We are not able to control for land quality. This may explain why some households experience low yields even with large land holdings, and this data would improve our ability to predict income.

A constraint in paper 4 is the lack of time use data. I use shadow wages to explain household's off-farm activity. At the same time, off-farm income is included in the model used to estimate household shadow wage. This is a weakness in the paper, but data limitations restrict the options available. Knowing how much time different household members spend on income generating activities would be very useful and improve the estimation of household specific shadow wages by allowing for seasonal variation and differences in returns to labor across household members.

6.2 Key conclusions

In addition to the methodological contributions, the papers included in this thesis contribute to a better understanding of which households have better access to land and the importance of forests to rural household's economy.

By decomposing differences in landholdings in Tigray, I find that female-headed households get lower returns to their characteristics and endowments. This suggests that some of the difference in land holdings is due to a gender bias in the allocation of land.

In paper 2, we identify a mismatch between the statutory and customary rights. Forests within village boundaries are not necessarily recognized as village lands by the state, while the village claims communal rights and also perceive their rights as secure. We find that factors internal to the village, such as low rule compliance and enforcement, are hurdles to achieve collective action and reduce deforestation and forest degradation.

Our findings in paper 3 differ from the commonly found pattern of high forest reliance among the income poor and high absolute forest among the income rich. One group stands out in terms of having both the highest forest reliance and absolute forest income, namely the stochastically rich. These asset poor (land in particular) households have enjoyed a high total income in the survey year, but have also significantly higher forest income. These high forest-users are not classified as poor when using observed income, but are when using predicted. On the other hand, the stochastically poor households, those that are asset rich but happen to have low income in the survey year, are not intensive forest users.

In paper 4, I go more into depth to look at why some households are more forest reliant. I estimate household shadow wage and find that the poorer households have lower returns to household labor, and rely on the forest as an employer of last resort. Forest activities are characterized by low returns, and poor households have few other options for income generating activities. Access to agricultural land is an important factor. The non-poor households have more agricultural land, and have more opportunities for income generating activities other than forests.

6.3 Policy implications

Both the "who" and the "why" questions from paper 3 and 4 have policy implications for the targeting of poverty-reducing measures in general, but also for how vulnerable different groups are to changes and restrictions in access to forest resources. These are important considerations to take

into account for proponents implementing REDD+ and for policy makers designing the national framework.

First, not all income poor are forest reliant. Some households experience a year of income short-fall, but they seem to have other coping mechanisms than forest resource extraction. The policy implication of this is to focus on the asset-poor households as a snap-shot of household income can be misleading.

Second, higher restrictions on forest use without full compensation is likely to harm the poorest households more, as these households are more resource poor and have fewer livelihood opportunities to meet their livelihood needs. Their limited options are reflected in their low shadow wage. I find the market wage is higher than the shadow wage, but still few households participate in the labor market. This suggests that gains can be made from expanding the opportunities for rural poor to access the market for casual labor. The implications for REDD+ implementation is that proponents and policy makers should take into account that households use the forest differently, and that this is driven mainly by access to productive assets, such as land and capital and skills for household business. If opportunities for off-farm labor and household business are part of the REDD+ initiative, proponents should focus on accommodating improvements for the resource-poor households.

6.4 Future research

A number of other interesting research questions have been identified, but were left unexplored due to time and data constraints.

Most studies, including this thesis, treat household size as exogenous. Still, in the long run, household size is likely to be endogenous and depend on income and access to productive assets. To study this would require a rich panel data set, but I believe it could enrich the knowledge of differences in access to land in particular, and the use of household size-adjusted output variables in general. One potential research question related to this is whether female-headed households are smaller than previously widowed/divorced male-headed households in Tigray because household members leave due to lack of productive assets available in the household.

Few panel data sets to study the poverty-environment relationship exists, and methods to identify structurally/stochastically rich/poor households when only cross-sectional data are available are needed. We have suggested a new method in paper 3, but we need a long panel data set to test the reliability of the method. Furthermore, the new classification changes a major conclusion in the

forest-poverty literature for our case. More case studies are required to test to what extent this conclusion can be generalized.

The same is true for paper 4 and its analysis on the links between shadow wages and forest reliance across households. Testing this relationship in other settings would provide more knowledge on to what extent the "employer of last resort" is an appropriate framework to understand forest reliance.

References

Agarwal, Bina. 1994a. *A Field of One's Own: Gender and Land Rights in South Asia*. Cambridge: Cambridge University Press.

Agarwal, Bina. 1994b. "Gender and Command over Property: A Critical Gap in Economic Analysis and Policy in South Asia." *World Development* 22 (10): 1455-1478.

Alexander, V., H. Thomas, A. Cronin, J. Fielding, and J Moran-Ellis. 2008. Mixed Methods. In Gilbert, N. (ed.) *Researching Social Life 3rd Edition*. London: Sage.

Angelsen, A, P. Jagger, R. Babigumira, Brian Belcher, Nicholas J. Hogarth, S. Bauch, Jan Börner, Carsten Smith-Hall, and S Wunder. 2014. "Environmental Income and Rural Livelihoods: A Global-Comparative Analysis." *World Development*. In press.

Angelsen, A., M. with Brockhaus, M. Kanninen, E. Sills, W.D. Sunderlin, and S. Wertz-Kanounnikoff. 2009. *Realising REDD+: National Strategy and Policy Options*. National Strategy and Policy Options. Bogor, Indonesia: Center for International Forestry Research (CIFOR).

Banerjee, Abhijit V., and Esther Duflo. 2007. "The Economic Lives of the Poor." *The Journal of Economic Perspectives* 21 (1): 141-168.

Brannen, Julia. 2005. "Mixing Methods: The Entry of Qualitative and Quantitative Approaches into the Research Process." *International Journal of Social Research Methodology* 8 (3): 173-184.

Bromley, Daniel. 1991. *Environment and Economy: Property Rights and Public Policy*. Oxford, UK: Blackwell.

Cavendish, William. 2000. "Empirical Regularities in the Poverty-Environment Relationship of Rural Households: Evidence from Zimbabwe." *World Development* 28 (11): 1979-2000.

Coase, R. H. 1960. "The Problem of Social Cost." *Journal of Law and Economics* III: 1 - 44.

Cotula, Lorenzo, and James Mayers. 2009. *Tenure in REDD - Start-Point or Afterthought?*: Natural Resource Issues No. 15. International Institute for Environment and Development. London, UK.

de Janvry, A., Gustavo Gordillo, E. Sadoulet, and Jean-Philippe Platteau (eds). 2001. "Access to Land, Rural Poverty and Public Action. Oxford, UK: Oxford University Press.

Deininger, Klaus, Daniel Ayalew Ali, Stein Holden, and Jaap Zevenbergen. 2008. "Rural Land Certification in Ethiopia: Process, Initial Impact, and Implications for Other African Countries." *World Development* 36 (10): 1786-1812.

Demsetz, Harold. 1967. "Toward a Theory of Property Rights." *American Economic Review* LVII (2).

Elbow, K., R. Furth, A. Knox, K. Bohrer, M. Hobbs, S. Leisz, and M. Williams. 1998. Synthesis of Trends and Issues Raised by Land Tenure Country Profiles of West African Countries, 1996. Research Paper No 130. In Bruce, J. (ed.) *In Country Profiles of Land Tenure: Africa 1996*. Madison, WI. Available from: http://pdf.wri.org/ref/elbow_98_synthesis.pdf (1 November, 2009): Land Tenure Center, University of Wisconsin.

Ellis, Frank. 2000. *Rural Livelihoods and Diversity in Developing Countries*. Oxford: Oxford University Press.

FAO. 2009. *Forest Tenure Assessment*. Rome: The Food and Agriculture Organization of the United Nations.

Feder, Gershon, and David Feeny. 1991. "Land Tenure and Property Rights: Theory and Implications for Development Policy." *World Bank Economic Review* 5 (1): 135-153.

Greene, Jennifer C., Valerie J. Caracelli, and Wendy F. Graham. 1989. "Toward a Conceptual Framework for Mixed-Method Evaluation Designs." *Educational Evaluation and Policy Analysis* 11 (3): 255-274.

Gujarati, Damodar N. 1995. *Basic Econometrics. Third Edition*. Singapore: McGraw-Hill.

Hardin, Garrett. 1968. "The Tragedy of the Commons." *Science* 162 (3859): 1243-1248.

Holden, Stein T. , and Mintewab Bezabih. 2009. Gender and Land Productivity on Rented Land in Ethiopia. In Holden, Stein T., Keijiro Otsuka, and Frank M. Place (eds) *The Emergence of Land Markets in Africa: Assessing the Impacts on Poverty, Equity and Efficiency*, pp. 179-198. Washington, DC: Resources for the future (RFF).

Jagger, P., E. Sills, K. Lawlor, and W.D Sunderlin. 2010. A Guide to Learning About Livelihood Impacts of REDD+. In *Occasional Paper 56*. Bogor, Indonesia: CIFOR - Center for International Forestry Research.

Jayne, T. S., Takashi Yamano, Michael T. Weber, David Tschirley, Rui Benfica, Antony Chapoto, and Ballard Zulu. 2003. "Smallholder Income and Land Distribution in Africa: Implications for Poverty Reduction Strategies." *Food Policy* 28 (3): 253-275.

Jodha, N. S. 1986. "Common Property Resources and Rural Poor in Dry Regions of India." *Economic and Political Weekly* 21 (27): 1169-1181.

Larson, A., D. Barry, G. R. Dahal, and C. J. P. Colfer (eds). 2010. "Forests for People: Community Rights and Forest Tenure Reform. London: Earthscan.

Larson, Anne M., Maria Brockhaus, William D. Sunderlin, Amy Duchelle, Andrea Babon, Therese Dokken, Thu Thuy Pham, I. A. P. Resosudarmo, Galia Selaya, Abdon Awono, et al. 2013.

"Land Tenure and REDD+: The Good, the Bad and the Ugly." *Global Environmental Change* 23 (3): 678-689.

Libecap, Gary D. 1989. *Contracting for Property Rights*. Cambridge, USA: Cambridge University Press.

McKean, Margaret A. . 2000. Common Property: What Is It, What Is It Good for, and What Makes It Work? In Clark C. Gibson, Margaret A. McKean, and Elinor Ostrom (eds) *People and Forests: Communities, Institutions, and Governance*. Cambridge MA and London: MIT Press.

North, Douglass C, and Robert Paul Thomas. 1973. *The Rise of the Western World: A New Economic History*. Cambridge, UK: Cambridge University Press.

Olson, Mancur. 1965. *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, Mass.: Harvard University Press. X.

Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University Press.

Ostrom, Elinor. 2003. "How Types of Goods and Property Rights Jointly Affect Collective Action." *Journal of Theoretical Politics* 15 (3): 239-270.

Rodrik, Dani. 2000. "Institutions for High-Quality Growth: What They Are and How to Acquire Them." *Studies of Comparative International Development* 35 (3): 3-31.

Schlager, Edella, and Elinor Ostrom. 1992. "Property-Rights Regimes and Natural Resources: A Conceptual Analysis." *Land Economics* 68 (3): 249-262.

Smith, Robert J. 1981. "Resolving the Tragedy of the Commons by Creating Private Property Rights in Wildlife." *Cato J.* 1: 439.

Stern, N. 2006. *The Stern Review: The Economics of Climate Change*. Cambridge, UK: Cambridge University Press.

Stern, Nicholas. 2008. "The Economics of Climate Change." *American Economic Review: Papers & Proceedings* 98 (2): 1-37.

Sunderlin, W., J. Hatcher, and M. Liddle. 2008. *From Exclusion to Ownership? Challenges and Opportunities in Advancing Forest Tenure Reform*. Washington, DC: Rights and Resources Initiative.

Sunderlin, W.D., A.M. Larson, A. Duchelle, E.O. Sills, C. Luttrell, P. Jagger, S. Pattanayak, P. Cronkleton, and A.D Ekaputri. 2010. "Technical Guidelines for Research on REDD+ Project Sites." Bogor, Indonesia: CIFOR - Center for International Forestry Research.

Sunderlin, W.D., A. Larson, A.E. Duchelle, I.A.P. Resosudarmo, T.B. Huynh, A. Abdon, and T. Dokken. 2014. "How Are REDD+ Proponents Addressing Tenure Problems? Evidence from Brazil, Cameroon, Tanzania, Indonesia, and Vietnam." *World Development* 55: 37-52.

Wooldridge, Jeffrey M. 2009. *Introductory Econometrics: A Modern Approach*. Mason, Ohio, US: South-Western Cengage Learning.

Wunder, Sven, Arild Angelsen, and Brian Belcher. 2014. "Forests, Livelihoods, and Conservation: Broadening the Empirical Base." *World Development* . In press.

PAPER 1

Allocation of land tenure rights in Tigray: How large is the gender bias?*

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Abstract

This study investigates gender differences in land ownership and use in northern Ethiopia. Female-headed households have 23% smaller owned landholdings and 54% smaller operational landholdings. Household endowments of non-land productive inputs are important, but decomposition analysis finds that differences in observable characteristics such as labor and oxen explain less than half of these differences, whereas the remaining differences can be attributed to differences in returns to these characteristics. The latter suggests a gender bias in the land allocation. The main policy recommendation is to strengthen women's opportunities to cultivate their land and continue the process of securing women's tenure rights.

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1 Introduction

This paper analyzes if and how household headship determines the allocation of tenure rights to arable land in Tigray, in the northern highlands of Ethiopia. Worldwide, women have less access to land compared to men (World Bank 2011), and the same is true in Ethiopia. Although many studies find that female-headed households have smaller landholdings, this paper takes the analysis a step further by decomposing the difference into what can be explained by differences in land availability and observable household characteristics and endowments and what can be explained by the returns to these characteristics and endowments. The differences in returns to characteristics and endowments can be defined as gender bias. The analysis suggests that less than half of the observed difference in landholdings between male- and female-headed households can be attributed to differences in observables.

Widespread social perceptions of women as dependent and men as breadwinners is one reason why men are often seen as the legitimate claimant of land (Agarwal 2003). According to Agarwal (1994a), the gender gap in the control and ownership of property is the main contributor to the gender gap in social status, empowerment and economic well-being. Investigating what drives the differences in the allocation of tenure rights to land is therefore key to understanding and correcting differences in these outcomes.

In Ethiopia, all land is formally state land, and households have been allocated land on which they are granted limited tenure rights in the form of usufruct rights for the purpose of sustaining a livelihood. The Ethiopian land reform was implemented in the Tigray region in the late 1990s. It aimed to secure access to arable land for peasants without differentiation between genders and to improve tenure security by issuing certificates to land owners (Deininger et al. 2008a). However, in Ethiopia, female-headed households are recognized as less tenure secure compared to their male counterparts (Holden and Bezabih 2008), and several studies have found that they have less access to agricultural land (Tadesse and Amare 2000; Teklu 2005; Yigremew 2005; Kebede 2008).

These studies put forward four possible explanations for the gender differences. The first two are rational economic responses, whereas the last two are based on institutional and cultural factors. First, female-headed households are typically divorced or widowed households and smaller in size. The tenure system in Ethiopia aims at allocating land based on livelihood needs, and one can therefore argue that smaller households need smaller landholdings. Second, female-headed households have less non-land resources, such as oxen and male labor, and thus they are less able to

cultivate the land. Third, the institution of patrilocality (women moving to the husband's village upon marriage) may cause a gender bias because land policies indicate that access to land depends on one's residential area. This implies that women forfeit their chances to acquire land, or have to give up the rights for the land they have, when at the time of marriage they move from their parents' to their husband's village. Women also risk losing access to land if they leave their marriage residence when they become widowed or divorced (Tadesse and Amare 2000; Yigremew 2005). Fourth is the tradition of plough cultivation. In addition to the physical requirements of this activity, there is a social taboo against women ploughing (Teklu 2005; Yigremew 2005; Holden and Bezabih 2008), and the cultural perceptions of women as weak farmers may explain the difference in landholdings.

The objective of this paper is to investigate whether there is a gender-based difference in landholdings in Tigray, and – if so – whether differences in landholdings across households can be explained by differences in household size and non-land resources or if it is due to a gender bias towards female-headed households. In addition to comparing simple means of landholdings and running regression analysis to control for determinants of land access, I use the Blinder-Oaxaca decomposition method to estimate the share of the difference that is due to observable household differences in endowments and characteristics and the share that is due to differences in returns to the endowments and characteristics as a measure of gender bias. I use data collected from 370 households in 17 villages across the Tigray region in 2006.

2 Tenure rights and gender

2.1 Conceptual issues

Tenure rights are a set of rules and norms that determine who can use what resource, under what conditions and for how long (FAO 2009). Tenure rights define to what extent a household or an individual can gain access to the benefit streams generated by land and provide a set of benefits that have positive impacts on livelihood outcomes as well as other factors that can further improve livelihood, such as access to credit, bargaining power and social status for rural households (Agarwal 1994b).

Two measures of landholdings are used in this paper: owned and operational landholdings. The category *owned* landholdings is the area of land to which the household has ownership rights. Such landholdings include the owned land the owners use themselves and the owned land they rent out

for a tenant to use. *Operational* landholding is the area of land the household uses for cultivation in the twelve months prior to the survey. Such landholdings include land owned and not rented out and additional rented land.

2.2 Empirical evidence on gender bias in access to land

In this paper, gender bias is measured as the difference in returns to observable endowments and characteristics, analogous to the definition of *gender discrimination* in the labor literature (Jones and Kelley 1984). A growing body of literature has documented a gender bias in the use of agricultural inputs (Udry 1996; Chen et al. 2011), asset ownership and welfare outcomes, both within and across households around the world (Agarwal 2003; Quisumbing and Maluccio 2003; Deere and Doss 2006). Worldwide, female farmers have less access to land (World Bank 2011), and studies on ownership and control of land have found gender inequalities in countries in Latin America (Deere and Leon 2003), Africa (Udry 1996; Bomuhangi et al. 2011) and Asia (Estudillo et al. 2001; Agarwal 2003).

Agarwal (2003) emphasizes social perceptions to be the reason why men are recognized as the legitimate claimant of land. Boserup (1970) argued that due to physical strength, men on average have an advantage in farming compared with women, resulting in a specialization of production along gender lines in societies that have traditionally practiced plough cultivation. The perception of women as "weak farmers" is also widespread in Ethiopia. In addition to the cultural taboo against women ploughing, women have less access to agricultural extension services (Pender and Gebremedhin 2008; Ragasa et al. 2013).

There are three main sources of access to arable land: the state, the family and the market (Agarwal 2003), and these are also the dominant sources of access to land in Ethiopia (Yigremew 2005). In her study from India, Agrawal (2003) found access through all three sources to be gender-biased.

In Ethiopia, all land ultimately belongs to the state, but the land certification process was started in the late 1990s to secure the land tenure rights of peasants. Article 4(1) of the national Rural Land Proclamation states: "Without differentiation of the sexes, any person who is willing to personally cultivate land shall be allotted rural land sufficient for his maintenance and that of his family" (cited in Frank 1999:8). Household size has been the main criterion for land allocations since 1975 (Holden and Yohannes 2002), and Ethiopia is one of the countries with the most equitable distribution of land. However, systematic differences across households remain. Yigremew (2005) found that the

administrative reallocations have not fully met the equity requirements in rural land policies and that female-headed households have smaller landholdings. These results are also supported by the country-wide study by Kebede (2008). The state can distribute land in a number of different ways. If titles are issued to an individual, such as the head of the household, other members of the household might be denied rights to the land (World Bank 2005). The practice of registration varies throughout Ethiopia. In some regions, the names of both spouses are on the certificate, whereas in Tigray, land is registered in the name of the household head only. The responsibility to allocate land from the state lay with the Peasant Associations (PAs), functioning as local community governments. Administrative redistribution by the state has been the most important mechanism of access to land for peasants (Yigremew 2005) but since 1997, land redistributions have been limited (Holden et al. 2011).

The second source of access to land is through transfers within the family. Such transfers can take two different forms: first, *inter-generational* transfers in the form of either (a) inheritance after parents' death or (b) inter-vivos transfers, such as land gifts upon marriage or anticipated inheritance. The other form of transfer within the family is *intra-household* allocation of plots to specific members (de Janvry et al. 2001). The family as a source of land is of great importance, especially when land markets are poorly developed or large-scale redistributive land reforms are not feasible (de Janvry et al. 2001). Intra-household allocation of land is not very relevant to Ethiopian households because men and women generally do not cultivate plots individually, but inter-generational transfers may become increasingly important as the number of reallocations decrease.

When examining patterns of parental transfers of assets and marriage in Ethiopia, Fafchamps and Quisumbing (2005) found that brides receive less land and other assets than grooms from their parents upon their first marriage and that women inherit less upon the death of their parents but also that there are regional differences. The Tigray State land law ensures inheritance, to increase security and further investment in land, but it also limits it, to prevent land from becoming sub-divided into pieces that are too small to be economically viable. Land should be given to the one child (usually only one child qualifies) without land or any other sources of income that stayed with the parents (Haile et al. 2005). This law makes married women less likely to inherit land because the custom of patrilocality leads women to move away from their parents' village to live with their husband's kin (Fafchamps and Quisumbing 2005). For the purpose of this study, the state and the family are not treated separately given that by far most of the land a household owned at the time of data collection was allocated by the state.

The market is the third main source of access to land, either in the form of a sales market or a rental market. Land sales are still illegal in Ethiopia after the passage of the new land law in 1997, but land rentals are common, with short-term sharecropping contracts dominating the market (Holden et al. 2011). A common feature of this market in Ethiopia, contrary to the rental market stereotype, is a reverse tenancy system with *poor landlords and rich tenants*. Tenants are typically the households that have better access to other important farming inputs, such as male labor and oxen. In the presence of imperfect factor markets for labor and oxen, land is rented in to equalize marginal productivities of the different inputs across farms (Deininger et al. 2008b). Female-headed households are commonly poor in these assets, which - in addition to the physical requirements and social taboo against women ploughing the land - leads female-headed households to rent out their land more often and engage in sharecropping arrangements with male-headed households (Tadesse and Amare 2000; Teklu 2005; Yigremew 2005; Kebede 2008; Holden and Bezabih 2008; Holden et al. 2011). Although lack of non-land resources is an important determinant for renting out one's land, for male- as well as female-headed households, the relative abundance of these resources is not necessarily a determining factor for renting-in behavior. In a study from Amhara, the neighboring region, Ghebru and Holden (2008) found that the relative amount of labor available in a household did not explain leasing-in behavior, and they suggest that potential female tenants are rationed out of the market, even if they have the oxen necessary for farming.

3 Study site and area

3.1 Setting

The Ethiopian land reform of 1975 made all land the property of the state. To provide land for new households and maintain a more or less equal distribution, follow-up redistributions were required, thus creating a situation of high tenure insecurity. Renting out land increased the risk of losing land in redistributions because it could be perceived as a lack of both cultivation ability and need for land. Tenure insecurity also reduced the incentives to invest in land (Deininger and Jin 2006). To address the tenure insecurity, a new law was passed in 1995 allowing regional governments to be responsible for land administration (Deininger et al. 2008a). The Tigray regional state responded by proclaiming the state legislation for land management in 1997, and the number of land redistributions was reduced. The proclamation aimed to provide higher tenure security, reduce

instances of litigation and dispute and facilitate land transactions through the rental market. All land continued to be owned by the state and selling land was still not allowed. Perpetual rights for access and withdrawal, management and exclusion were given to households, and tenure right holders were given the right to make short-term land rental contracts as a limited right for alienation. Plots were measured and demarcated, land registry books established at district levels and one-page handwritten certificates with information about the soil quality, location and size of the plots were issued in the name of the household head. The method was low-cost, and by 1999, more than 80% of the rural households in Tigray had land certificates (Holden et al. 2011).

3.2 Data

The household and individual response data were collected in Tigray over the period June to August 2006 with the help of 27 local bilingual enumerators and are part of a panel data set started in 1997/1998. The sampling method for the data was administered at two levels. At the village level, there was stratified sampling, taking into account agricultural potential, population pressure, access to irrigation and access to the market. At the household level, 25 households were randomly sampled from each village. Despite the fact that the data set is part of a panel, some of the specific data used in this paper were collected in the 2006 round only, and thus, the analysis is limited to cross-section analysis. Due to attrition, the number of households from each village varied in the 2006 round, and the total number of households was reduced to 370. Due to missing information for some of the households, the number included in the analysis is further reduced to 357 (Table 1).

Table 1 Overview of data at household and individual level (in #)

	Household level data		Individual level data	
	Female headed	Male headed	Females	Males
Previously divorced	27	70	61	41
Previously widowed	53	66	66	31
Neither divorced nor widowed	23	118	-	-
Total	103	254	127	72
(of which are presently unmarried)	(99)	(33)		

The war between Eritrea and Ethiopia in 1998-2000 left many widows behind in the villages. In addition, the fact that husbands are relatively older than their wives leaves more female widows than male widows. Divorce is also a common phenomenon in the region, and the share of female-headed

households in the sample is 29%. This includes households where the female head has never been married and four households where the husband resides off-farm.

In each of the 370 households, the household head and (if married) the spouse was interviewed (separately) and asked whether they had been married before. The individuals who had been through either a divorce or death of spouse are included in a sample of individuals. The individual level data is included in the analysis to study allocation of land after household dissolution. Most single heads of male- and female-headed households are part of this group, given that most of these are either divorced or widowed, but also individuals that remarried and were part of a new household upon the time of the interview. Some individuals are dropped from the sample due to missing information, and the total sample of previously divorced or widowed consists of 199 individuals.

4 Hypotheses

In this paper, gender bias is defined as a preference for one sex over the other in the allocation of tenure rights for land from the state, the family and the market. This bias exists when the same characteristics and endowments are valued more highly for male-headed households compared to female-headed households. The latter is an important qualification when seeking to control for any systematic differences between male and female-headed households, e.g., that a smaller household size might justify less land being allocated to that household.

Given that most female heads of households are either divorced or widowed, the allocation of land upon household dissolution is a potentially important determinant of female-headed household's landholdings. The land proclamation of 1997 states that men and women should receive equal shares of household land upon divorce (Deininger et al. 2008a). It also strengthens women's rights in the case of a husband's death.

To guide the empirical analysis, the following hypotheses are tested:

Hypothesis 1. Gender has no impact on the allocation of land upon household dissolution due to divorce or death of spouse.

Hypothesis 2. Female headship has no impact on the size of a household's (i) owned and (ii) operational landholdings, after controlling for observable differences in endowments and characteristics.

5 Estimation strategy

Gender differences in landholdings, household characteristics and endowments are identified by comparing means between households headed by males and by females as well as between subgroups of these households. An ordered probit model is developed to determine whether men and women receive different shares of household land in the case of death or divorce. These estimation results are used to address whether household dissolution is a main driver of the gender differences in landholdings. Further, OLS regression models are estimated to control for observable endowments and characteristics, including village fixed effects. The differences in landholdings are decomposed to estimate how much of the landholdings can be explained by differences in the observable endowments and characteristics and how much can be explained by the returns to the same endowments and characteristics.

5.1 Allocation of land upon household dissolution

We asked the previously divorced/widowed respondents how much land they received upon household dissolution. The alternatives were: all, more than half, half, less than half and nothing. Ordered probit models are developed to analyze the probability of a respondent receiving a particular share of land. For each individual, *i*, there is an underlying response variable Y^*_i. The regression model takes the following form:

$$Y^*_i = \beta' X_i + \varepsilon_i \qquad [1]$$

where X_i is a vector of explanatory variables discussed further below, β is a vector of regression parameters and ε is the random, normally distributed disturbance term with constant variance and zero mean. Y^*_i is not observed, but an indicator variable Y_i, is observable, and this variable follows the sign of Y^*_i:

$$\begin{aligned} Y_i &= 1 \ \text{if} \ Y^*_i \le 1 && \text{(if receive no land),} \\ &= 2 \ \text{if} \ 1 < Y^*_i \le \mu_2 && \text{(if receive land, but less than half)} \\ &= 3 \ \text{if} \ \mu_2 < Y^*_i \le \mu_3 && \text{(if receive half the land)} \\ &= 4 \ \text{if} \ \mu_3 < Y^*_i \le \mu_4 && \text{(if receive more than half but less than all)} \\ &= 5 \ \text{if} \ \mu_4 \le Y^*_i && \text{(if receive all land)} \end{aligned} \qquad [2]$$

where the μ values are unknown threshold parameters, or cut points, that are estimated using the β values.

Therefore, the probabilities of receiving land of different degrees are as follows:

$$
\begin{aligned}
&Prob\ [Y=1] = \Phi(-\beta' X_i) \\
&Prob\ [Y=2] = \Phi(\mu_2 - \beta' X_i) - \Phi(-\beta' X_i) \\
&Prob\ [Y=3] = \Phi(\mu_3 - \beta' X_i) - \Phi(\mu_2 - \beta' X_i) \\
&Prob\ [Y=4] = \Phi(\mu_4 - \beta' X_i) - \Phi(\mu_3 - \beta' X_i) \\
&Prob\ [Y=5] = 1 - \Phi(\mu_4 - \beta' X_i)
\end{aligned}
\qquad [3]
$$

Φ is the cumulative normal distribution function, and the sum of the abovementioned probabilities is equal to one. To obtain estimates of the β and μ values, the log-likelihood function is maximized (Greene 2002) with White's (1982) robust standard errors.

To test the hypothesis regarding allocation of land upon household dissolution, the sample of the 199 *individual* responses was used. Matching in the marriage market is not random (Fafchamps and Quisumbing 2005), and neither is divorce. Tilson and Larsen (2000) found that 45% of all first marriages end in divorce in Ethiopia and that early age at marriage and childlessness increased the likelihood of divorce. Furthermore, allocation of land from the state is dependent upon marriage, thus some choose to marry to receive land. Couples that did not receive land upon marriage are more likely to divorce. Due to these factors, respondents with no land in their previous marriage were omitted from the sample. This omission does not fully solve the problem of the non-randomness of marriage and divorce, but due to a lack of data regarding the previous marriage, this is as far as the data set allows for a partial correction of this selection bias.

To capture the potential effect of the land reform, a dummy variable indicating whether the household dissolution happened before or after *certification* in the village is included in the models. In Tigray, certificates are issued in the name of the household head only, and the updating of certificates after a household dissolution is incomplete. Thus, women do not necessarily receive a certificate for the land they receive upon divorce, and widows tend to inherit the certificate issued in the name of their deceased husband rather than an updated certificate in their name. Whether or how this practice matters for the allocation of land between the spouses upon divorce or death is uncertain.

Land is an immobile asset, and according to the Tigray law, land rights can be lost if the holder of the user rights move away from the village. Thus, if the respondent was expected to move after the dissolution, he or she is expected to receive less land upon divorce or death of spouse. Respondent without relatives in the village might have been more likely to move away. Given the tradition of patrilocality, this is particularly true for women. A variable to control for this is included

in the model, taking a value 1 if the respondent stayed in the village after the household dissolution. All variables included in the models are listed in under individual level variables in Table 2.

The models are run on three different samples: male respondents only, female respondents only and a pooled sample with both males and females. In the last models, a dummy variable indicating whether the respondent is male or female is included to capture potential gender differences. Land is split differently upon divorce and death, but due to the limited number of responses, the sample cannot be split further to allow for separate models for divorced and widowed respondents.

Table 2 Overview of variables and descriptive statistics

Variable	Description	Obs	Mean	Std.dev
Household level variables				
Sex of the hh head	Dummy variable indicating the sex of the household head, 0=male, 1=female	357	0.29	
Household size	Total number of members in the household	357	5.07	2.50
Age hh head	Age of household head (in years)	357	54.72	14.39
Oxen	Number of oxen the household owns	357	0.92	0.99
Male wf	Male workforce, number of men aged 15 up to 64	357	1.40	1.17
Female wf	Female workforce, number of women aged 15 up to 64	357	1.34	0.87
Owned holding	Area of land the household has owner rights to, in tsimdi^2	357	3.84	2.71
Operational holding	Area of land the household use for cultivation, in tsimdi	357	3.80	3.41
Per cap owned hold	Per capita owned landholding in tsimdi (Owned landholding/Household size)	357	1.04	0.06
Per cap oper hold	Per capita operational landholding in tsimdi (Operational landholding/Household size)	357	0.91	0.06
Literacy	Dummy variable indicating whether the household head is literate, 0=no, 1=yes	357	0.32	
Dependents	Number of household members below 15 and above 64	357	2.34	1.64
Divorcee	Dummy indicating whether the household head has been divorced, 0=no, 1=yes	357	0.27	0.45

Oxen dummy	Dummy indicating whether the household have one or more oxen, 0=no, 1=yes	357	0.57
Village	Dummy variables indicating which village the household is located in		
Individual level variables			
Land received	Share of land received upon household dissolution, 1=no land, 2=some, but less than half, 3=half, 4=more than half but less than all, 5=all	199	2.79
Dissolution after cert.	Dummy indicating when the dissolution happened, 0=before certification, 1=after	199	0.36
Sex of the respondent	Dummy variable indicating the sex of the respondent, 0=male, 1=female	199	0.64
Literacy	Dummy indicating whether the respondent is literate, 0=no, 1=yes	199	0.17
Reason dissolution	Dummy variable indicating the reason for household dissolution, 0=death, 1= divorce	199	0.51
Stayed in the village	Dummy indicating whether the respondent stayed in the village after the divorce/death of spouse, 0=no, 1=yes	199	0.76

[2]1 tsimdi is a local measure based on the area a pair of oxen can plough in a day, and is approximately 0.25 hectares.

5.2 Gender bias in landholdings

To test the second hypothesis, two measures of landholdings are used; owned landholding and operational landholding. The size of the owned landholdings reflects how much land the household accesses through the state and the family, whereas the operational landholdings reflects how the household is adjusting the amount of land it cultivates through the rental market. As the number of reallocations of land is limited in Tigray, the market is becoming a more important source of access to land for rural households, and thus the operational landholding forms the variable of main interest in this paper.

Three approaches are used to identify explore the gender bias in landholdings. First, the simple means of household landholdings are compared to determine whether there are significant differences between female- and male-headed households. Second, OLS regressions are used to correct for observable differences between the two groups of households. The dependent variable is the total household landholding. There are several factors that can potentially influence the

landholdings of rural farmers, and by estimating OLS models, these variables can be controlled for. A list of the variables is included under the household level variables in Table 2. A dummy variable of headship is included in the model to test the hypothesis of gender differences in landholdings after controlling for the household and geographical variables. To control for village fixed effects, village dummies are included. In addition to a pooled model, models are run separately for male- and female-headed households. A chi-square test is performed to test whether the coefficients are significantly different across the separate models. To correct for heteroskedasticity, robust standard errors are estimated, referring to a minimum ignorance estimator (White 1982).

The main dependent variable in the models is the total household landholding, not per capita landholdings. Although need for land and ability to cultivate it have been determinants for land allocation from the state (Holden et al. 2011), reallocations have been limited in Tigray since 1997. Thus, looking at land per capita in 2006 can be misleading when we are interested in the allocation of land across households and not household welfare per se, as the landholding per capita for a household will change over time depending on the household life cycle. However, the robustness of the findings on total household landholdings is explored by running the same models with per capita landholding as the dependent variable.

While empirical studies typically treat family size as given in the short term, this variable can be endogenous in the longer term, particularly in the models for owned landholding. Thus, the relationship between the household size variables and landholdings should be interpreted with caution, without implying too much about the direction of causality. This is also recognized by Jayne et al. (2003) in their study of land distribution in Africa.

The third approach used is the Blinder-Oaxaca technique to decompose the landholding differences and estimate how much of the differences can be explained by differences in observable characteristics and endowments and what can be explained by differences in returns to these characteristics and endowments (Blinder 1973; Oaxaca 1973). Jones and Kelley (1984) determine discrimination to exist when the same bundle of productivity-related characteristics are valued differently between men and women. Thus, the measure of discrimination and gender bias is the residual remaining after controlling for the differences in observable characteristics and resource endowments. This measure will depend on how well the model is specified and the level of measurement error. A share of what is measured as gender bias might be due to unobservable characteristics other than gender, but by including the variables known to influence landholdings the residual measured will give an indication of the degree of the gender bias.

In the decomposition analysis, separate regressions are estimated for male-headed (m) and female-headed (f) households:

$$Y_{\mathrm{m}} = \mathrm{X_m}\beta_{\mathrm{m}} + \varepsilon_{\mathrm{m}} \quad , \; E(\varepsilon_{\mathrm{m}}) = 0 \qquad [4]$$

$$Y_{\mathrm{f}} = \mathrm{X_f}\,\beta_{\mathrm{f}} \; + \varepsilon_{\mathrm{f}} \quad , \; E(\varepsilon_{\mathrm{f}}) = 0 \qquad [5]$$

where Y is the landholding, X is a vector of the observed characteristics and endowments also included in the OLS models, β contains the slope parameters and ε is the error term with zero expectations. The mean difference in landholdings $(\overline{D})$ can be expressed as the difference in the linear prediction at the gender-specific means of the regressors:

$$(\overline{D}) = \overline{\mathrm{X}}_{\mathrm{m}}\,\hat{\beta}_{\mathrm{m}} - \overline{\mathrm{X}}_{\mathrm{f}}\,\hat{\beta}_{\mathrm{f}} \qquad [6]$$

Following Jones and Kelley's (1984) and Jann's (2008) application, this expression can be rearranged and decomposed into three parts:

$$(\overline{D}) = \; (\overline{\mathrm{X}}_{\mathrm{m}} - \; \overline{\mathrm{X}}_{\mathrm{f}})\,\hat{\beta}_{\mathrm{f}} \quad + \quad \overline{\mathrm{X}}_{\mathrm{f}}(\hat{\beta}_{\mathrm{m}} - \; \hat{\beta}_{\mathrm{f}}) \quad + \quad (\overline{\mathrm{X}}_{\mathrm{m}} - \; \overline{\mathrm{X}}_{\mathrm{f}})(\hat{\beta}_{\mathrm{m}} - \; \hat{\beta}_{\mathrm{f}}) \qquad [7]$$

The first part of the right hand side of Equation [7] measures the share of the landholding differentials that can be explained by differences in observed characteristics and endowments between male and female-headed households. This is also referred to as the endowment effect.

The second part measures the share of the differences that is due to differences in the coefficients, meaning the returns to characteristics and endowments. This is often referred to as the *unexplained* differences and is commonly used as a measure of discrimination. This term also captures all potential effects of unobserved group differences. For example, skills are unobserved in the model but may vary across the groups. With respect to operational landholdings, differences in returns to characteristics and endowments may also reflect a rational response to differences in agricultural skills and not only gender bias per se. Although the main critical variables believed to be important for agricultural productivity is included in the model, we cannot rule out that there are systematic differences between male- and female-headed households. Therefore, the measured bias should be considered as an upper level.

The third part is an interaction term taking into account the fact that differences in endowments and coefficients occur simultaneously between male and female-headed households and is a measure of the difference between valuing the observed endowments at female-headed households 'returns rather than male-headed households' returns. Jones and Kelley (1984) recommend keeping this term separate unless specific arguments can be made for adding this to the measure of discrimination. In this paper, the interaction term is treated separately.

6 Results and discussion

6.1 Differences in endowments and characteristics

There are significant differences in key characteristics between male- and female-headed households in Tigray (see Table 3).

Table 3 Comparison of means between male- and female-headed households

	Mean values for *all* households				
Variable	Male	Female	Difference	t-value	N (m+f)
Household size	5.80 (0.15)	3.29 (0.19)	2.50 (0.26)	9.60***	254+103
Age hh head	55.7 (0.85)	52.2 (1.54)	3.49 (1.67)	2.09**	254+103
Oxen	1.16 (0.06)	0.31 (0.06)	0.85 (0.11)	7.97***	254+103
Male wf	1.71 (0.07)	0.62 (0.09)	1.09 (0.12)	8.76***	254+103
Female wf	1.40 (0.06)	1.18 (0.08)	0.21 (0.10)	2.11**	254+103
Owned holding	4.10 (0.18)	3.19 (0.22)	0.91 (0.31)	3.91***	254+103
Operational holding	4.50 (0.22)	2.07 (0.22)	2.43 (0.38)	6.44***	254+103
Per cap owned hold	0.91 (0.06)	1.35 (0.13)	-0.44 (0.12)	-3.59***	254+103
Per cap oper hold	0.96 (0.07)	0.76 (0.11)	0.21 (0.13)	1.66*	254+103
	Mean landholding size for *subgroups* of households				
Variable	Male	Female	Difference	t-value	N (m+f)
Mean values for presently unmarried households					
Owned holding	4.01 (0.47)	3.14 (0.22)	0.87 (0.47)	1.84*	33+99
Operational holding	4.08 (0.50)	1.95 (0.22)	2.13 (0.48)	4.44***	33+99
Per cap owned hold	1.40 (0.18)	1.37 (0.13)	0.03 (0.25)	0.10	33+99
Per cap oper hold	1.34 (0.20)	0.75 (0.11)	0.63 (0.23)	2.69***	33+99
Mean values for households where head is previously divorced					
Owned holding	3.66 (0.28)	2.24 (0.26)	1.42 (0.49)	2.91***	70+27
Operational holding	3.56 (0.31)	1.16 (0.26)	2.40 (0.52)	4.60***	70+27
Per cap owned hold	0.80 (0.09)	0.91 (0.17)	-0.12 (0.18)	-0.64	70+27
Per cap oper hold	0.78 (0.09)	0.41 (0.11)	0.36 (0.17)	2.19**	70+27
Mean values for households where head is previously widowed					
Owned holding	4.04 (0.34)	3.52 (0.36)	0.52 (0.50)	1.03	66+53
Operational holding	4.14 (0.49)	2.49 (0.35)	1.65 (0.63)	2.60**	66+53
Per cap owned hold	1.09 (0.12)	1.68 (0.22)	-0.59 (0.24)	-2.48**	66+53
Per cap oper hold	1.09 (0.15)	0.99 (0.20)	0.10 (0.24)	0.43	66+53

Significance levels * p<0.10, ** p<0.05, *** p<0.01.

Most female-headed households are the result of household dissolution, either because of divorce or death of husband; thus, the households are on average smaller compared to male-headed households. In addition, female heads are on average younger, and their literacy rate is much lower

(12% vs. 40%). Female-headed households are also significantly poorer in land and important non-land productive assets, e.g., male and female labor and oxen ownership.

Even though most female-headed households in Tigray are the result of household dissolution, the differences in owned and operational landholdings remain (0.9 and 2.1 tsimdi respectively) when comparing unmarried male and female-headed households as well. The reason for the dissolution matters for how the household land is shared. In the case of a divorce, land is split between the husband and wife. In the case of death of one of the spouses, the land is usually either kept in full by the surviving spouse or split between the surviving spouse and the deceased spouse's children and/or other family. We observe that households where the head is previously divorced have smaller landholdings compared to households where the head is previously widowed. Previously divorced male-headed households have 9% smaller owned landholdings compared to widowers, whereas previously divorced female-headed households have 36% smaller owned landholdings than widows. In other words, the gender difference is much larger when divorced (and have to share with the spouse) than when widowed (keep all or share with the children).

When comparing all households, female-headed households have significantly larger per capita owned landholding. This is not surprising, given that the per capita own land holding is negatively correlated with household size (correlation value -0.45), indicating that the smaller households have on average more land per capita.

Sharecropping is the traditional form of land rentals, and the most common contract is 50% output sharing, i.e., the landlord receives half of the crop after the harvest without providing any non-land inputs, such as seeds and labor (Table 4).

Table 4 Percent of households that participate in the land rental market and contract type

Variable	Male-headed			Female-headed			All		
Renting out land (landlord)	21			45			28		
Renting in land (tenant)	38			8			29		
Type of land rental contract									
Fixed rent (cash)	1			1			1		
Fixed rent (kind)	< 1			0			< 1		
Sharecropping (output after deduction of input costs)	5			1			3		
Sharecropping (output only)	91			97			93		
Share of output to landlord	*50%*	*33%*	*25%*	*50%*	*33%*	*25%*	*50%*	*33%*	*25%*
	57	16	23	66	14	20	60	15	22

A higher share of female-headed households is renting out their land, and few participate in the market as tenants. This is also reflected in the gender differences in operational landholdings in Table 3. Female-headed households have less than half the operational landholdings compared to male-headed households. The difference is particularly large for the households where the household head is previously divorced; female-headed households have less than a third of the mean operational landholding in male-headed households. Renting in and out land is a way to adjust the operational landholding to the need for agricultural land and productive inputs available at household level. Thus, we should expect the per capita landholding to be less correlated with household size. This is supported by the data, as the correlation value for operational landholding is less than half compared to owned landholding (-0.1863). The negative correlation value still indicates that smaller households have larger operational landholdings, but the gender differences in operational landholdings remain at the per capita level; female-headed households have 22% smaller per capita operational landholdings.

6.2 Allocation of land upon divorce or death

To explore what drives the differences in landholdings between male and female-headed households, I start by analyzing what happened with the household land upon household dissolution. I use the sample of the 199 individual responses.

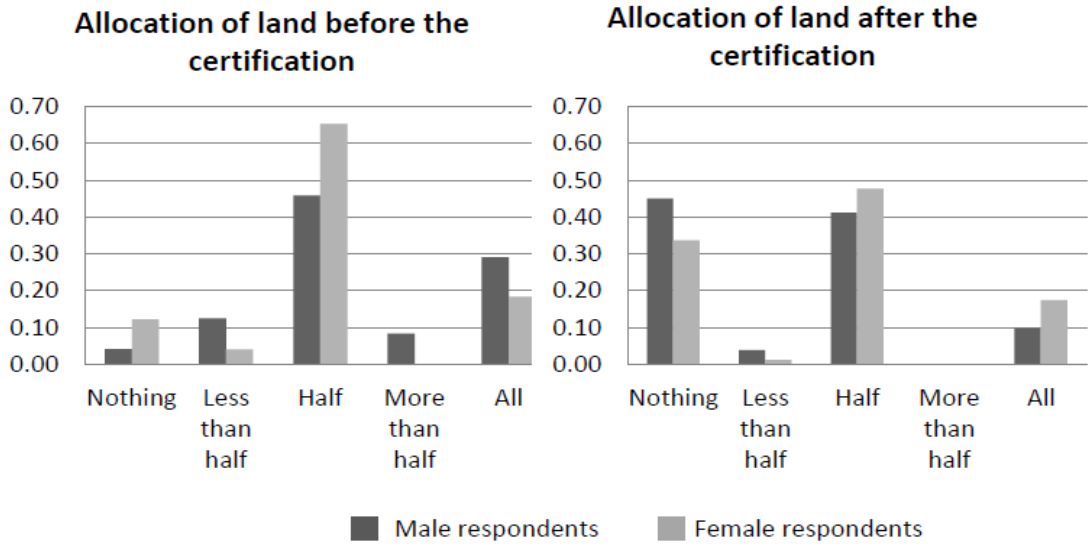

Figure 1 Share of land received upon divorce and death of spouse

Figure 1 illustrates the share of household land received upon death or divorce by men and women in our sample, before and after the certification process. Overall, a higher share of the male respondents received more than half of the household land upon divorce or death of spouse compared to the female respondents before the certification process, whereas the opposite is true after the certification. In addition, a higher share of the female respondents received no land after the certification, but that is true also for the male respondents.

On average, 17% of the individual respondents are literate and 51% are previously divorced (Table 2), but there are gender differences. Compared to the male respondents, less female respondents are literate (32% vs. 8%), and a smaller share is previously divorced (57% vs. 48%), indicating that a higher share of the female respondents is widowed. Looking at the shares of male and female respondents that stayed in the village after the divorce or death of spouse, we observe the effect of the tradition of patrilocality. Whereas 17% of the men left the village, 28% of women did the same. The difference is particularly large when comparing individuals who have been divorced; 24% of the men and 49% of the women left the village after a divorce. To control for the different characteristics, ordered probit models were used. A positive coefficient indicates a higher probability that a respondent with the particular characteristic received more land upon divorce or death of spouse (Table 5).

Overall, men were not more likely to receive more land upon household dissolution (sex of the respondent variable is insignificant). The dummy variable included to capture the effect of the certification is non-significant in the model with female respondents, whereas it is positive and significant for male respondents and in the pooled sample with both male and female respondents. This result indicates that men were likely to receive more land upon household dissolution after the certification reform compared to before the reform. The positive effect for men runs contrary to the intentions stated in the land reform, and the result should be interpreted with caution. Changes occur over time, and the change that the certification variable captures could also reflect changes over time that is not linked to the reform[5].

[5] A possible way to correct for this in the model would be to include the exact year of household dissolution in addition to the certification variable, but this information was not collected at the time of field work.

Table 5 Ordered probit models on share of land received upon household dissolution

Variables	Males	Females	All
Sex of respondent 0=male, 1=female			0.03 (0.18)
Dissolution after cert. 0=no, 1=yes	0.89*** (0.28)	0.31 (0.21)	0.53*** (0.16)
Literacy 0=no, 1=yes	-0.33 (0.31)	-0.41 (0.36)	-0.35 (0.24)
Reason dissolution 0=death, 1=divorce	-0.84*** (0.29)	-0.77*** (0.22)	-0.81*** (0.18)
Stayed in the village 0=no, 1=yes	-0.03 (0.34)	0.61** (0.26)	0.39 (0.21)
N	72	127	199

Significance levels * p<0.10, ** p<0.05, *** p<0.01. Heteroskedasticity robust standard error in brackets. Dependent variable: Share of land received upon divorce or death of spouse (1=Nothing, 2=Less than half, more than nothing, 3=Half, 4=Less than all, more than half, 5=All)

The effect of the certification reform also appears to contradict the findings shown in Figure 1, and this emphasizes the importance of controlling for the reason for the dissolution. A divorce rather than the death of the spouse decreased the probability that the respondent received more land in all models, in line with previous results. The variable indicating whether the respondent stayed in the village after the divorce or death of spouse is positive and significant in the first model for female respondents. This variable captures the effect of patrilocality: women are often expected to move back in with their blood relatives after a household dissolution. To test for endogeneity of the decision to stay or leave, models are run excluding this variable (not included in the table). This did not change the significance levels or sign of the other variables in the models, and the estimates in the models included in Table 5 are robust.

6.3 Estimation of the Gender Bias

The potential determinants of access to land vary systematically between male- and female-headed households (Table 3). The OLS regressions explores to what extent these differences drive the gender differences in landholdings (Table 6). Because there might be systematic differences in terms of where male and female-headed households live, the model controls for village fixed effects. Several of these village dummy variables are significant, indicating that there are geographical differences across the study area. Whether the household has oxen or not might be endogenous, and to check for reverse causality between landholding and oxen, an alternative

model specification excluding the oxen dummy variable is included as a robustness check (Table A1).

Table 6 Estimated coefficients from OLS models for owned and operational landholdings

	Owned landholdings			Operational landholdings		
Variables	*Pooled*	*Male hhh*ʃ	*Female hhh*ʃ	*Pooled*	*Male hhh*¤	*Female hhh*¤
Sex of hh head (0=male, 1=female)	-0.657** (0.304)			-1.534*** (0.378)		
Age of the hh head (in number of years)	0.009 (0.008)	0.032** (0.011)	-0.034* (0.018)	-0.012 (0.010)	0.002 (0.014)	-0.026 (0.021)
Literacy (0=no, 1=yes)	-0.045 (0.268)	0.129 (0.263)	-0.409 (1.000)	-0.289 (0.346)	-0.141 (0.352)	-0.430 (1.238)
Dependents (<15, >64)	-0.029 (0.072)	-0.067 (0.077)	0.102 (0.132)	0.039 (0.093)	-0.002 (0.107)	0.174 (0.153)
Male wf (men aged 15-64)	0.461*** (0.110)	0.406*** (0.120)	0.564** (0.255)	0.495*** (0.183)	0.489** (0.221)	0.344 (0.257)
Female wf (women aged 15-64)	0.112 (0.117)	0.204 (0.129)	-0.300 (0.306)	-0.036 (0.167)	-0.027 (0.220)	-0.099 (0.234)
Divorcee (0=no, 1=yes)	-0.401 (0.206)	-0.329 (0.259)	-1.165*** (0.432)	-0.938*** (0.271)	-1.004*** (0.354)	-1.466** (0.521)
Oxen dummy (0=no, 1=yes)	0.297 (0.270)	0.189 (0.314)	0.816* (0.472)	1.811*** (0.358)	1.743*** (0.460)	2.186*** (0.525)
Village	16 village dummies included in the analysis. but left out of the table					
Constant	3.076** (0.962)	1.910 (1.173)	5.258*** 1.268	1.641 (1.070)	1.036 (1.052)	1.080 (1.153)
R-squared	0.506	0.576	0.535	0.463	0.480	0.448
N	357	254	103	357	254	103

Significance levels: *p<0.1, **p<0.05, ***p<0.01. Robust standard errors.
ʃThe estimated coefficients for Age of the hh head, Female wf and Divorce are significantly different across the separate models for owned landholdings. The respective chi-square test statistics: chi2(1) =11.76 Prob>chi2=0.0006, chi2(1) =2.92 Prob>chi2=0.0877, chi2(1) =3.43 Prob>chi2=0.0642.
¤None of the estimated coefficients are significantly different from each other across the separate models for operational landholdings.

Each model of total household landholding was run on three different samples: the complete sample of all households (*pooled*), a sub-sample of male-headed households only (*male hhh*) and a sub-sample of female-headed households only (*female hhh*). The results suggest that female-headed households have smaller owned and operational landholdings compared to male-headed

households after controlling for household size, non-land resources, previous divorce and local land availability. The negative marginal effect of female headship is relatively large and robust over alternative model specifications for total household landholdings. The female work force and the total number of dependents in the household are not significant in any of the models, indicating that household size as such is not significantly correlated with access to land.

The experience of a previous divorce has a large negative effect (-1.2 tsimdi) on the amount of land female-headed households own, but there is no significant effect for male-headed households. A chi-square test confirms that the coefficients are significantly different at the 10% level. The gender difference is not necessarily a result of a biased allocation of land upon divorce. This result may also reflect that male-headed households are more likely to be compensated for "the lost land" through additional land allocations from the PAs and/or through inter-generational transfers, whereas female-headed households are less likely to be allocated land and to inherit land from parents, particularly if they moved to the husband's village upon marriage and stayed there after the divorce.

A notable difference between male and female-headed households is the returns to age in the models explaining the size of owned landholdings. While returns to age is positive (0.032) in the model for male-headed households, it is negative (-0.034) for female-headed households. There are at least three alternative explanations for this gender-differentiated age effect. First, older female-headed households may give relatively more land to children. Such female heads of household may give children more land because they are expected to do so and to be included as a member of the child's household to be taken care of in the future, or it can be a rational solution due to a lack of male labor as a husband is missing and sons become ready to form their own households. However, the difference between male workforce available in households headed by older females (age 65 and above) and other female-headed households is small (-0.03) and not significant, lending no support to the relative lack of male labor as an explanation. Second, female-headed households might have lost land in previous land allocations whereas male-headed households have gained land. If that is the case, this result could indicate a higher status for older males than for older women and a gender bias in the reallocation of land. Lack of data makes it hard to explore this relationship, but previous studies have suggested that female-headed households are more tenure insecure (Holden and Bezabih 2008; Holden et al. 2011), and it is a reasonable assumption that higher perceived insecurity is due to a higher risk of losing one's land. Third, the gender bias might have decreased over time, i.e., younger women have been able to keep more land after household dissolution. The results presented in Table 5 do not support this notion. There is no significant effect of the variable controlling for whether the dissolution happened

before or after the certification in the ordered probit models for the female respondents. An interaction variable was added to the OLS model for female-headed households in Table 6 to test for the effect of being older and previously divorced, but the variable was not significant. Another possibility is that younger female-headed households have been allocated more in land reallocation or inherited more from their parents compared to female-headed households that were formed a long time ago, which might be a positive effect of the land reform, but a lack of data limits the possibility to test for this effect.

While male-headed households have larger owned landholdings in total, female-headed households have larger per capita holdings. This is mainly driven by their smaller household size. In the regression for owned landholdings per capita, there is no significant effect of the gender of the household, whereas the household size variables are all negative and significantly correlated with per capita owned landholdings (Table A2). Per capita landholding can be a measure of land scarcity, but with respect to household agricultural produce and livelihoods, operational landholdings are more important.

Operational landholding is affected by the household's position in the land rental market, and the market can help adjust the operational landholding to the household's needs and endowments. Access to non-land resources, such as oxen and total male work force, are potentially important determinants of behavior in the land rental market. The marginal effects of ownership of oxen and the amount of male labor available indicate that there is some adjustment, but even after controlling for these non-land agricultural inputs, the negative impact of female headship is more than twice as large for operational landholdings compared to owned landholdings.

The results from the operational landholding at per capita level support the finding of a gender difference in operational landholdings (Table A2). Everything else constant, female-headed households have on average 0.46 tsimdi less land per capita. This is a huge difference given that the sample mean per capita operational land is only 0.91 tsimdi.

This result supports the findings obtained from other studies that indicate the rental market is not a source of access to land for female-headed households but that they rather are renting out land. The tendency that female-headed households are more likely to rent out all or a share of their land may reflect a rational response to differences in skills and capacity between male and female-headed households. These variables are unobserved, and not controlled for in the models. Previous studies have found, after controlling for plot quality, that plots operated by female-headed households are less productive compared to plots operated by male-headed households (e.g., Holden et al. 2001; Pender and Gebremedhin 2008). This lower productivity may motivate female-headed households to rent out their land to more productive male tenants. On the other

hand, studies of the land rental market in Ethiopia have also found that productivity is lower on plots rented out by female-headed households (Holden and Bezabih 2008; Ghebru and Holden 2012). This lower productivity may be due to the relatively lower bargaining power of female-headed households in the land rental market. Due to female-headed households' tenure insecurity and economic dependency, they are less able to screen tenants and have limited power to evict them (Holden and Bezabih 2008; Ghebru and Holden 2012). Both factors may adversely affect the tenants' effort and reduce the potential gain for female-headed households when renting out land. Thus, the gender differences in operational landholdings may not fully be explained as a rational response for female-headed households to rent out their land.

The results of all three models for operational landholdings indicate that those who are previously divorced have less land, in line with the previous findings obtained when comparing simple means of landholdings across previously divorced male and female-headed households as well. The oxen dummy variable has a large and significant effect in all models, whereas male workforce is not significant for female-headed households. There is, however, no statistically significant difference in the coefficients across the separate models.

The results of the OLS models indicate that access to land through the state/family and the land rental market is influenced by more or less the same variables. The exception is the effect of oxen holding. Oxen holding do not appear to have a significant impact on land accessed through the state (owned landholdings), whereas it does have a large and highly significant effect on land accessed and disposed through the market (operational landholdings).

The results from the OLS models are in line with the results of previous studies, suggesting that female-headed households own less land and that the market is not a source of *access* to land for female-headed households in Tigray. The results of the models also suggest that not all the difference can be explained by differences in observable characteristics, endowments and local land availability. To divide the differences in landholdings between male and female-headed households into a share that can be explained by the observable differences and what can be explained by the *returns* to these observables, the mean differences are decomposed as shown in Equation [7]. The results are presented in Table 7.

Table 7 Decomposition of landholding differences

	Owned landholding	Operational landholding
Mean landholdings	4.100	4.496
Male-headed households	(0.182)	(0.228)
Mean landholdings	3.188	2.067
female-headed households	(0.235)	(0.241)
Mean	0.911***	2.429***
difference	(0.297)	(0.332)
Decomposition estimates		
Observed	0.529	1.278**
endowments	(0.499)	(0.516)
Return to	0.695*	1.657***
endowments	(0.372)	(0.489)
Interaction	-0.312	-0.506
	(0.559)	(0.650)
Number of observations	357	357

Significance levels: * p<0.10, ** p<0.05, *** p<0.01. Robust standard

In the first panel, the mean predictions of male and female-headed households' landholdings and the differences are reported. The results in the second panel indicate how much of the observed differences in landholdings are due to differences in observable endowments and characteristics and how much are due to differences in returns to the endowments. The first term, *observed endowments,* reflects the predicted mean increase in female-headed households' landholdings if they had the same endowments as male-headed households. The second term, *return to endowments*, reflects the level of gender bias, that is, changes in female-headed households' landholdings when applying the male-headed households' coefficients to the female-headed households' endowments. The interaction term is a measure of the difference between valuing the *observed endowments term* at female-headed household's returns rather than male-headed household's returns.

The results indicate that gender bias may accounts for as much as 57% and 56% of the differences in owned and operational landholdings, respectively. As expected, there is no evidence of a gender bias in per capita owned landholdings, while the gender bias in operational landholdings is confirmed by the per capita decomposition (Table A3).

7 Conclusion

Gender differences in landholdings in Ethiopia have been explained by differences in household characteristics and endowments, particularly household size, male labor and oxen ownership. In addition, institutional factors such as patrilocality and plough cultivation have been emphasized as possible explanations. By decomposing the differences in landholdings, the analysis in this paper shows that observable characteristics and endowments matter, but it explains less than half the difference. The remaining differences in owned and operational landholdings can be explained by gender bias, measured by differences in returns to the observable characteristics and endowments, as well as by unobservable factors.

The observed gender bias can be explained in several ways. The reform, with its land certification and proclamation targeting enhanced gender equality, did not eradicate the gender bias with respect to household's allocation of land. Whereas previously divorced female-headed households have less land, male-headed households seems to be able to compensate for the lost land through allocations of land from the state or the family and through the land rental market.

Linked to this is the perception of female farmers as "weaker". The reason for their constraint in farming their land can be due to either lack of skills, physical requirements, a social taboo against women ploughing or a combination thereof. The result is the same; male-headed households seem to be preferred as land owners and operators, and female-headed households are more likely to rent out their land. Targeting the social taboo could be a first step for national policy makers and local Peasant Associations to ensure that women who would like to cultivate land are not harassed or stigmatized in any way. Improving women's access to agricultural extension services could be a second step. If the reason is lack of physical capacity, on the other hand, measures to improve functioning on non-land input markets, such as the hiring of oxen and male labor, is one possibility to reduce the difference caused by differences in household endowments.

The Ethiopian land rental market is characterized by poor landlords and rich tenants, contrary to the rental market stereotype. Further improving the tenure security for households renting out land would be a positive policy intervention. There are laws regulating how much land a household can rent out and under what contract the land can be rented out regarding length and payments. Households breaking these laws are in danger of losing the rights to their land. Such limitations in the land rental market might increase landlord's tenure insecurity, making them less able to screen tenants and use threat of eviction as a means to increase productivity on the land they rent out (Holden and Bezabih 2008). Limitations in the land rental market are likely to affect female-headed households more than their male counterparts. Whether renting out one's land rather than operating it oneself is the preferred option for female landlords or not; the fact is that they both

rent out land more often and also rent out a larger share. There are few non-agricultural livelihood opportunities for women in rural areas, and thus putting limitations on the land rental market will harm female-headed households.

Other studies from Ethiopia have found that a certificate to the landholdings has a positive impact on tenure security in general (e.g., Deininger and Jin 2006; Holden et al. 2011). The fact that a smaller share of female-headed households holds a certificate for their land and a lack of updating certificates after a household dissolution might therefore have a gender-biased impact on tenure security, distribution of land when a household dissolves and female-headed households' ability to protect their rights to keep the land in the case of a land conflict. The last policy recommendation concerns the certificate itself. For now, only the household head is registered as the "owner" of the land. This has been emphasized as a constraint for the spouse's access to and control of land in other studies, and including the names of both the husband and the wife on the certificate could give more secure rights to women when a household dissolves and improve female-headed household's tenure security in areas with slow or non-existing updating of issued certificates.

Too little research is conducted on the different titling systems in Ethiopia to draw strong conclusions on the negative impacts of non-joint titling, and therefore, a comparative study of the impact of certification on gender and the allocation of land tenure rights for land across the regions in Ethiopia is needed. Furthermore, a study of the dynamics of changes in household land would be useful to yield insight into how male- and female-headed households gain and lose access to land from the state, their family and the market over time.

References

Agarwal, Bina. 1994a. "Gender and Command over Property: A Critical Gap in Economic Analysis and Policy in South Asia." *World Development* 22 (10): 1455-1478.

Agarwal, Bina. 1994b. *A Field of One's Own: Gender and Land Rights in South Asia*. Cambridge, NY: Cambridge University Press.

Agarwal, Bina. 2003. "Gender and Land Rights Revisited: Exploring New Prospects Via the State, Family and Market." *Journal of Agrarian Change* 3 (1-2): 184-224.

Blinder, Alan S. 1973. "Wage Discrimination: Reduced Form and Structural Estimates." *The Journal of Human Resources* 8 (4): 436-455.

Bomuhangi, Allan, Cheryl Doss, and Ruth Meinzen-Dick. 2011. *Who Owns the Land? Perspectives from Rural Ugandans and Implications for Land Acquisitions*. IFPRI Discussion Paper 01136. Washington, DC: International Food Policy Research Institute.

Boserup, Ester. 1970. *Women and Economic Development*. New York: St.Martins Press.

Chen, Susan E., Priya Bhagowalia, and Gerald Shively. 2011. "Input Choices in Agriculture: Is There a Gender Bias?" *World Development* 39 (4): 561-568.

de Janvry, Alain, Jean-Philippe Platteau, Gustavo Gordillo, and Elisabeth Sadoulet. 2001. "Access to Land and Land Policy Reform". In de Janvry, Alain, Jean-Philippe Platteau, Gustavo Gordillo, and Elisabeth Sadoulet (eds) *Access to Land, Rural Poverty, and Public Action*, pp. 1-26. Oxford, UK: Oxford University Press.

Deere, Carmen Diana, and Magdalena Leon. 2003. "The Gender Asset Gap: Land in Latin America." *World Development* 31 (6): 925-947.

Deere, Carmen Diana, and Cheryl R. Doss. 2006. "The Gender Asset Gap: What Do We Know and Why Does It Matter?" *Feminist Economics* 12 (1): 1 - 50.

Deininger, Klaus, and Songqing Jin. 2006. "Tenure Security and Land-Related Investment: Evidence from Ethiopia." *European Economic Review* 50 (5): 1245-1277.

Deininger, Klaus, Daniel Ayalew Ali, Stein Holden, and Jaap Zevenbergen. 2008a. "Rural Land Certification in Ethiopia: Process, Initial Impact, and Implications for Other African Countries." *World Development* 36 (10): 1786-1812.

Deininger, Klaus, Daniel Ayalew Ali, and Tekie Alemu. 2008b. "Assessing the Functioning of Land Rental Markets in Ethiopia." *Economic Development and Cultural Change* 57 (1): 67-100.

Estudillo, Jonna P., Agnes R. Quisumbing, and Keijiro Otsuka. 2001. "Gender Differences in Land Inheritance and Schooling Investments in the Rural Philippines." *Land Economics* 77 (1): 130-143.

Fafchamps, Marcel, and Agnes R. Quisumbing. 2005. "Marriage, Bequest and Assortative Matching in Rural Ethiopia." *Economic Development and Cultural Change* 53 (2): 347-380.

FAO. 2009. *Forest Tenure Assessment*. Rome: The Food and Agriculture Organization of the United Nations.

Frank, Emily. 1999. "Gender, Agricultural Development and Food Security in Amhara, Ethiopia. The Contested Identity of Women Farmers in Ethiopia." USAID/Ethiopia. Washington, DC: United Stated Agency for International Development.

Ghebru, Hosaena H., and Stein T. Holden. 2008. Factor Market Imperfections and Rural Land Markets in Northern Ethiopian Highlands. In Holden, S.T., K. Otsuka, and F. Place (eds) *The Emergence of Land Markets in Africa: Assessing the Impacts on Poverty, Equity and Efficiency*, pp. 74-92. Washington, DC: Resources for the future Press (RFF).

Ghebru, Hosaena H., and Stein T. Holden . 2012. *Reverse Share-Tenancy and Marshallian Inefficiency: Bargaining Power of Landowners and the Sharecroppers' Productivity*. CLTS Working Papers No 2/12. Aas, Norway: Centre for Land Tenure Studies, Norwegian University of Life Sciences.

Greene, William H. 2002. *Econometric Analysis*. 5 ed. London: Prentice Hall.

Haile, Mitiku, Wray Witten, Kinfe Abraha, Sintayo Fissah, Adane Kebebe, Getahun Kassa, and Getachew Reda. 2005. *Research report 2. Land Registration in Tigray, Northern Ethiopia*. London: International Institute for Environment and Development

Holden, Stein, Bekele Shiferaw, and John Pender. 2001. "Market Imperfections and Land Productivity in the Ethiopian Highlands." *Journal of Agricultural Economics* 52 (3): 53-70.

Holden, Stein, and Hailu Yohannes. 2002. "Land Redistribution, Tenure Insecurity, and Intensity of Production: A Study of Farm Households in Southern Ethiopia." *Land Economics* 78 (4): 573-590.

Holden, Stein T., Klaus Deininger, and Hosaena Ghebru. 2011. "Tenure Insecurity, Gender, Low-Cost Land Certification and Land Rental Market Participation in Ethiopia." *Journal of Development Studies* 47 (1): 31-47.

Holden, Stein T. , and Mintewab Bezabih. 2008. "Gender and Land Productivity on Rented Land in Ethiopia". In Holden, Stein T., Keijiro Otsuka, and Frank M. Place (eds) *The Emergence of Land Markets in Africa: Assessing the Impacts on Poverty, Equity and Efficiency*, pp. 179-198. Washington, DC: Resources for the future Press (RFF).

Jann, Ben. 2008. "A Stata Implementation of the Blinder-Oaxaca Decomposition for Linear Regression Models." *The Stata Journal* 8 (4): 453-476.

Jayne, T. S., Takashi Yamano, Michael T. Weber, David Tschirley, Rui Benfica, Antony Chapoto, and Ballard Zulu. 2003. "Smallholder Income and Land Distribution in Africa: Implications for Poverty Reduction Strategies." *Food Policy* 28 (3): 253-275.

Jones, Frank L., and Jonathan Kelley. 1984. "Decomposing Differences between Groups: A Cautionary Note on Measuring Discrimination." *Sociological Methods & Research* 12 (3): 323-343.

Kebede, Bereket. 2008. "Land Reform, Distribution of Land and Institutions in Rural Ethiopia: Analysis of Inequality with Dirty Data." *Journal of African Economies* 17 (4): 550-577.

Norton, Edward C., Hua Wang, and Chunrong Ai. 2004. "Computing Interaction Effects and Standard Errors in Logit and Probit Models." *The Stata Journal* 4 (2): 154-167.

Oaxaca, Ronald 1973. "Male-Female Wage Differentials in Urban Labor Markets." *International Economic Review* 14 (3): 693-709.

Pender, John, and Berhanu Gebremedhin. 2008. "Determinants of Agricultural and Land Management Practices and Impacts on Crop Production and Household Income in the Highlands of Tigray, Ethiopia." *Journal of African Economies* 17 (3): 395-450.

Ragasa, Catherine, Guush Berhane, Fanaye Tadesse, Alemayehu Seyoum Taffesse. 2012. "Gender Differences in Access to Extension Services and Agricultural productivity." ESSP Working Paper 49. Washington, DC: International Food Policy Research Institute (IFPRI).

Quisumbing, Agnes R., and John A. Maluccio. 2003. "Resources at Marriage and Intrahousehold Allocation: Evidence from Bangladesh, Ethiopia, Indonesia, and South Africa." *Oxford Bulletin of Economics and Statistics* 65 (3): 283-327.

Tadesse, Zenebework, and Yared Amare. 2000. "Women's Land Rights in Ethiopia." *Birchi: The Journal of Ethiopian Women Lawyers Association* 1 (1): 25-51.

Teklu, Askale. 2005. *Research Report 4. Land Registration and Women's Land Rights in Amhara Region, Ethiopia.* London: International Institute for Environment and Development (IIED).

Tilson, Dana, and Ulla Larsen. 2000. "Divorce in Ethiopia: The Impact of Early Marriage and Childlessness." *Journal of Biosocial Science* 32 (03): 355-372.

Udry, Christopher. 1996. "Gender, Agricultural Production, and the Theory of the Household." *The Journal of Political Economy* 104 (5): 1010-1046.

White, Halbert. 1982. "Maximum Likelihood Estimation of Misspecified Models." *Econometrica* 50 (1): 1-25.

World Bank. 2005. *Gender Issues and Best Practices in Land Administration Projects: A Synthesis Report.32571*. Washington, DC: The World Bank.

World Bank. 2011. *World Development Report 2012: Gender, Equality and Development*. Washington, DC: The World Bank.

Yigremew, Adal. (2006). "Rural Women's Access to Land in Ethiopia". In Rahmato, Dessalegn and Taye Assefa (eds) *Land and the challenges of sustainable development in Ethiopia*, pp 19-40. Ethiopia: Forum for social studies.

Appendix

Table A1Estimated coefficients from OLS models for owned and operational without oxen

Variables	*Owned landholding*	*Operational landholding*
Sex of the hh head (0=male, 1=female)	-0.772*** (0.290)	-2.164*** (0.390)
Age of hh head (in number of years)	0.009 (0.008)	-0.011 (0.011)
Literacy (0=no, 1=yes)	-0.070 (0.264)	-0.375 (0.350)
Dependents (<15, >64)	-0.014 (0.068)	0.142 (0.093)
Male wf (men aged 15-64)	0.487*** (0.106)	0.644*** (0.156)
Female wf (women aged 15-64)	0.121 (0.116)	-0.030 (0.177)
Divorcee (0=no, 1=yes)	-0.421** (0.207)	-1.085*** (0.291)
Village	16 village dummies included in the analysis but left out of the table	
Constant	3.194*** (0.976)	1.641 (0.917)
R-squared	0.470	0.376
N	359	357

Significance levels: *p<0.10, **p<0.05, *** p<0.01.
Robust standard errors

Table A2 Estimated coefficients from OLS models for owned and operational per capita landholdings

Variables	*Owned landholding*	*Operational landholding*
Sex of the hh head	-0.060	-0.463***
(0=male, 1=female)	(0.136)	(0.167)
Age of hh head	0.009**	0.000
(in number of years)	(0.003)	(0.004)
Literacy	0.128	0.156
(0=no, 1=yes)	(0.156)	(0.184)
Dependents	-0.231***	-0.229***
(<15, >64)	(0.034)	(0.045)
Male wf	-0.178***	-0.140***
(men aged 15-64)	(0.034)	(0.043)
Female wf	-0.267***	-0.253***
(women aged 15-64)	(0.048)	(0.059)
Divorcee	-0.145*	-0.220**
(0=no, 1=yes)	(0.076)	(0.097)
Oxen dummy	0.081	0.512***
(0=no, 1=yes)	(0.100)	(0.140)
Village	16 village dummies included in the analysis but left out of the table	
Constant	2.027***	1.148***
	(0.566)	(0.346)
R-squared	0.521	0.322
N	359	357

Significance levels: * p<0.10, ** p<0.05, *** p<0.01.
Robust standard errors

Table A3 Decomposition of per capita landholding differences

	Owned landholding	Operational landholding
Mean landholdings Male-headed households	0.910*** (0.060)	0.970*** (0.069)
Mean landholdings female-headed households	1.351*** (0.136)	0.758*** (0.241)
Mean difference	-0.440*** (0.149)	0.212 (0.142)
Decomposition estimates		
Observed endowments	-0.455 (0.302)	0.205 (0.306)
Return to endowments	0.035 (0.149)	0.559*** (0.186)
Interaction	-0.021 (0.298)	-0.552* (0.326)
Number of observations	357	357

Significance levels: * p<0.10, ** p<0.05, *** p<0.01. Robust standard errors

PAPER 2

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Article

Tenure Issues in REDD+ Pilot Project Sites in Tanzania

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Abstract: REDD+ has been proposed as a viable option for addressing climate change in the near term, and at relatively low cost. There is a broad consensus that clearly defined tenure rights are important for the implementation and success of REDD+, both to manage forests effectively and to protect local communities' livelihoods. We use primary data from 23 villages in six REDD+ pilot sites in Tanzania to identify causes of deforestation and forest degradation, and tenure rights issues, at the village level prior to project implementation. Further, interviews with project proponents and examination of project documents yields insights into how the proponents plan to address tenure issues. Most villages perceive their tenure as secure and have exclusion rights, while collective action challenges are prevalent in villages experiencing deforestation and forest degradation. These findings suggest that the main tenure issues are related to internal institutional arrangements. While we find that tenure is high on the agenda for all the project proponents, they are mainly focusing on formalization and securing tenure rights from state to community level. Though we do find this to be a precondition for reducing deforestation and degradation, some of their focus should be shifted to strengthening village institutions and enhancing internal compliance.

Keywords: community forestry; property rights; deforestation; forest degradation; tenure; Tanzania

1. Introduction

Reducing emissions from deforestation and forest degradation and enhancing forest carbon stocks in developing countries (REDD+) has been recognized as a viable option for addressing climate change early and at relatively low cost [1]. REDD+ can potentially facilitate large reductions in greenhouse gas emission by compensating forest owners and users for lost forest income and livelihood opportunities [2]. Tanzania is a UN-REDD Programme Partner Country, and also a member of World Bank's Forest Carbon Partnership Facility (FCPF) along with 12 other African countries [3]. Tanzania signed a bi-lateral agreement with Norway in 2008 that provides funding (NOK 500 million) for REDD+ readiness activities, pilot projects and policy reforms. As of 2013, there are nine national and international NGOs implementing local REDD+ pilot projects in the country [4].

A broad consensus exists among national governments, donor organizations, third party certifiers, and civil society on the importance of clarifying tenure prior to the implementation of REDD+. The Stern Review [1] states that clearly defined property rights to forest land at the national level are key for effective forest management. The Climate, Community and Biodiversity Alliance (CCBA) requires that tenure is given early attention in their third party certification standards for REDD+ projects, as part of the implementation of REDD+ safeguards [5]. Beyond these standards, there is a growing body of literature on the general importance of secure tenure rights for effective forest management [6] and REDD+ implementation in particular [1,7]. Secure tenure rights can contribute to the success of REDD+ in several ways. A core idea of REDD+ is conditional payments to forest carbon rights holders. This requires that the rights-holders are rewarded for maintaining or enhancing the carbon sequestration and that the right holders can be held accountable, in case they fail to fulfill their obligation. Further, even without performance-based payments, legitimate and clear rights and responsibilities are needed to avoid a land rush. Finally, pre-existing access and management rights need to be protected to maintain or enhance local livelihoods [8].

Clarification of user rights and responsibilities and greater participation by local forest users in forest management have been recognized among the important factors for more effective forest governance [9]. Decentralization of tenure rights from the state to village level has been an ongoing process in Tanzania since the early 1990s as a means to achieve sustainable forest management and development, but the process has been slow. By 2008, approximately 10% of the forest area was registered and reserved or managed by communities, while 90% of the forest estate in Tanzania was both owned and managed by the government [10]. A key element of the Tanzanian national REDD+ strategy is to speed up this process and strengthen community rights and local management of forest resources [11]. Thus, land tenure as it relates to REDD+ is particularly salient in Tanzania, where tenure reforms and REDD+ implementation will move in tandem over the next few years.

While attention to decentralization and clarifying formal boundaries and statutory tenure rights are necessary for the success of REDD+, there is also a need to assess whether the existing institutional

arrangements in the villages are sufficient to overcome collective action challenges. Secure tenure rights for the users of natural resources provide incentives to invest in conservation [12], but to what extent this is achieved depends on how they organize to ensure a high level of compliance with resource use rules to avoid maximizing individual gains at the expense of the group [13,14].

This paper addresses three research questions: (1) what are the drivers of deforestation and forest degradation in REDD+ pilot project villages; (2) what are the land tenure issues identified by the villagers; and (3) what are the land tenure issues identified by the proponents and how are they planning to address them? The unit of analysis is the village, and we use data from key informant interviews and focus group interviews held in 23 villages and from six pilot sites in Tanzania prior to REDD+ project implementation, as well as interviews with the NGOs implementing the pilot projects (referred to as the proponents) and project documents. We make no attempt to address the full range of factors determining effectiveness, nor do we address questions of efficiency (costs) and social equity.

The article is organized as follows: Section 2 provides background information on the importance of tenure for the success of REDD+ and how tenure has an impact on community forests; Section 3 presents the study area and methods of data collection and analysis; Section 4 presents the findings of the empirical analysis, followed by discussion and conclusions in Sections 5 and 6.

2. Why Tenure Matters for the Level of Deforestation and Forest Degradation

2.1. Definition and Concepts

Kiser and Ostrom [15] identify three categories of variables that influence how decisions regarding management of natural resources are made: (1) the institutions and rules used by the community to organize resource use; (2) attributes of the goods the natural resource provides; and (3) characteristics of the community.

Institutions and rules include both property and tenure rights. *Property rights* are the "authority to undertake particular actions related to a specific domain" ([16,17], p. 250). Within this context, the word *property* is not restricted to an area of land, but to the full range of benefits derived from a resource. *Tenure* is defined as institutions and rules which regulate property rights and resource use, and determine who can use what resource, under what conditions and for how long [18].

Bromley [19] identifies four possible stylized property rights regimes: (1) open access or non-property; (2) state property; (3) private property; and (4) common property regimes. While a useful first classification, real-life property regimes are more complex. The regimes can overlap with one another and occupy the same physical space, different users can benefit from the same resource, the same resource can provide several different benefits to different rights holders, and *de jure* and *de facto* rights differ.

The focus of this paper is common property regimes, which are governed by two main sets of rules. First, there are access rules to define outsiders and insiders. If there are no such rules, or they are not enforced, the resource is a *de facto* open access regime. Second, there are rules that regulate the use of the resource. Following Baland and Platteau [20], regimes that impose and enforce user rules can be defined as *regulated* common property, while regimes that have no rules or do not enforce them can be defined as *unregulated* common property. We find this distinction useful in the empirical analysis, *i.e.*,

access rules, regulating the external relationship between the group and outsiders, and *user rules*, regulating the internal rules for resource use and management.

The nature of the rights varies: *de jure* rights are based on official laws, while *de facto* rights are based on local practices. The former, statutory tenure system is enforced by governments and recognized by legal, formal institutions, while the latter, customary tenure system is based on oral agreements and tradition [10]. In developing countries, customary regimes often exist alongside the formal legal tenure system [21]. The result of this can be both overlapping and contradicting rights to particular resources. The state claims ownership to most of the forested area in developing countries, while people living in the forest often oppose state control and continue to claim customary rights. They may also co-exist more harmoniously, if statutory rights acknowledge and validate customary claims [10], and the differences between the two classes of rights are not apparent unless the *de facto* rights are challenged [17].

The second category of variables identified by Kiser and Ostrom [15] is the attributes of the goods the natural resource provides. The goods from common pool resources, such as forests and other natural resource systems, are characterized by problems of excludability (ability to exclude competing claimants) and rivalrous consumption. Excludability can be both too costly and/or undesirable, and may lead to problems of overuse and low investment in maintenance. Further, the goods that affect the level of deforestation and forest degradation are characterized by high levels of subtractability or rivalry in consumption. This means negative externalities arise and the resource can be depleted. If common pool resources are managed as common property, the externalities can be internalized [22].

Still, when a group of resource users organizes to manage a resource, collective action problems can occur [13,23,24]. To what extent individuals in a group act to achieve a common interest differs, depending on the incentives to do so. These incentives can be of monetary value or in the form of formal laws and informal norms [25]. This is what we refer to as the *internal factors*. They are related to the third variable identified by Kiser and Ostrom [15]: the characteristics of the community. This includes the strength of village institutions governing the use of forest resources, local leadership and organization, overall level of compliance with forest use rules, rule enforcement and sanctioning of rule breakers and community incentives and interests in organizing community forestry.

2.2. The REDD+ Context

In addition to the Stern Review [1], several studies emphasize the importance of tenure rights clarification for the implementation and success of REDD+, including Sunderlin *et al*. [26], Streck [27], Larson [28], and Corbera and Schroeder [29]. Tenure rights tend to be insecure for communities living in forested areas in the countries where REDD+ projects are implemented. In the 30 most forested countries in the world covering 85% of the global forest estate, the government owns most of the forest estate and the area of forest where communities and indigenous groups have statutory access or ownership rights tends to be small [10]. Customary claims to forest tenure are often unrecognized, leaving people living in forests vulnerable to exploitation [30,31]. To what extent REDD+ will benefit or marginalize forest communities depends on resource tenure arrangements [32] and incentive schemes. In studies on REDD+ and tenure, much focus has been on tenure security and decentralization

of rights from the state to the communities, while less focus has been given to the internal factors, such as community incentives and interests in organizing community forestry.

Identifying the holders of rights and responsibilities in a community are important for the success of REDD+ as well. A core component of REDD+ is to provide incentives to parties who successfully reduce deforestation and forest degradation, but these incentives must be conditional on documented improvement relative to counterfactual scenarios [33]. This is also reflected in the common standards used in the voluntary carbon market, e.g., the VCS [34]. To enable payment of incentives, the responsible party/rights-holders to that benefit stream must be identified. Further, REDD+ can potentially give value to a new commodity, forest carbon; in order to prevent a resource rush, the rights and responsibilities must be legitimate and clear. Lastly, REDD+ will, to varying degrees, reduce certain uses of forest resources, and tenure rights must be clarified in order to make sure pre-existing rights are not violated without due process [8].

2.3. Tenure in Tanzania

All land in Tanzania is held in trust by the president on behalf of the nation [35], and the nation is the only body that can alienate property rights. This means the state is the *de jure* owner of land according to the statutory tenure system. The state has retained exclusion, management, access and withdrawal rights for all land categorized as "Reserved Land". This category is land set aside for special purposes, including forest. For other categories of land, rights are decentralized. For example, Village Land is allocated to villages under long term management agreements and the state is no longer considered to be the statutory manager. On General Lands, the manager is not identified, and forests on General Land are characterized as "open access" [11].

During the period 2002–2008, the area for community forestry increased significantly worldwide at the expense of state property. The same development took place in Tanzania, where the forest area registered and reserved or managed by communities increased from 1% to approximately 10% [10]. This increase was carried out using participatory forest management (PFM). There are two main approaches for PFM in Tanzania that differs in the level of decentralization of rights and responsibility. The first approach, covering the largest area of forested land, is *community based forest management* (CBFM). CBFM takes place on land registered under the Village Land Act [35] and managed by the village council. Village forest reserves are designated by the village and district government and managed by a village natural resource committee, a group or an individual. The village has management responsibility and retains all forest-generated revenue [36]. The second approach is a collaborative management approach, called *joint forest management* (JFM). It takes place on national forest reserves or local government reserves. Forest management responsibility and revenues are divided between the state and the community and formalized through a joint forest management agreement [37].

PFM is an important element of the national framework for REDD+, and access to REDD+ finances might potentially facilitate and speed up the PFM process [11]. The intention of the Village Land Act of 1999 (implemented in 2001) was to protect community land rights and acknowledge the customary tenure system. In the latest draft of The National REDD Strategy [11], on the other hand, the customary tenure system does not seem to be recognized and is in conflict with the statutory rights as phrased in the Village Land Act. The Village Land Act states that Village Land shall consist of

"land, other than reserved land, which the villagers have been, during the twelve years preceding the enactment of this Act regularly occupying and using as village land", and that this applies "whether that demarcation has been formally approved or gazetted or not" as long as the boundaries are agreed upon with the neighboring villages and/or other users of the land ([35], Art. 7). In the latest draft of the National REDD Strategy the Village Land category does not include unregistered land. It is stated that "most of the villages are not yet registered and their lands may be categorized as General Land" ([11], p. 25), and further, that 57% of all forest in Tanzania is on general lands with open access. Whether or not unregistered land within village boundaries is recognized as Village Land has an impact on what tenure arrangements apply to areas designated for REDD+ project activities [38]. Whereas forest reserves on land registered as Village Land can be managed as CBFM with extensive management rights to the communities, forest reserves on general lands are considered state property and should therefore be managed as JFM.

3. Data and Methods

Our data set is part of the Global Comparative Study on REDD+ (GCS-REDD) conducted by the Center for International Forestry Research (CIFOR) and its partners [39]. This is a comprehensive research project on REDD+ projects in nine countries. In this paper, we present research conducted by module 2, which focuses on 23 REDD+ project sites in six countries and aims to understand the effectiveness, efficiency, equity and co-benefits of design and early implementation. It involves collecting both qualitative and quantitative data before and after implementation of REDD+ at the national, project, village and household levels. In selected project sites, we also collect data in villages that are comparable with respect to a set of variables, such as market access and tenure rights, but not engaged in a REDD+ project [40]. These villages function as "control villages", although they may not fully qualify as such in our analysis, given the small number of villages.

In this paper, the units of analysis are projects and villages, and we use information from focus group interviews in 23 villages included in six different REDD+ pilot project sites in Tanzania and proponent appraisals with the five implementing NGOs (Table 1).

We use GCS-REDD baseline data only, collected between March and July 2010, at a very early stage of project implementation. Initially, four villages were selected in each REDD+ project site. In the case of Kilosa, one village had to be dropped because the proponent decided not to include the village in their project at a later stage We interviewed 2–3 key informants in each of the 23 villages, such as village and sub-village chairmen and village executive officers. We also arranged village focus group meetings with 10–15 participants to collect perceptions of forest cover change and tenure security over agricultural and forest resources, causes and drivers of change in forest cover and tenure security, as well as the participation of local population from the early stage of REDD+ project in their different areas and their current perception of the orientations and expectations from REDD+ in terms of livelihoods and conservation. Separate women's group meetings were also conducted, using similar survey instruments to the village focus groups. For some of the questions, this enables us to compare responses from both groups in order to check the consistency of our data. Formal survey interviews with technical staff of the proponent organizations were conducted and we also use project documents publicly available and/or provided by the proponents.

Table 1. Overview of REDD+ Pilot Project Sites Included in the Study.

Abbre-viation	Name of REDD+ project (Region)	Proponent	Description of the project
TaTEDO	Community Based REDD Mechanisms for Sustainable Forest Management in Semi-Arid Areas (Shinyanga)	Tanzania Traditional Energy Development and Environmental Organization	The project is targeting *Ngitili* owners in two different districts in Shinyanga. *Ngitili* is a local word meaning enclosure, and involves conservation of forest, grazing and fodder lands by encouraging vegetation regeneration and tree planting. The project "aims at promoting sustainable natural resource management and reducing greenhouse gas emissions from deforestation and forest degradation from restored Ngitilis. Through this project a robust local institutional framework to help Ngitili owners manage forest and benefit from carbon funds will be established" ([41], p. 4).
TFCG Kilosa	Making REDD work for Communities and Forest Conservation in Tanzania: Kilosa (Morogoro)	Tanzania Forest Conservation Group	The project is implemented in two biodiversity hotspots in Tanzania, and they target areas with relatively moderate levels of deforestation. The project "aims to reduce greenhouse gas emissions from deforestation and degradation in Tanzania in ways that provide direct and equitable incentives to communities to conserve and manage forests sustainably" ([42], p. 2). They will support the development of a community carbon cooperative that will aggregate voluntary emission reductions to be marketed according to internationally recognized standards. The drivers of deforestation and forest degradation in the area include wildfires, shifting cultivation, timber logging, fuel wood collection and charcoal making.
TFCG Lindi	Making REDD work for Communities and Forest Conservation in Tanzania: Lindi (Lindi)		
HIMA	HIMA—Piloting REDD in Zanzibar through Community Forest Management (Unguja/ Zanzibar)	CARE	The project is located in Zanzibar, where the organization has been working since 1995. Their REDD project specifically aims to "promote a pro-poor gender-equitable approach to community forest management in Zanzibar" using Community Forest Management ([43], p. 1). The strategy emphasizes securing property rights and distributing rewards in an equitable manner.
JGI	Building REDD Readiness in the Masito Ugalla Ecosystem Pilot Area in Support of Tanzania's National REDD Strategy (Kigoma)	Jane Goodall Institute	The project is working in the western part of Tanzania, where they plan to work with communities surrounding the Masito Ugalla Ecosystem, which is at this point largely open access. They plan to use participatory methods to assign forest rights and management responsibilities to sections of the Ecosystem so that the communities can capture the benefits of the forests and REDD and the system can be better managed [44].
MCDI	Combining REDD, PFM and FSC certification in South-Eastern Tanzania (Lindi)	Mpingo Conservation and Development Initiative	The project is targeting three causes of deforestation and forest degradation: illegal logging, charcoal burning, and forest fires. They plan to use the revenue generated by REDD credits to maintain accreditation as a carbon credit seller, expanding MCDI's forest certification scheme, provide interim income to communities where timber stocks need time to regenerate, support local fire management regimes, and provide long-term payments to reduce incentive to deforest in the future [45].

The variables from the focus group interviews we used for our analysis is described in Table 2. In addition to the data collected in 2010, we use information from a supplementary survey interview on tenure with the proponents in 2011. Household level data is available for a total of seven villages in two of the sites, but given that community tenure, deforestation and forest degradation are village level issues, we chose to limit our analysis to village and project level only.

Table 2. Overview of the Main Variables Used in the Analysis.

Variable	Definition
Changes in forested areas	Perception of changes in the forest areas between June/July 2008 to June/July 2010. The variable indicates increase, no change or decrease. *Then*, *list the causes of forest cover change in rank order.*
Changes in forest quality	Perception of changes in the quality of the forest between June/July 2008 to June/July 2010. Quality refers to availability of goods and services; density of woody material, forest health, and biological productivity and diversity. The variable indicates increase, no change or decrease. *Then*, *list the causes of forest cover change in rank order.*
Distance to market	Number of kilometers from the village center to the nearest market for durable goods.
Exclusion rights	Exclusion rights indicate that the village has the right to exclude unauthorized outside users from forests within their village boundaries "Yes" indicate that the village focus group perceive that the village has this, either by customary and/or formal/statutory law.
Tenure security	Tenure security is defined as confidence that the households in the village would continue to be able to use all the land and forest they benefit from in at least the next 25 years. A binary variable. "Yes" indicate that the focus group as a community was confident their rights were secure for *all* the areas within the village boundaries and "no" indicate the group was not confident in their rights for at least one area within the village boundaries.
Compliance	Village focus group's perception of the overall village compliance with forest use rules. Three alternative answers: Low (people often do not follow the rules), moderate and high.
Enforcement	Village focus group's perception of whether rules are enforced and rule-breakers sanctioned. Four alternative answers: no or rarely, sometimes/selectively (shortened to "sometimes" in Table 2), often, and always.

Our analysis relies on perception-based assessments of changes in forest cover and quality. Ideally, we would be able to do a validity test of the data, and compare the village focus group's perceptions with biophysical data, but this kind of data is not available to us. Relying on perceptions is not uncommon. In a meta-study of 52 articles comparing community forestry and forest conservation, Casse and Milhøj [46] found that 21 depended on perception based assessments of forest changes. When comparing forest conservation outcomes reported in the studies (positive, ambiguous, negative, none), they find no significant difference between inventory, remotely sensed, and perception based data.

We collected data in six project sites, covering six of the nine REDD+ project sites launched in Tanzania. While only 10% of the forested area is under some form of community management [10], all the project sites in our study involve community user rights of forests either by statutory and/or

customary law. Thus, the sites are not representative for the overall forest tenure conditions in the country. However, since PFM is an important element of the national framework for REDD+, our results provide useful insight for the ongoing REDD+ process as we cover a significant share of the REDD+ pilot projects launched to date. To assess the representativeness of our intervention (pilot) villages, we compare some of them with the control villages in Kahama and Kilosa.

Deforestation and forest degradation are not taking place in all villages included in the REDD+ pilot projects in our sample, and focus groups in some villages report that both the forested area and the quality of the forest are increasing. This may indicate that some of the REDD+ projects are undertaken in areas where forests are already managed relatively well. It may also be an indication of at least partial success of efforts to reduce deforestation and forest degradation—either by the proponent organization or by other organizations—that predate REDD+. This has implications for REDD+ and the degree of additionality, as well as the potential to scale-up the pilot experiences to other more challenging areas. When selecting villages to include in their projects, some of the proponents included in our sample targeted villages where tenure rights to land and forests were relatively clear, and areas where deforestation and degradation were not severe. This makes sense, given the costs and difficulties of implementing a project in an area where borders are contested. We know of at least two instances of villages that had to be excluded from the REDD+ projects due to border disputes that the NGOs were not able to solve. Choosing areas with moderate levels of deforestation and forest degradation in the pilot phase also makes sense, given limited budgets and high opportunity costs of forest conservation in areas where deforestation and forest degradation is severe.

4. Results

4.1. Extent and Drivers of Deforestation and Forest Degradation

We asked the village focus groups about their perceptions of changes in the forested areas and the quality of the forests within their village boundaries compared to two years prior to our visit. With the exception of MCDI in Kilwa and JGI in Kigoma, a majority of the village focus groups in each site claimed that the forested area within the village boundary had decreased (see Table 3 for details). Only a third of the village focus groups reported a decrease in the quality of the forest. When asked to describe the change in forest quality, their main concerns were a decrease in trees in general and particularly large trees.

We asked the group to list the agents of forest cover change in rank order. Fourteen of the 15 focus groups that reported a decrease in net forested area within their village boundaries said that the main agents of deforestation were the villagers themselves. Other responses were drought, forest fires and harvest of forest products by people from neighboring villages. We also asked whether there were particular underlying driving forces related to the forest cover changes. The need for new agricultural land was the most frequently mentioned driver of deforestation, while increased demand and prices of forest products such as charcoal and building poles were ranked second. Other driving forces mentioned were lack of rule enforcement, lack of rules in general, lack of knowledge of conservation and population pressure. When asked about the causes of forest quality change (degradation), the villagers said they themselves were the main agents, mentioned in all seven villages reporting a decrease in

overall quality of the forest, while people from neighboring villages were mentioned as the second most important cause in three of the villages. Driving forces related to reduction in forest quality were lack of rules and rule enforcement in four of the seven villages, while increased profitability from charcoal production were the driving force in the remaining three villages. The groups reporting an increase in forested area and/or quality in the JGI site said this was due to conservation education, while the village in TaTEDO's site emphasized strong rules as a driver for the increase in the forested area. The groups reporting an increase in the overall quality of the forest also emphasized the role of conservation education. Reduced frequency or lack of forest fires and strong rule enforcement was other causes mentioned by the village focus groups.

Table 3. Overview of Study Villages. Market Access, Institutions and Rules, and Perceived Changes in Forest Cover and Quality.

Village	Distance to market (in km)	Tenure secure for all land	Have exclusion rights	Overall level of forest user rule compliance	Forest user rules are enforced and sanctioned	Change in area of forest	Change in quality of forest
Tatedo_1	13	No	Yes	High	Always	Decreased	Decreased
Tatedo_2	4	Yes	Yes	High	Always	Decreased	Decreased
Tatedo_3	18	No	Yes	Moderate	Often	Decreased	Decreased
Tatedo_4	15	Yes	Yes	High	Always	Increased	Increased
TFCG_K1	30	Yes	Yes	Moderate	Often	No change	No change
TFCG_K2	10	Yes	Yes	Moderate	Sometimes	Decreased	Decreased
TFCG_K3	32	No	No	Low	No/rarely	Decreased	Decreased
TFCG_L1	40	No	Yes	Low	No/rarely	Decreased	Decreased
TFCG_L2	40	Yes	Yes	Low	No/rarely	Decreased	No change
TFCG_L3	29	No	Yes	Moderate	*Missing*	No change	No change
TFCG_L4	10	Yes	Yes	Moderate	Always	Decreased	No change
HIMA_1	65	No	Yes	High	Always	Decreased	Decreased
HIMA_2	4	Yes	Yes	High	Sometimes	No change	No change
HIMA_3	64	Yes	Yes	High	Sometimes	Decreased	Increased
HIMA_4	53	No	Yes	High	Sometimes	Decreased	Increased
JGI_1	10	Yes	Yes	Moderate	Sometimes	Decreased	Increased
JGI_2	40	Yes	Yes	High	Sometimes	Increased	Increased
JGI_3	170	Yes	Yes	High	No/rarely	Decreased	Increased
JGI_4	26	Yes	Yes	High	Sometimes	Increased	Increased
MCDI_1	26	Yes	Yes	High	*Missing*	Decreased	No change
MCDI_2	0	Yes	Yes	Moderate	Often	Decreased	No change
MCDI_3	5	Yes	Yes	Moderate	Always	No change	No change
MCDI_4	15	Yes	Yes	Moderate	Always	No change	Increased
Total	31.3	7 no 16 yes	1 no 22 yes	3 low 9 moderate 11 high	4 no/rarely 7 Somet. 3 often 7 always	3 increased 5 no change 15 decrease	8 increased 8 no change 7 decreased

In order to check the validity of the data, we compared the responses from the village focus group to the responses from the women's focus group in the same village. In some cases, the groups disagree

on the direction of overall changes in forest cover and quality, but the responses from women's groups support the findings on the agents of deforestation and forest degradation. All the women's groups that reported a decrease in the net forested area said the main agent of deforestation was the villagers. The same is true for twelve of the 15 groups that reported a decrease in the quality of the forest.

Access to markets is commonly found to be an enabling factor for marketing of forest goods, such as timber and charcoal, and thus market access can be an important driver of forest degradation. When calculating the mean distance to the nearest market for durable goods, we find that villages experiencing degradation are on average closer to the market compared to villages that did not experience degradation (26 compared to 32 km). The pattern is different when we look at distance and change in forest area: the villages experiencing deforestation are on average the most market remote (37 km compared to 20.5 km).

4.2. What Are the Land Tenure Issues Identified by the Villagers?

In order to identify critical tenure issues in the REDD+ sites, we asked about both external and internal tenure factors. We asked each focus group about their perception of their right to exclude unauthorized users of forest areas within their boundaries (Table 3). Twenty two of the 23 villages concluded that they have this right either by customary (18 villages) or statutory law (four villages). With the exception of two villages, the focus groups also claim their villages can enforce this right, and that they are *usually* able to exclude unauthorized users as needed. In total, only three villages reported unsuccessful attempts to exclude unwanted outsiders' using their forest over the two years prior to our visit. This is in line with the responses analyzed in the previous section, where we found that pressure from outsiders was less of an issue in the study sites than the villagers themselves. In order to assess the representativeness of our villages relative to non-pilot REDD+ villages, we compared these findings with data from eight control villages in Kahama and Kilosa. Six of the eight control villages report that they have exclusion rights, three by statutory law and three by customary law. The two villages without exclusion rights claim that there are no unwanted outsiders and in neither of these villages are there external users to the village using the forest.

While we recognize there are intra-village threats to household's tenure security, the variable included in the analysis captured external threats to tenure security only (Table 2). Sixteen out of 23 of the focus groups responded that they were confident about their rights to continue to use *all* the land within their village boundaries, while the focus groups in seven villages were not confident about their rights for at least a part of the land within the village boundaries. In four of these villages, the area of land perceived to be insecure was in places where the government was the statutory owner/manager of the land. The focus groups were not sure the households in the village would be able to continue to use the areas because the village did not hold a title to the areas (two villages) or that there were restrictions on land use by the government and that it might be taken away from the village (two villages). In the remaining three villages, the focus groups claimed that the community was the statutory owner/manager of the land and that the land was used by the community and not individual households. Yet, the focus groups in all three villages said that these rights could be easily revoked. One focus group worried that if they did not work the land, the government would take it. Among the control villages in Kilosa and Kahama, five villages (out of eight) perceive their tenure rights as secure against external threats for *all*

the village land, while three villages perceive their rights as insecure for a share of the land. Although our sample of control villages is small and not matched to all study sites, we believe the findings from the sampled villages have broader relevance for how people in villages with community user rights in Tanzania perceive the external tenure situation.

With respect to internal tenure conditions, the level of village compliance with forest use rules is high in eleven villages, while it is moderate or low in the remaining twelve. Both TFCG sites have relatively low levels of compliance. Rules are enforced and rule-breakers sanctioned in an even smaller share of the villages, but there are large variations across sites. Both the TaTEDO and MCDI sites can be characterized by high level of rule enforcement, while the same is not true for the JGI site and the TFCG sites. Our overall findings on the internal factors, compliance and enforcement, indicate that the local institutions are weak in some of the villages. This is in line with the findings in the previous section, where lack of rule enforcement and lack of rules in general was mentioned by several of the village focus groups as the main reasons for deforestation and forest degradation.

In order to see how the external and internal factors are linked with forest outcomes, we compare the four tenure variables across villages experiencing either increasing or decreasing forest area/quality. Overall, we find that a higher share of the villages experiencing an increase in the forested area/quality had exclusion rights, tenure security and compliance with forest user rules compared to villages that experienced a decrease in forest area/quality. We see that the three villages experiencing an increase in the forested area had favorable external tenure conditions; they all had exclusion rights and they perceived their tenure rights as secure. The same is true for the eight villages that experienced an increase in the quality of their forests, except for one village that was not tenure secure for all land within the village boundaries. The level of compliance with forest use rules is also clearly higher in villages where area and quality increased compared to the villages where it decreased. Most of the villages experiencing a decrease in the forested area had unfavorable internal tenure conditions (low level of compliance and enforcement) compared to the villages that experienced an increase in the forested area, but there are noteworthy exceptions among these villages. Two villages that experienced decreased area had favorable internal tenure conditions with high levels of rule compliance and were always enforcing rules. They were, however, among the villages that were not tenure secure.

4.3. What are the Land Tenure Issues Identified by the Proponents and How are They Planning to Address Them?

All proponents acknowledge that there have been issues regarding tenure over land, forests or carbon that require their attention, and all the proponents have attempted to address these issues. The proponents already have introduced (or plan to introduce) restrictions on the use of village land, forests and resources. The nature of these restrictions will differ across the sites, and include establishing community forest reserves, forest patrols undertaken by villagers, and measures to reduce charcoal production. These responses are presented in Table 4.

The most frequently mentioned issues are related to the external tenure conditions, such as lack of tenure clarity to both forest and carbon in the national policies, length of management agreements, village land certificates and unclear village boundaries. Issues related to the internal tenure conditions are mentioned less frequently, two exceptions being elite capture in the HIMA project in Zanzibar, and

how logging and livelihood needs undermine sustainable forest management in the MCDI site in Kilwa.

Table 4. Changes in Resource Use and Tenure Issues Identified by the Proponents.

Site	Undertaken (U) or planned (P) restrictions on village land, forest or resource use	Tenure challenges that have required attention by the proponents
TaTEDO	Reduced land for grazing, especially for outsiders who used to bring big number of cattle to the project villages (U). Reduced charcoal making in ngitilis included in the project (U).	Lack of clarity on rights of communities to directly access benefits from carbon credits attributable to their village land. There is no policy to ensure that villages retain ownership over carbon in their forests.
TFCG Kilosa and Lindi	Have set up community forest reserves, but these are restrictions agreed to by community (U).	National policy unclear on who owns/has the right to access revenues from carbon. Classification of land as village land rather than general land. Most villages do not have land certificates yet need them for REDD. To get certificates villages must develop land use plans. In Kilosa village boundaries defined years ago but not done well and this is causing conflict.
HIMA	Land use zoning, forest patrolling, environmental education *etc*. (P)	In the past, local leaders have taken advantage of customary practice to give favors to the elite. Need for stability and transparency for REDD; modify CFM template from 5 to 20 years.
JGI	Village patrols regulate but do not restrict forest use. It is up to villagers to decide what to do (U). We will facilitate the restrictions by villagers and will not impose ourselves. This might have some negative effect on livelihoods (P).	There is need for clarification of ownership by CBOs. The time frame of the tenure is unclear. Forest law can say 99 years but land law can say 3 years.
MCDI	Forest is set aside in all villages (U). Limited logging rotation period, prohibition against hunting, fire restrictions, reduced forest clearing for agriculture, and reduced charcoal production (P).	The government did not map village boundaries accurately. People engaged in logging undermine sustainable forest management. There is a boundary dispute between 2 villages, mediation has not solved it. There was a land purchase deal that went awry.

In all the villages where restrictions were already introduced, the villagers have in one way or another been part of designing the management plan. HIMA at Zanzibar had not yet introduced restrictions at the time of the interview (May–June 2011), but did plan to do so in a participatory

manner. Development of land use plans is a first step for villages to attain certificates to the land within the village boundaries.

In addition to the interventions planned and implemented related to strengthening tenure rights (both formalizing the devolved rights and strengthening internal village forest management), all proponents are also planning/implementing interventions to reduce household demand for forest products and/or support livelihoods through alternative income-generating activities. This includes introduction of fuel efficient stoves to reduce the demand for fuel wood in the village, beekeeping for honey production, agricultural extension services to improve productivity and small scale solar- and bio-plants to support business activities such as charging electric devices and bakeries. Some of the livelihood enhancements are non-conditional (requiring no forest protection activities as basis for obtaining the benefit), whereas some are conditional.

5. Discussion

5.1. Internal Drivers of Deforestation, Market Drivers of Forest Degradation

Given that we rely on perceptions of changes in forest cover and quality rather than quantitative assessments the results linking forest outcome and control should be interpreted with caution. The fact that a higher share of the villages with improved forest outcomes report that they have favorable external and internal tenure conditions can be biased by strategic answering or a tendency of villages that perceive to be in control also are more likely to perceive improved forest outcomes. On the other hand, in subjective reporting, we would expect the focus groups to be biased toward blaming others. The main issues in the villages where the participants in the focus group perceive a decrease in forested area and/or quality are the internal factors, with low levels of compliance and rule enforcement. Adding to this, they do not blame others for causing the negative changes, but rather report that they are responsible themselves for the activities causing deforestation and forest degradation.

In a meta-analysis of forest cover change studies, Rudel [47] found that state-initiated deforestation shifted to enterprise-driven deforestation in Asia and Latin America between 1970 and 2000. Large-scale agricultural producers and cattle ranchers expanded at the expense of forests, while in many countries in Africa, smallholders are the main source of deforestation. In our study sites in Tanzania we find the same. Large enterprises are not the main drivers of deforestation and forest degradation, nor is it caused by migrants or colonists from outside. We find that both deforestation and forest degradation are mainly caused by actions by the villagers themselves. Deforestation is mainly driven by household food and income needs. Our findings are in line with other studies from Tanzania, such as Fisher *et al*. [48]. Over the last decade, population has increased by 2.6%–3.0% per year [49], and although agricultural productivity has also increased [50], there has still been a need for more crop land. We generally find this to be the situation in our sampled villages as well.

The dynamics for deforestation in the villages included in our sample are different from those of forest degradation. While deforestation is driven by subsistence needs in the form of higher demand for agricultural land because of population growth, degradation is primarily driven by the market demand for charcoal. Firewood is the main energy source in rural households, while the urban population is still reliant on charcoal for cooking [48]. Making and selling charcoal is prohibited in

most of the villages, even in the private *ngitilis* in Kahama, but the rules are not enforced and/or the income generated from the activity is worth the risk of getting caught and fined, as production of charcoal is an important income source for many households. Previous efforts to halt the unregulated production of charcoal have been unsuccessful, due to both protests from the urban consumers and lack of incentives and capacity to monitor and enforce regulations at the local level [51].

5.2. Mismatch Between Local Perceptions and Proponents' Interventions?

The second major finding is the apparent mismatch between what villagers and proponents perceive as critical tenure issues in halting deforestation and forest degradation at the early stage of project implementation. While proponents have their main focus on formalizing and strengthening the external, devolved rights, village focus groups identify internal, collective action issues such as low level of compliance with forest use rules and lack of enforcement as the underlying drivers of deforestation and forest degradation. The focus groups perceive the land rights of the village secure for the next 25 years in a majority (70%) of the villages, and a higher share of the village focus groups also perceive they have the rights to decide who can and cannot access the forest within the village boundaries. This indicates that there is a discrepancy between what proponents and villages identify as pressing tenure issues in the early implementation phase of REDD+.

To limit deforestation and forest degradation, our findings indicate that both external and internal tenure arrangements must be favorable. Tenure security and enforceable rights of exclusion are important because REDD+ presumes local stakeholders are responsible for forest management and can protect forests without outside interference. Further, all villages that experienced an increase in the forested area over the past two years perceive their rights as secure, that they have the right to decide who can and cannot access their forests and that they are able to exercise this right, and the same is true for all but one of the villages experiencing an increase in the quality of the forest. This supports the theory that favorable external tenure conditions are enabling factors for effective forest management at the local level in Tanzania. Perhaps surprisingly, neither tenure security or exclusion rights are reported to be a major problem by the focus groups in the villages in our sample. Whereas perceptions do not necessary reflect villages' formal, *de jure* rights, perceptions are important because they shape the actions of the villagers.

The picture is different when considering the internal tenure conditions. Gibson *et al*. [52] argue that local enforcement of rules is necessary for successful resource management. Weak institutions at the local level seem to be a limiting factor for effective forest management and lead to collective action challenges in the REDD+ project sites as well. In our sample, eleven of the villages that perceived a decrease in the forested area have low or moderate compliance and/or sometimes no enforcement of forest use rules. Compliance with forest use rules and sanctioning of rule-breakers are important indicators of whether the village institutions are strong enough to ensure sustainable management of the forests within the village boundaries. With the enforcement variable we measure to what extent the village leadership institutions are *able* to enforce the forest use rules and sanction rule breakers, but the answer we get may also reflect to what extent there is a *need* for enforcement and sanctioning in the village. Among the eleven villages reporting low enforcement (no/rarely or sometimes/selectively) six state that the levels of compliance with forest use in the village is high. In these villages, there may be

less need for enforcement of forest user rules, and/or it may not be necessary because the rules regulating forest use are few.

In the process of attaining a certificate for the land within their boundaries, the village develops a land use plan. Most of the villages in our sample already had village rules and regulations dictating which forested areas could be accessed and which products could be harvested for subsistence and/or commercial purposes prior to REDD+ implementation. REDD+ interventions may provide additional incentives to conserve the forest, but strengthening of existing village institutions is needed in order to be able to achieve compliance and enforcement of the rules and regulations in the plan. Judging from the responses from the proponents during the early phase of implementation, there does not seem to be an immediate plan as to how to achieve this. Most of the focus appears to have been on ensuring the decentralization of tenure rights from the government level to the village level, while less focus has been on internal tenure issues.

5.3. Explaining the Apparent Mismatch

Without making an attempt to single out which is the most important, we identify four possible explanations to this mismatch. First, proponents understand the need to clarify and formalize local tenure arrangements as a requirement for stable forest management in REDD+, whereas village stakeholders, because they are not the initiators of REDD+, do not have this in mind. Villagers might underestimate the future external threats to their forest resources as REDD+ proceeds and the value of the forest increases, while the project proponents are aware of this, and are concerned about fulfilling the legal and administrative requirements for securing the villages' *de jure* tenure rights. Most of the village focus groups in our sample consider land and forests within their village boundaries as their own unless there is a government forest reserve. Previous mapping and boundary demarcation between villages has not necessarily been successful, and in the process of making land use plans as a step in the process of formalizing the villages' *de jure* rights, several of the proponents discovered unclear boundaries between villages, including TFCG in their site in Kilosa and MCDI in Kilwa. Further, forested land within customary village boundaries is not necessarily recognized as village land in the Tanzania National Strategy for REDD+ [11]. Community rights to forests and land within their village boundaries are weak in the latest draft, and land is categorized as open access general lands unless it is registered (gazetted). Thus, villager perceptions are likely to mainly be based on past experiences, which may not fully reflect the security and rights in the future if conflicts over forest land and its resources and services should arise due to REDD+.

The second possible explanation of the mismatch is that the proponents underestimate the threats from internal, collective action challenges in the villages within their project boundaries at the very early stage of project implementation. While strengthening of tenure rights is important to ensure reduced deforestation and forest degradation, it is also important to keep in mind the importance of forest products for people's livelihoods and the need for new cropland. REDD+ will ultimately rely on reducing the amount of land cleared for agricultural purposes and harvest of forest products. Agricultural extension advice and increased productivity may lead to reduced demand for agricultural land to support household needs and thus reduce deforestation, but may also have the opposite effect as the value of agricultural land increases. Although the key idea of REDD+ is to make forest conservation

more beneficial to local users compared to forest conversion and unsustainable use, it might be that the current and planned benefits of keeping forests are simply too small. Similarly, the short term benefits of unsustainable harvesting might outweigh the long term benefits of sustainable forest management. REDD+ interventions can alter this benefit–cost calculation of forest users, for example, by paying individual households for retaining forests (PES), as TFCG is doing in their sites in Lindi and Kilosa. Alternatively, it can be achieved by reducing the need for forest products in local livelihoods, as TaTEDO is doing by introducing improved stoves in their site in Kahama in order to reduce the amount of fuel wood needed for cooking. Introduction of beekeeping and other alternative livelihood activities may also replace lost income from charcoal production. Whether the sum of these measures will be able to reduce the rate of deforestation and forest degradation in the villages remains to be seen.

The third possible explanation for the mismatch is that by focusing on external factors and the formalization of the villages' *de jure* tenure rights at the early stage of implementation, the proponents might gain more collaboration from the villages within their project boundaries, rather than initiate conflict by interfering in the internal resource management regime in the village.

This is closely linked with the fourth and final explanation: the role of the proponents. Studies of common property institutions have highlighted the importance of locally designed access and management rules [53]. Against this backdrop, to what extent can external agents initiate change to community management tenure regimes? It might as well be that the proponents are better able to initiate change at the national level.

On the basis of the data available, we cannot give weights to the relative importance of these four explanations. Further investigation is needed on the apparent mismatch between villagers' perceptions and proponents' planned activities. We feel confident that this mismatch applies beyond our sample villages, *i.e.*, that the mismatch cannot fully be explained by selection biases of proponents' location of REDD pilot projects. Proponents are expected to select villages with a minimum degree of community organization (in order to have local partners), and proponents have had pre-REDD+ activities in some of the villages. Thus if anything, we expect the internal conditions to on average be better than in the full population of forest villages in Tanzania. As for external pressure, proponents may follow a triage principle in the selection [54]. We can then expect some of the high (external) pressure (and high deforestation/degradation) villages to be excluded as making a difference will simply be too difficult. However, the most remote locations are also expected to be excluded as the forest pressure is low and therefore with limited scope to make a difference.

6. Conclusions

Unclear and weak tenure arrangements jeopardize the realization of project goals, thus it is generally agreed by all parties that tenure clarification (where it is unclear) is key to achieving effectiveness (and equity) in REDD+. This is true for REDD+ proponents in Tanzania, and we find that formalization and securing tenure rights from the state to the village level is high on the agenda in the early phase of implementation.

Although a majority of the villages perceive their tenure rights as secure and assume they have the right and ability to decide who can and cannot access the forest within the village boundaries, their perceptions do not necessarily reflect their *de jure* rights. Land within village boundaries is not

necessarily recognized as Village Land in the Tanzania National REDD+ Strategy, and as REDD+ proceeds and the value of the standing forest increases, communities' *de jure* tenure rights can be more important and knowledge of these rights can change villagers' perceptions of security. This justifies the proponents' emphasis on formalizing village tenure rights.

Without underestimating the importance of tenure security and enforceable exclusion rights, we also emphasize that there should be a greater focus on strengthening village institutions to ensure higher levels of compliance and enforcement of forest user rules. Data indicate that the main threat to the effectiveness of REDD+ in the pilot sites in Tanzania is from activities undertaken by the villagers themselves, not outsiders. These circumstances mean concern about external claimants on local forests is less a concern than claims within project boundaries. The need for agricultural land to cover subsistence needs is a main cause of deforestation while degradation is mainly caused by charcoal demand from nearby towns, providing a possible source of cash income from production and sale for households in the villages. In many of the villages, these activities were prohibited prior to REDD+ project implementation. The REDD+ projects will introduce measures to increase agricultural productivity and various incentives that include forest access restrictions, fuel efficient stoves, alternative livelihood activities and payment for environmental services. These interventions are both important and necessary, but lack of compliance and enforcement of village forest use rules was prevalent in villages experiencing deforestation and/or forest degradation. This problem needs to be tackled side-by-side with the process of tenure formalization with the state, if REDD+ implementation is to succeed.

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Conflicts of Interest

The authors declare no conflict of interest.

References

1. Stern, N. *The Stern Review*: *The Economics of Climate Change*; Cambridge University Press: Cambridge, UK, 2006.
2. Angelsen, A.; with Brockhaus, M.; Kanninen, M.; Sills, E.; Sunderlin, W.D.; Wertz-Kanounnikoff, S. *Realising REDD+*: *National Strategy and Policy Options*; Center for International Forestry Research (CIFOR): Bogor, Indonesia, 2009.

3. Forest Carbon Partnership Facility REDD+ Country Participants. Available online: http://www.forestcarbonpartnership.org/redd-country-participants (accessed on 10 April 2013).
4. REDD+ initiative in Tanzania. Available online: http://www.reddtz.org (accessed on 10 April 2013).
5. CCBA. *Climate*, *Community and Biodiversity Project Design Standards*, 2nd ed.; The Climate, Community, and Biodiversity Alliance: Arlington, VA, USA, 2008.
6. Pagdee, A.; Kim, Y.-S.; Daugherty, P.J. What makes community forest management successful: A meta-study from community forests throughout the world. *Soc*. *Nat*. *Resour*. **2006**, *19*, 33–52.
7. Westholm, L.; Biddulph, R.; Hellmark, I.; Ekbom, A. *REDD+ and Tenure: A Review of the Latest Developments in Research, Implementation and Debate*; Focali: Gothenburg, Sweden, 2011.
8. Sunderlin, W.D.; Larson, A.; Duchelle, A.E.; Resosudarmo, I.A.P.; Huynh, T.B.; Abdon, A.; Dokken, T. How are REDD+ proponents addressing tenure problems? Evidence from Brazil, Cameroon, Tanzania, Indonesia, and Vietnam. *World Dev*. **2014**, *55*, 37–52.
9. Agrawal, A.; Chhatre, A.; Hardin, R. Changing governance of the world's forests. *Science* **2008**, *320*, 1460–1462.
10. Sunderlin, W.; Hatcher, J.; Liddle, M. *From Exclusion to Ownership? Challenges and Opportunities in Advancing Forest Tenure Reform*; Rights and Resources Initiative: Washington, DC, USA, 2008.
11. United Republic of Tanzania. *National Strategy for Reduced Emissions from Deforestation and Forest Degradation (REDD+)*; Second Draft, June 2012; The Vice President's Office: Dar Es Salaam, Tanzania, 2012.
12. Feder, G.; Feeny, D. Land tenure and property rights: Theory and implications for development policy. *World Bank Econ*. *Rev*. **1991**, *5*, 135–153.
13. Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*; Cambridge University Press: New York, NY, USA, 1990.
14. Ostrom, E. *Understanding Institutional Diversity*; Princeton University Press: Princeton, NJ, USA, 2005.
15. Kiser, L.L.; Ostrom, E. The Three Worlds of Action: A Metatheoretical Synthesis of Institutional Approaches. In *Strategies of Political Enquiry*; Ostrom, E., Ed.; Sage: Beverly Hills, CA, USA, 1982.
16. Commons, J. *Legal Foundations of Capitalism*; University of Wisconsin Press: Madison, WI, USA, 1968.
17. Schlager, E.; Ostrom, E. Property-rights regimes and natural resources: A conceptual analysis. *Land Econ*. **1992**, *68*, 249–262.
18. FAO. *Forest Tenure Assessment*; The Food and Agriculture Organization of the United Nations: Rome, Italy, 2009.
19. Bromley, D.J. *Environment and Economy: Property Rights and Public Policy*; Blackwell: Oxford, UK, 1991.
20. Baland, J.-M.; Platteau, J.-P. *Halting Degradation of Natural Resources*: *Is There a Role for Rural Communities?* Food and Agriculture Organization of the United Nations: Rome, Italy, 1996.

21. Elbow, K.; Furth, R.; Knox, A.; Bohrer, K.; Hobbs, M.; Leisz, S.; Williams, M. Synthesis of Trends and Issues Raised by Land Tenure Country Profiles of West African Countries, 1996. Research Paper No 130. In *Country Profiles of Land Tenure*: *Africa 1996*; Bruce, J., Ed.; Land Tenure Center, University of Wisconsin: Madison, WI, USA, 1998. Available online: http://pdf.wri.org/ref/elbow_98_synthesis.pdf (accessed on 1 November 2009).
22. Demsetz, H. Toward a theory of property rights. *Am*. *Econ*. *Rev*. **1967**, *57*, 347–359.
23. Ostrom, E. How types of goods and property rights jointly affect collective action. *J*. *Theor*. *Polit*. **2003**, *15*, 239–270.
24. Ostrom, E. A general framework for analyzing sustainability of social-ecological systems. *Science* **2009**, *325*, 419–422.
25. Reynolds, T.W. Institutional determinants of success among forestry-based carbon sequestration projects in Sub-Saharan Africa. *World Dev*. **2012**, *40*, 542–554.
26. Sunderlin, D.; Larson, A.M.; Cronkleton, P. Forest Tenure Rights and REDD+: From Inertia to Policy Solutions. In *Realising REDD+*: *National Strategy and Policy Options*; Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W.D., Wertz-Kanounnikoff, S., Eds.; Center for International Forestry Research (CIFOR): Bogor, Indonesia, 2009; pp. 139–149.
27. Streck, C. Rights and REDD+: Legal and Regulatory Considerations. In *Realising REDD+*: *National Strategy and Policy Options*, Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W.D., Wertz-Kanounnikoff, S., Eds.; Center for International Forestry Research (CIFOR): Bogor, Indonesia, 2009; pp. 151–162.
28. Larson, A.M. Forest tenure reform in the age of climate change: Lessons for REDD+. *Glob*. *Environ*. *Chang* **2011**, *21*, 540–549.
29. Corbera, E.; Schroeder, H. Governing and implementing REDD+. *Environ*. *Sci*. *Policy* **2011**, *14*, 89–99.
30. Larson, A.; Barry, D.; Cronkleton, P.; Pacheco, P. *Tenure Rights and Beyond*: *Community Access to Forest Resources in Latin America*. *Occasional Paper No*. *50*; Center for International Forestry Research (CIFOR): Bogor, Indonesia, 2008.
31. Larson, A.; Barry, D.; Dahal, G.R.; Colfer, C.J.P. *Forests for People*: *Community Rights and Forest Tenure Reform*; Earthscan: London, UK, 2010.
32. Cotula, L.; Mayers, J. *Tenure in REDD-Start-Point or Afterthought?* Natural Resource Issues No. 15; International Institute for Environment and Development: London, UK, 2009.
33. Angelsen, A.; Wertz-Kanounnikoff, S. What are the Key Design Issues for REDD and the Criteria for Assessing Options? In *Moving Ahead with REDD*: *Issues*, *Options and Implications*; Angelsen, A., Ed.; Center for International Forestry Research (CIFOR): Bogor, Indonesia, 2008; pp. 11–21.
34. Verified Carbon Standard. Available online: http://www.v-c-s.org/ (accessed on 9 January 2014).
35. United Republic of Tanzania. *The Village Land Act, 1999*; The United Republic of Tanzania: Dar Es Salaam, Tanzania, 1999.
36. United Republic of Tanzania. *Community Based Forest Management Guidelines*; Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism: Dar Es Salaam, Tanzania, 2007.

37. United Republic of Tanzania. *Joint Forest Management Guidelines*; Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism: Dar Es Salaam, Tanzania, 2007.
38. MJUMITA and TFCG Policy Brief: A One-Step Guide to Making the National REDD Strategy More Pro-poor. Dar Es Salaam, Tanzania, 2011. Available online: http://www.tfcg.org/pdf/MJUMITA%20and%20TFCG%20Policy%20Brief%20on%20Land%20Issues%20and%20REDD.pdf (accessed on 5 November 2011).
39. Global Comparative Study on REDD+. Available online: http://www.cifor.org/gcs/global-comparative-study-on-REDD.html (accessed on 6 January 2014).
40. Sunderlin, W.D.; Larson, A.M.; Duchelle, A.; Sills, E.O.; Luttrell, C.; Jagger, P.; Pattanayak, S.; Cronkleton, P.; Ekaputri, A.D. *Technical Guidelines for Research on REDD+ Project Sites*; Center for International Forestry Research (CIFOR): Bogor, Indonesia, 2010.
41. TaTEDO. *Community Based REDD Mechanisms for Sustainable Forest Management in Semi-Arid Areas (Case of Ngitilis in Shinyanga Region)*; Project Proposal; Tanzania Traditional Energy Development and Environment Organization: Dar Es Salaam, Tanzania, 2009.
42. TFCG and Mjumita. *Making REDD and the Carbon Market Work for Communities and Forest Conservation in Tanzania*; Project Proposal Tanzania Forest Conservation Group and Mjumita: Dar Es Salaam, Tanzania, 2009.
43. CARE. *HIMA-Piloting REDD in Zanzibar through Community Forest Management*; Project Proposal; CARE International in Tanzania: Dar Es Salaam, Tanzania, 2009.
44. *JGI Building REDD Readiness in the Masito Ugalla Ecosystem Pilot Area in Support of Tanzania's National REDD Strategy Project Proposal*; The Jane Goodall Institute: Dar Es Salaam, Tanzania, 2009.
45. MCDI Combining REDD, PFM and FSC Certification in South-Eastern Tanzania. *A Proposal Submitted to the Royal Norwegian Embassy in Dar Es Salaam and the National REDD Taskforce*; Mpingo Conservation and Development Initiative: Kilwa Masoko, Tanzania, 2009.
46. Casse, T.; Milhøj, A. Community forestry and forest conservation: Friends or strangers? *Environ*. *Policy Govern*. **2011**, *21*, 83–98.
47. Rudel, T.K. Changing agents of deforestation: From state-initiated to enterprise driven processes, 1970–2000. *Land Use Policy* **2007**, *24*, 35–41.
48. Fisher, B.; Lewis, S.L.; Burgess, N.D.; Malimbwi, R.E.; Munishi, P.K.; Swetnam, R.D.; Kerry Turner, R.; Willcock, S.; Balmford, A. Implementation and opportunity costs of reducing deforestation and forest degradation in Tanzania. *Nat*. *Clim*. *Change* **2011**, *1*, 161–164.
49. World Bank Data-indicators-population growth (annual %). The World Bank: Washington, DC, USA. Available online: http://data.worldbank.org/indicator/SP.POP.GROW (accessed on 22 May 2013).
50. Pauw, K.; Thurlow, J. Agricultural growth, poverty, and nutrition in Tanzania. *Food Policy* **2011**, *36*, 795–804.
51. *World Bank Enabling Reforms: A Stakeholder-Based Analysis of the Political Economy of Tanzania's Charcoal Sector and the Poverty and Social Impacts of Proposed Reforms*; The World Bank: Washington, DC, USA, 2010.
52. Gibson, C.C.; Williams, J.T.; Ostrom, E. Local enforcement and better forests. *World Dev*. **2005**, *33*, 273–284.

53. Agrawal, A. Common property institutions and sustainable governance of resources. *World Dev*. **2001**, *29*, 1649–1672.
54. Noss, R.; Nielsen, S.; Vance-Borland, K. Prioritizing Ecosystems, Species, and Sites for Restoration. In *Spatial Conservation Prioritization*: *Quantitative Methods and Computational Tools*; Moilanen, A., Wilson, K.A., Possingham, H., Eds.; Oxford University Press: London, UK, 2009.

PAPER 3

Forest reliance across poverty groups in Tanzania

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Abstract

An emerging body of knowledge has established that poorer households are generally more forest reliant (higher income share) while richer households extract more and generate higher absolute forest environmental income. These studies commonly categorize households based on observed income in cross-section data, presenting a snap-shot reflecting both inter-household and inter-annual income variation. This paper use household data from Tanzania and categorize households based on a combination of the observed one-year income and predicted income. This enables us to discuss some aspects of poverty, normally confined to analysis of poverty dynamics with panel data. Categorizing our sampled households based on predicted rather than observed income suggests an even stronger pro-poor forest reliance, in fact, the predicted poor use forests as much as the predicted rich.

Keywords: Forest dependency, poverty categories, cross-sectional data

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1 Introduction

An emerging body of knowledge demonstrates the importance of forest income to rural household's livelihoods in developing countries. Most of the studies rely on cross-sectional data, and provide a static analysis of the forest-poverty nexus. The objective of this paper is to introduce a new approach to analyze cross-sectional household data, and demonstrate how certain dynamic aspects of poverty can be analyzed even without panel data. We do this by first testing the commonly observed relationship: are poor households more forest reliant while better-off households have higher absolute income from the forest? Second, we explore how the answer to this question sensitive to the method used to categorize households based on predicted income. Third, we show how the distinction between structurally and stochastically poor can yield new insights into the role for forests in rural livelihoods.

Forest income include cash and subsistence incomes from products harvested in forested areas, such as firewood, timber, food and other non-timber forest products (NTFPs). Quantifying the contribution of forest income in rural economies in developing countries is important to understand the welfare implications of deforestation and forest degradation and to design effective development and conservation strategies (Cavendish 2002; Angelsen and Wunder 2003; Vedeld et al. 2004; Angelsen et al. 2014). We can distinguish three potential functions of forest income to rural household's economy in developing countries (Cavendish 2002; Angelsen and Wunder 2003). First, forest income supports current consumption and subsistence needs in terms of providing sources of energy, nutrition, construction material and medicinal plants. Second, forest income can serve as a safety net to overcome an unexpected income loss. Third, forest incomes may provide a possible pathway out of poverty by providing regular cash income.

In a global-comparative analysis of environmental income in 58 sites in 24 developing countries, Angelsen et al. (2014) find that forest income on average account for 22.2% of total household income. This number is similar to the figure reported in an earlier meta-analysis of 51 case studies (Vedeld et al. 2007). A well-established pattern is that the poorer households obtain a higher relative share of their total income from the forest while richer households extract more forest resources and generate a higher absolute value of forest income (Cavendish 2000; Adhikari et al. 2004; Fisher 2004; Mamo et al. 2007; Vedeld et al. 2007; Babulo et al. 2009; Kamanga et al. 2009; Nielsen et al. 2012; Rayamajhi et al. 2012; Angelsen et al. 2014). Further, many studies find that forest income mainly support current consumption., such as the study by Kamanga et al. (2009) from Malawi, Nielsen et al. (2012) in the Democratic Republic of Congo, Heubach et al. (2011) in Benin and by Rayamajhi et al. (2012) in Nepal. These studies also recognize that forest income may serve as a safety net in case of a negative income shock. This is also supported by

Debela et al. (2012) in their study from Uganda, where large negative shocks were associated with a higher use of forest resources in subsequent periods, particularly among the asset poor households. Wunder et al. (2014) question, however, the universality of the forest safety net function. Although some households are able to accumulate cash from forest use, the role of forest income as a pathway out of poverty is even more contested (Angelsen and Wunder 2003). This partly reflects the subsistence nature of most forest uses, and that if profitable opportunities exist they tend to be captured by elites (Dove 1993). But positive case studies exist; Ainembabazi et al. (2013) find that production of charcoal in Western Uganda may provide a stepping stone out of poverty for some rural households, and Shackleton et al. (2007) finds that forest products offer a pathway out of poverty for some households in South Africa.

The share of forest income (FI) relative to the total income (TI) of the household is the most commonly used measure of forest reliance (FR) or forest dependence, i.e., FR = FI/TI. Studies typically classify households in poverty categories based on observed income and investigate how FR varies across these. Forest reliance also forms the main variable of interest in this paper, but we use both observed and predicted income to define poverty groups and estimate forest reliance. Using a one-year income only provides a static picture of the households' economic status and fails to take into account the dynamics of poverty (see e.g. Hulme and Shepherd 2003). While some households are consistently poor, others might have been unlucky that particular survey year, but had a higher income the previous year and are expected to have a higher income the next year. Likewise, some households that normally have incomes below the poverty line might have had a bumper harvest in the survey year. The snapshot provided by cross-sectional data might therefore be misleading. The definition of poverty groups matters for policy makers because it can improve the targeting of households and identify structurally vulnerable households (not just temporarily misfortuned ones) and large extractors when designing conservation policies.

Carter and May (2001) among others highlight the importance of assets in poverty analysis, and distinguish between stochastic and structural poverty. Nielsen et al. (2012) present a simple approach to use both income and households' liquid asset holdings to define poverty groups when assessing forest resource use in DRC. Their approach takes into account that households can liquidate assets to overcome income shocks. There are, however, other assets that are potentially more important to define the long-term income of a household, such as land holdings and human capital assets, which are not taken into account when they define poverty groups. We argue that predicted income is a better measure of long-term income than the observed one-year income, and that predicted income should be used when defining poverty groups.

A key finding of this paper is the insight from separating between the structurally and stochastically poor/rich households. We confirm the commonly found pattern that the poor households are the most forest reliant. When differentiating between categories of poor households, we find forest reliance to be high among households that are poor in both assets and observed income (structurally poor), but it is higher among the households that are categorized as stochastically rich. Households in this category have high incomes in the survey year, but we do not expect them to be able to sustain this high level of income due to low levels of productive and human capital assets. In fact, this last group, the stochastically rich, are the ones expected to be the most forest reliant in the longer term, because they are not only forest reliant, but also derive high absolute values of income from forest resources.

The rest of the paper is organized as follows. In Section 2 we provide an overview of the study context, design and the data collection. We define the key terms and describe the methods used for analysis in Section 3, while the results of the analysis is presented and discussed in Section 4. We report the full results of predicting income and discuss forest resource use across the alternative categorizations of households. In Section 5 we conclude the paper and provide some policy recommendations.

2 Study context and data collection

The study was conducted in Kilosa District in the Morogoro region in Tanzania in 2010. The district has an area of 14 245 km^2 and had a population of 488 191 in the latest (2002) census. Agriculture is the main income generating activity, employing about 85% of the labor force (URT 2007).

The area of land under forest cover in Kilosa district is approximately 52%[1] (URT 1997). All villages in our sample have some level of community rights to harvest forest resources from forests within their village boundaries, either by statutory or customary laws, but user rules and regulations exist. Both commercial and subsistence uses of timber are regulated, as well as commercial use of NTFPs. Subsistence use of NTFPs are allowed in all villages, except in certain areas that are protected as state forest reserves.

Our data set is part of the Global Comparative Study on REDD+ (GCS-REDD) conducted by the Center for International Forestry Research (CIFOR) and its partners. Kilosa is one of the

[1] The exact number is unknown (URT 2007), and different estimates occur in the literature. Our number is estimated based on numbers from 1997 (URT 1997).

six study sites in Tanzania[2]. Three of the villages are included as pilot projects of the global effort aimed at reducing emissions from deforestation and forest degradation (REDD+) implemented by a national NGO, and were randomly selected from all villages included in this project. The two last villages were selected as control villages from a pool of other villages in the district, based on how well they matched on a to a set of village level variables, such as market access and tenure rights (Sunderlin et al. 2010).

We use data from a sample of 150 randomly selected households in the five villages. Detailed information on household characteristics, asset holdings and incomes was recorded through household surveys in July and August 2010. If possible, both the head of household and the spouse were present if the head of household was married. A one year recall period was used. Total income is defined as the sum of cash income, subsistence income and net gifts/transfers of cash or in-kind. The accounting methods from different sources of incomes draw primarily on Cavendish (2002) and the PEN survey (Angelsen et al. 2011).

Some goods, particularly environmental goods, are for self-consumption and not traded in a market. The goods sold are typically traded only locally. We used own reported values to get a more realistic estimate of the real price (value to the household) rather than inflated prices in a far-way regional market. To calculate income from each source we deduced the cash costs of inputs and hired labor from the value (price * quantity collected or produced). Due to lack of data we do not deduct the depreciation of farm implements. The value of family labor is not included in the costs, and should not be based on the standard definition of income. For all agricultural, forest and livestock products, we used a test to identify outliers and checked total values and prices for each product by unit combination, and reviewed outliers manually. In the case of a missing value of an item, the mean village value was used. Given restrictions on the harvest in protected areas or of certain products, such as woody material for production of charcoal, some activities are illegal and may be underreported in the household surveys. We are not able to test or control for this potential bias in our data, but tried to limit this during data collection by underscoring to respondents that none in our group of field workers were linked to government or any environmental NGO and that the households' information would remain confidential.

The income variables are divided by adult equivalent units (AEU). There is a range of methods to account for differences in household composition and thereby different consumption needs across households (Deaton 1997). We adapt a version of the OECD scales, whereby adults aged 15-64 are given full weight while dependents (below 15, above 64) are given half a weight (Atkinson et al. 1995). As a measure of the level of land scarcity, operational agricultural land

[2] For more details about the project, see http://www.cifor.org/gcs/global-comparative-study-on-redd.html

holding is also divided by AEU. Crop income is by far the main component of the total household income, accounting for some two thirds of the income in the study villages, followed by forest income (Table 1)[3]. The mean forest reliance – the share of forest environmental income on total household income - among the households in the sample is 13%. The single most valuable forest product is firewood.

The households' liquid assets include livestock, business capital stock and household and farm implements. The value of these items were determined by asking for the current sale price of the item, taking into account the age and condition of the asset. We did not collect information about cash savings, but assume (based on non-systematic information) that most savings are in livestock and other assets rather than cash.

[3] We also recorded negative income for some households, e.g. were they have had large input costs for crops but experienced a crop failure.

Table 1 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	% share[1]
Household income per AEU (in TSH)*						
Total household income	150	189 675	213 410	-46 900	1 886 057	
Crops	150	127 182	153 149	-87 500	1 042 000	67.4
Business	150	22 167	107 982	0	1 192 000	5.3
Forest	150	16 099	20 797	0	144 000	12.7
Firewood	150	10 252	10 363	0	60 000	8.9
NTFPs	150	2 787	8 810	0	73 234	2.1
Timber prod, incl. charcoal	150	3 061	15 825	0	133 333	1.8
Salary	150	10 983	55 117	0	637 500	5.7
Non-forest environmental	150	8 267	24 102	0	258 462	6.1
Livestock	150	2 732	12 891	-60 667	97 500	1.6
Miscellaneous	150	2 245	7 076	0	51 429	1.2
Human capital assets						
Household size (#)	150	5.09	2.09	1.00	14.00	
AEU (#)	150	3.98	1.61	1.00	9.50	
Age household head (years)	150	45.56	14.41	20.00	98.00	
Education household head (years)	150	4.43	2.94	0.00	11.00	
Illness household head (days)	150	11.63	22.90	0	182	
Illness spouse (days)	150	7.45	14.61	0	90	
Female headed household (0-1)	150	14%				
Salary income (0-1)	150	25%				
Household business (0-1)	150	19%				
Productive and liquid assets						
Agricultural land per AEU (ha)	150	0.51	0.37	0.08	2.23	
Hh./farm implements (TSH)	150	55 347	95 055	0	840 000	
Large livestock (#)	150	0.03	0.41	0	5	
Medium livestock (#)	150	0.70	2.73	0	24	
Chicken chicken (#)	150	9.11	10.60	0	64	
Contextual variables						
Distance to village center (min)	150	92.98	87.57	0.00	360.00	

*Exchange rate July 1st 2010: 1 USD = 1599 TSH (From: http://www.exchangerates.org.uk/USD-TZS-exchange-rate-history-full.html). [1]The mean income shares are calculated by taking the mean income shares for the households

Methods

2.1 Observed versus predicted income

Most forest-poverty studies use observed one-year income, both to classify the households into poverty groups and to calculate forest reliance. The commonly observed pattern is a negative correlation between total household income and forest reliance and a positive correlation between absolute forest income and total income. Most studies therefore conclude that the poorest households are the most forest reliant (Mamo et al. 2007; Vedeld et al. 2007; Babulo et al. 2009; Heubach et al. 2011; Nielsen et al. 2012; Rayamajhi et al. 2012).

Cross-sectional studies typically do not take into account that incomes fluctuate greatly from year to year. Panel data studies of poverty have found that households that are classified as poor in one period may not be in another period (and vice versa) due to random fluctuations in crop yields and prices, and irregular earnings from casual labor, remittances etc. (Carter and Barrett 2006). Thus, household identified as poor in the survey year may not be persistent poor over time. Similarly, some of the households with high observed income might have been lucky in the year of the survey, but that will again be among the low-income households next year. In a study from Ethiopia, Dercon and Krishnan (2000) found that one third of the households identified as poor in the first year in a two-year panel data set were different from the households identified as poor the second year.

Nielsen et al. (2012) present a simple framework to take some of the dynamics aspects of poverty into account the when studying poverty-environment relations in cross-section data based on the observed household income and liquid asset holdings. A limitation of their approach is that they use only a subset of assets. Agricultural crop income is the dominant income source in our sample, similar to most rural households in Africa (Davis et al. 2010; Angelsen et al. 2014), and thus the amount of land and labor are important productive assets. Human capital assets, such as health and education are potentially important for household income as well as income diversification. We therefore use an augmented asset approach to predict household income, including liquid and non-liquid assets, human capital assets as well as contextual variables, and argue that the resulting predicted income is a better measure for the poverty status of a household. Also, the regression analysis gives an estimate of the relative importance of various assets and it avoids the problem of converting all assets into monetary value.

2.2 Estimating predicted income

To predict household income, we estimate the following log-linear[4] regression:

$$lnY = \beta_0 + \beta_1 Householdcharacteristics + \beta_2 Assets + \beta_3 Distance + \beta_6 Village + u \quad (1)$$

The absolute income data is measured in Tanzanian Shillings (TSH) and log-transformed to account for non-normality in the distribution and to reduce the impact of outliers. *lnY* is the logarithmic transformation of household income[5]. *Householdcharacteristics* is a vector of household characteristics which are expected to be correlated with household income: number of adult males, adult females, elderly, young and children. These variables are indicators of the labor available in the household, and we expect households with more adults to have higher total income. The number of children may have a negative effect on household income, as this might require more time set aside for care and other non-productive activities. A dummy variable for gender of the household head is included in the vector, along with the age of the household head. We also include a squared value of age, to accommodate any non-linear effects of this variable. The number of years the household head has been in school is included, and we expect more educated household heads to have higher incomes due to better agricultural skills, better access to information and off-farm income generating activities. A dummy variable for business is included, taking the value 1 if any of the household members have a family business. We expect this variable to be positively correlated with household income. In addition, a dummy indicating whether or not any household member receive salary is included as a proxy for off-farm income opportunities. Charcoal production is particularly profitable, and a dummy variable is included taking the value 1 if any in the household are engaged in this activity. Finally, health is expected to affect total household income, and the number of days the household head and spouse were ill in the previous 12 months are included as proxies of health, and expected to be negatively correlated with total income.

Assets is a vector of productive, liquid and non-liquid assets, all expected to be positively correlated with household income. Crop income is the main source of income for most households, and agricultural land is an important productive asset. Size of land measured in hectares (ha) that the household had access to cultivate at the time of the survey, and includes owned land not rented out and rented in land. The total value of farm and household implements (in TSH 1000) is included, as well as the number of large, medium and small livestock.

[4] The main purpose of predicting income is to classify households into poverty categories, and as a robustness test we predict income based on a model where all continuous variables are log-transformed.

[5] One household has negative total net income because of high costs related to agricultural production; this household is not included in the regression.

Distance is the walking time from the residence to the village center (in minutes), and we expect remote households to have lower total incomes. To control for village specific variations in income, *Village* dummies are included. When transforming the income variable back from log to the level variable to estimate the predicted income, we adapt the smearing estimate developed by Duan (1983) to avoid the retransformation bias and underestimation of predicted income.

2.3 Forest reliance

The share of forest income (FI) relative to the total income (TI) of the household is the most commonly used measure of forest reliance (FR) or forest dependence, i.e. FR = FI/TI. Given the yearly fluctuations in income, this is not necessarily an accurate measure for long term or structural forest reliance. If the degree of fluctuation varies across income sources, and forest incomes are more stable over time compared to non-forest income sources, a potentially better measure for the structural forest reliance is the *observed forest income* as a share of the *predicted total income*. The critical assumption for this to be a preferred measure is that forest incomes are more stable over time compared to non-forest income sources. There are good arguments to believe so. Much of the forest income is for subsistence, and it is therefore more sheltered against price fluctuations in the markets (Angelsen et al. 2014). Compared to crop production, the supply of forest products are – in general – also less sensitive to climate variability (e.g., rainfall). Lack of good panel data sets makes it hard to find good empirical evidence for this, but one of the few panel data sets from Malawi supports our assumption (Chilongo and Angelsen 2014).

The second possibility is not only to predicted total household income, but also to use predicted forest income and predicted forest reliance. We do this by estimating the same equation as (1), except using forest income[6] or forest reliance as the dependent variable. The predicted forest income is divided by predicted total income as an alternative measure of structural forest reliance. Similarly, we predict the household specific forest reliance by estimating Equation 1 as a linear model, using the observed forest reliance as the dependent variable.

2.4 Categorizing Households

The first approach is to divide the sample into five quintiles based on either observed or predicted income. Although most households in our sample are probably poor in a macro context, the focus of this paper is inter- and intra-village variation, and households are categorized from poor to rich relative to the other households in the sample. As a measure of the poverty profile of forest income, Vedeld et al. (2004) suggest using the Kuznets Ratio; the ratio between the mean

[6] 17 households did not harvest forest resources. In order to be able to include these households in the estimation, we added 1 to forest income when taking the log of this variable.

forest income going to the 20% highest-earning households and the forest income going to the 40% lowest-earning households. If the ratio is below 1, low-income households have higher mean forest income. We calculate the both the Absolute Kuznets Ratio (absolute forest incomes) and the Relative Kuznets Ratio (forest income shares).

The second approach is to categorize households based on both observed and predicted total income. Carter and May (2001) distinguish between stochastic and structural poverty. Following their categorization, households are defined as structurally poor, stochastically poor, stochastically rich or structurally rich based on their level of observed household income and predicted income.

Households in the lower observed income quintiles but in the higher predicted income quintiles are expected to be able to earn a higher income in a future or in a normal year. Either they were unlucky this year and thereby achieved a low income or they have not been able to make the full use of their productive resources. Thus these households are categorized as stochastically poor. The households with high reported income but low predicted income, on the other hand, are expected to earn less in the future, and their high income this year might be explained by luck or they have sold off some of their assets over the year. These households are categorized as stochastically rich. Characteristics of households are compared across quintiles and the household categories. Means of variables are compared and one-way ANOVA with Bonferroni and Kruskal-Wallis tests are applied to assess the statistical significance of the results.

3 Results and Discussion

3.1 Predicted Income

The results of the regression model used to predict income are reported in Table 2. Several of the asset variables are significant predictors of household income, as expected. Household with more adult labor available in the household tend to have higher incomes; the same is true for households with better educated household heads. The coefficient for age is negative while the coefficient for squared age is positive. The turning point is 44.5 years in a U-shaped relationship, meaning that per adult equivalent income is decreasing with age until 44.5, then increasing with age. This can be an effect of larger family size and thus lower incomes per AEU in families with younger heads of households. Agricultural land is the main productive asset, and households with more land have higher total incomes. The exponentiated coefficient for land is 1.22, indicating that households with one hectare more have on average 22 percent higher total incomes. Among the liquid assets, households with more farm and household implements have slightly more total income, while the number of chickens is the only significant variable among the livestock variables.

Further, households with business incomes have approximately 63% higher incomes than households with no business income, whereas households further from the center of the village have lower total incomes.

Table 2 Regressions of log of total household income, forest income and forest reliance against socio-economic variables

Variables	Total Income[1]	Forest Income[1]	Forest reliance
Household characteristics			
Adult males in the hh	0.1585**	0.4411	0.0062
(aged 16-64)	(0.646)	(0.3628)	(0.0159)
Adult females in the hh	0.1571**	0.5911	-0.0066
(aged 16-64)	(0.0690)	(0.3753)	(0.0158)
Elderly in the hh	-0.0242	-1.3522	-0.0311
(aged 65 and above)	(0.1771)	(1.2266)	(0.0350)
Young in the hh	0.0825	0.5622	0.0159
(aged 10-15)	(0.0643)	(0.3593)	(0.0204)
Children in the hh	0.0021	0.1214	0.0192**
(aged 9 and below)	(0.0475)	(0.2727)	(0.0094)
Gender household head	0.1234	0.9714*	0.0307
(1 if female)	(0.1686)	(0.5717)	(0.0458)
Education of household	0.0484**	-0.0714	-0.0019
head (years)	(0.0185)	(0.0811)	(0.0049)
Age of household head	-0.0459*	-0.1294	-0.0004
(in years)	(0.0238)	(0.1017)	(0.0043)
Age of household head	0.0005**	0.0015	0.0000
(squared)	(0.0003)	(0.0010)	(0.0000)
Business dummy	0.4901***	0.2249	-0.1039***
(1 if any in the hh own business)	(0.1418)	(0.6002)	(0.0289)
Salary dummy	0.0980	-2.0060**	-0.1079**
(1 if any in the hh earn salary)	(0.1508)	(0.9620)	(0.0457)
Days of illness	-0.0047	0.0231**	0.0009*
household head	(0.0029)	(0.0110)	(0.0005)
Days of illness	-0.0028	-0.0025	0.0005
Spouse	(0.0032)	(0.0129)	(0.0007)
Household assets			
Total farmland size	0.1950***	-0.2377	-0.0314***
(in hectares)	(0.0566)	(0.2452)	(0.0103)
Value of farm and household	0.0014**	-0.0017	-0.0000
implements (in 1000TSH)	(0.0005)	(0.0040)	(0.0000)

Table 2 cont.

Variables	Total Income[1]	Forest Income[1]	Forest reliance
Large livestock (number of oxen and other large animals)	-0.0753 (0.0952)	0.4025 (0.6559)	-0.0188 (0.0256)
Medium livestock (number of sheep and goats)	0.0234 (0.0166)	0.1073 (0.1202)	0.0032 (0.0055)
Small livestock (number of chicken)	0.0187*** (0.0048)	-0.0224 (0.0384)	-0.0026** (0.0012)
Charcoal dummy (1 if produce charcoal)	0.1306 (0.1986)	0.9631 (0.7990)	0.1151* (0.0648)
Contextual variables[2]			
Distance from hh to village center (in minutes walking)	-0.0020*** (0.0006)	-0.0086** (0.0042)	-0.0000 (0.0002)
Constant (Intercept)	12.6776*** (0.5547)	11.7576*** (2.4755)	0.1588* (0.0938)
R-squared	0.5225	0.2064	0.2902
N	149	150	150

*, **, *** significant at 0.1, 0.05 and 0.01 levels. Robust std. errors in brackets. [1] Values reported are the coefficients from a log-transformed dependent variable. To interpret the effect, we need to take the exponentiated coefficient. [2] Controlled for village fixed effects by including village dummy variables, but these are not reported in the table.

We obtain a relatively high R^2 value and explain 52% of the variation in total income. Several of the variables included are significant predictors of household income. In in general, households with high income tend to have more males and females in their productive age, more education have more land and farm/household implements, more small (but not medium or large) livestock, be engaged in business and live closer to the village center. All these results are in line with expectations. Since the main purpose of the model is to predict income, we do not discuss the model results in details.

As to be expected, predicted income varies less than the observed income, and the maximum predicted income is less than half the observed income (Table 3). The difference in mean observed and predicted income is due to the smearing estimate adapted to avoid the retransformation bias. A number of underlying unobservable household characteristics are not included in the model. This may bias our results. We are, for example, not able to predict total household income well for the households with high forest income. The correlation coefficient between the error term of the predicted income and forest income is 0.17, which indicates that predicted income is systematically lower for households with high forest income.

Table 3 Observed and predicted income

Per adult equivalent income	Obs	Mean	Std. Dev.	Min	Max
Observed total income	150	189 675	213 410	-46 900	1 886 057
Predicted total income	150	191 876	130 153	42 233	736 996

The model for forest income explain about 20% of the variation in forest income across households (R^2 =0.206), suggesting a large random element in the observed forest income, not captured by variations in asset holdings and other household characteristics. Forest income is correlated with different variables than the total income. None of the household labor endowment variables are significant, but male headed households have on average 264% higher forest income compared to female headed households when everything else is kept constant. Households where the head has been more ill in the previous year also have higher forest income, and this can be an indication of a safety net function of forest income. Households with salary income earn only 13% of the forest income of a non-salary earning household. Similar to total income, households living further from the village center earn less forest income.

The dependent variable in the third model is forest reliance. Variables that are correlated with total income are expected to have the opposite effect on forest reliance, while variables positively (negatively) correlated with forest income are expected to be positively (negatively) correlated with forest reliance. With some exceptions, this is mainly what we find. Households with more land, more livestock and households with their own business are less forest reliant due to higher total incomes, while households earning a salary are less forest reliant due to their lower forest incomes. Similarly, households where the head has been more ill are more forest reliant because of higher forest incomes. The exceptions, where there is no significant effect on the income variables, is that households with more children are more forest reliant. The same is true for households that produce charcoal, although none of these variables are significantly correlated with the income variables. Similar to the model for forest income, there is a lot of the variation in forest reliance that is not explained by the model.

3.2 Forest Reliance across Observed and Predicted Income Quintiles

As expected, forest reliance measured by the share of observed income is negatively correlated with observed total income (-0.256, in Table A1). This pattern is also shown in the top panel of Table 4. The findings are supported by the Kuznets Ratios. The Relative Kuznets Ratio is 0.27, i.e. forest reliance among the poorest 40 % is close to four times higher among the poorest compared to the top 20%. Households in the highest income quintile earn on average less than 5% of their total income from forest, compared to 18% in the lowest quintile. Compared to other studies,

including the comparative work reported in Angelsen et al. (2014), the pro-poor profile of forest reliance is very strong in our Tanzanian sample.

Table 4 Comparison of mean incomes per AEU, value of assets and forest reliance across poverty quintiles constructed based on observed and predicted income

	Q1	Q2	Q3	Q4	Q5	Test statistics[1]	Kuznets Ratio
Observed income quintiles							
Observed income	51 644	82 860	126 260	195 690	493 483	F=46.57***	
Predicted income	123 657	132 866	158 008	191 451	353 401	F=26.30***	
Value of liquid assets	85 770	66 633	110 420	220 733	409 450	F=9.74***	
Absolute forest income	9 543	13 023	13 344	27 066	17 519	F=3.36**	1.55
Forest reliance (observed)	0.1848	0.1558	0.1070	0.1473	0.0454	F=4.03***	0.27
Long term FR (FI/PTI)	0.1020	0.1198	0.1032	0.1851	0.0575	F=2.43*	0.52
Predicted forest reliance	0.1548	0.1637	0.1183	0.1336	0.0699	F=7.05***	0.44
Predicted income quintiles							
Observed income	76 087	117 634	145 131	195 219	415 866	F=16.75***	
Predicted income	78 171	112 848	148 742	213 360	406 261	F=146.63***	
Value of liquid assets	51 370	104 867	129 287	214 450	393 033	F=8.32***	
Absolute forest income	10 555	18 535	23 063	13 391	14 951	NS	1.03
Forest reliance (observed)	0.1509	0.1960	0.1665	0.0850	0.0419	F=5.73***	0.24
Long term FR (FI/PTI)	0.1390	0.1662	0.1608	0.0633	0.0383	F=4.10***	0.25
Predicted forest reliance	0.1784	0.1672	0.1325	0.1099	0.0522	F=15.64***	0.30
N	30	30	30	30	30		

*, **, *** significant at 0.1, 0.05, and 0.01 levels respectively. [1] One-way ANOVA

While households in the lowest income quintile earn a higher share of their total income from forest resources, households in the highest quintiles have higher forest income in absolute terms. The Absolute Kuznets Ratio is 1.55, i.e., the mean absolute forest income among the households in the top income quintile is 1.55 higher than in the two lowest quintiles. However, total income is not correlated significantly with absolute forest income (correlation coefficient 0.032). This indicates that this relationship is not robust, and the difference between the lowest and the fourth quintile is the highest. The high forest income among the households in the second richest income quintile can be explained by the fact that the majority of the households producing charcoal are found in this quintile, not the richest.[7]

The mean absolute forest income is the lowest among the households in the first quintile while they also have the highest observed forest reliance at 18%. This is not surprising, given that their observed forest reliance is high due to low observed total income. The households are not expected to continue to have this low income in the future, and their predicted income is more

[7] This also illustrates a weakness of the Kuznets ratio, namely that it ignores two middle-income quintiles (40-80%), and in our case "much of the action" (highest forest use) is happening here.

than twice as high. Thus, if the harvest of forest resources is more stable, their long term forest reliance is lower than what we observe. This is reflected in the forest reliance measured as the share of absolute forest income relative to predicted income is lower, at 10%. The Relative Kuznets Ratio is 0.52, almost twice as high as the ratio for the observed forest reliance commonly found in cross-section analysis. The other alternative measure of long term forest reliance, predicted forest reliance, does not provide much new insight and when predicting it we obtain a low R^2-value. Similar to forest income, it might be that this is better predicted with another model than the one we used. Thus, this measure should be interpreted with caution and we do not follow this line of investigation any further.

Using quintiles based on predicted income, the overall pattern of the observed forest reliance is similar to the pattern we found across the observed income quintiles, and the Relative Kuznets Ratio is 0.24. The differences across the alternative measures of forest reliance are smaller, because there are smaller differences between observed and predicted income across the quintiles.

When comparing the absolute forest income, on the other hand, the pattern is different. There is no significant difference in mean absolute forest income across the quintiles, and the correlation coefficient between absolute forest income and predicted total income is virtually zero (0.007). This is also supported by an Absolute Kuznets Ratio very close to unity (1.03). Whereas most studies find that absolute forest income is highest among the richest households, we find no such distinct pattern. This suggests that comparing households based on predicted income may provide new insight in the poverty-environment analysis. A seemingly minor change in the way to classify households leads in our case to a qualitatively different results.

3.3 Poverty categories

Combining the classification based on observed and predicted incomes enables a further analysis of the poverty-environment relation. The poorest households based on observed income in one year are not necessarily the poorest in the future. We then identify the four household categories discussed earlier: structurally poor, stochastically poor, stochastically rich and structurally rich (Table 5). We define the cut-off line between high and low income between quintile 3 and 4, meaning that 60% of the households are defined as low income households. This cut-off line is close to the commonly used poverty line of "a dollar a day"[8]. Further, the mean observed income is not significantly different across the three lowest income quintiles while the mean observed income among the households in the fifth quintile is significantly higher than all

[8] If we apply a rural poverty line below this, at 1 USD/day, we get a poverty line at an annual income of 188 293 TSH with a 2010 PPP conversion rate at 515.87 (http://www.econstats.com/weo/V013.htm). This line is found at the beginning of the fourth quintile for both observed and predicted income.

others. Mean income in the fourth quintile is significantly higher than mean income in the two lowest quintiles.

Table 5 Comparison of households' rank in observed and predicted income quintiles.

Observed income quintiles	Predicted income quintiles					
	1	2	3	4	5	Total
1	15	9	6	0	0	30
2	9	8	4	8	1	30
3	2	8	12	6	2	30
4	3	4	6	12	5	30
5	1	1	2	4	22	30
Total	30	30	30	30	30	150

Structurally poor
Structurally rich
Stochastically rich
Stochastically poor

We see from Table 5, for example, that among the 30 households in the lowest observed income quintile, only half are in the lowest quintile for predicted income. The 17 households that have low observed income this year but high predicted income is not expected to stay poor in the long run, and are thus categorized as stochastically poor.

Distinguishing between structurally and stochastically poor/rich households yields additional insights into the patterns of forest reliance. Households categorized as stochastically rich earn the highest absolute income from forest, and they are also the most forest reliant, independent which measure of forest reliance we use (Figure 1).

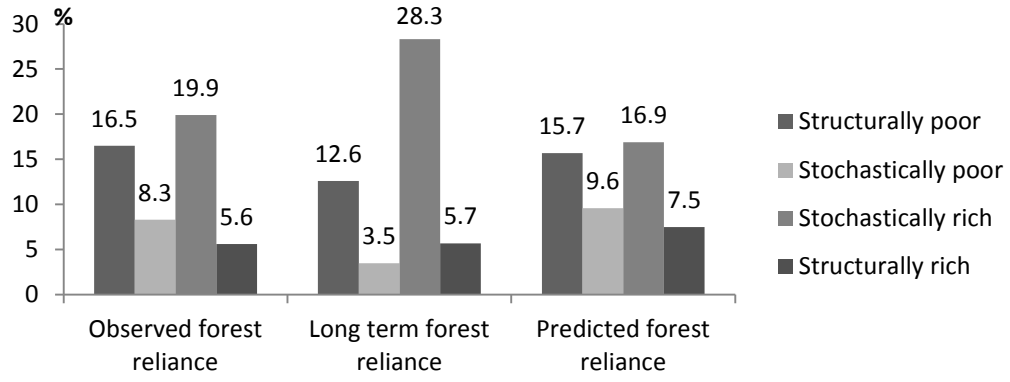

Figure 1: Forest reliance across household groups

This finding differs from most studies of forest reliance, which identify the poorest households as the most forest reliant. This include studies categorizing households based on observed income only, such as Heubach et al. (2011) and Rayamajhi et al. (2012) , but also Nielsen et al. (2012) who

combine income and liquid asset holdings. The pattern of forest reliance is stable across household categories with the alternative functional form to predict total income (Table A2).

With the exception of forest income, the structurally rich earn higher incomes from most of the income sources (Table 6).

Table 6 Comparison of income (per AEU) and key characteristics across household categories

	Structurally poor n=73	Stochastically poor n=17	Stochastically rich n=17	Structurally rich n=43	Test statistics[1]
Income variables					
Crops	55 218	68 218	169 445	258 196	F=26.00***
Business	2 141	5 188	0	71 641	F=4.52***
Forest (FI)	12 915	7 915	36 579	16 645	F=7.92***
Firewood	9 578	7 038	9 383	13 009	NS
NTFP	2 452	609	9 188	1 686	F=3.80**
Timber/charcoal	885	268	18 008	1 950	F=6.39***
Salary	6 976	6 359	12 701	18 934	NS
Non-forest environmental	5 275	7 168	9 597	13 254	NS
Livestock	2 079	173	1 778	7 531	F=2.77**
Miscellaneous	641	2 294	2 937	4 676	F=3.12**
Total income (TI)	85 096	94 761	232 563	388 874	F=32.10***
Predicted total inc. (PTI)	109 205	262 585	130 638	328 481	F=65.71***
Basic household characteristics					
AEU (number)	4.41	3.38	3.85	3.53	F=3.88**
Female headed	0.12	0.18	0.29	0.09	NS[§]
Age (years)	46.32	45.29	47.00	43.81	NS
Education (years)	3.86	4.76	3.82	5.51	F=3.30**
Agricultural land	0.34	0.83	0.40	0.71	F=18.97***
Value liquid assets	84 948	99 029	139 088	384 674	F=14.29***
Illness hh head	11.55	19.65	10.06	9.23	NS
Illness spouse	8.33	5.71	4.00	8.02	NS
Dist. to village center (min)	119.12	57.82	88.41	64.30	F=5.01***
Share commercial FI	0.02	0.06	0.08	0.01	NS

*, **, *** statistical significance at 0.1, 0.05 and 0.01. NS=Not significant. [1]One-way ANOVA with Bonferroni. [§]Kruskal-Wallis equality of population rank test for this non-parametric variable.

The structurally rich are also the highest educated group, have more liquid assets and have significantly more land than the structurally poor and stochastically rich households.

The stochastically poor households have low observed income, but high predicted income. We do not have data to study explicitly whether these households have in fact experienced a shock during the previous year. On average, these households have been more prone to illness

(household head), but the difference in is not significant across the household categories. They have on average more than twice the land compared to the structurally poor and still there is no significant difference in crop incomes. This indicates an agricultural income shock, or that the households for some other reason have not been able to make the full use of their productive assets. Some studies find that forest income serve as a safety net after an income shock (Pattanayak and Sills 2001; Debela et al. 2012). If the incidence of income shocks is higher among the stochastically poor, we might therefore expect higher forest incomes in this group, but we find no evidence of this. The lack of evidence of a safety net function of forest income among the stochastically poor in our sample might be explained by how we define this group. Debela et al. (2012) find that asset poor households use the forest to cope with large negative shocks, while households with more land and non-land assets are less reliant on forest in the case of a shock. The stochastically poor households have, by definition, relatively high asset holdings, and might therefore have other means to cope with shocks.

The households categorized as stochastically rich have high observed income, but have low predicted income given their relatively low asset holdings. This group has less agricultural land and earns less income from crop compared to the structurally rich households. They are less educated and have less liquid assets. They are both the most forest reliant and have the highest absolute forest income among the four household categories. Some of the difference is derived from higher incomes from collection of non-timber forest products, but the main explanation is the higher incomes from timber and charcoal for some of the households in this group.

The stochastically rich have, on average, higher crop income compared to their agricultural land holdings and this is the main difference compared to the structurally poor. This can be due to higher yields, higher prices, or a combination of the two. We do not know the area of land used to grow the different crops, and crop produce was given in local units. This makes it hard to compare across households. The two most important crops (in terms of shares of crop income) are maize and beans. Maize is mainly for subsistence use, while households producing beans sell on average 52% of their output. The most commonly used output measure is 'sacks', which is not a standardized unit. Yet we find little variation in the price of a sack of maize across the different household categories. The average price of beans is 13% higher among the stochastically rich compared to the structurally poor (Table A3). The difference is not significant, but can still be an indication that the households in this group are able to get a higher price for the marketed agricultural crops. This might partly explain why the stochastically rich households have higher crop income relative to their land holdings compared to the structurally poor. Still other explanations that we are not able to fully test with the available data seem likely to explain the

difference in output value per hectare, including unobservable inputs such as managerial and agronomic skills and soil quality.

If households in the in the stochastically rich category have been able to engage in highly productive and profitable agricultural activities or have other productivity-enhancing characteristics that we have not measured, their higher-than expected income levels might not necessarily be temporary. The prices received for marketed crops may not fluctuate randomly, but may be due to better relation with buyers or better information about prices in different markets. Similarly if they make use of communal resources to engage in sustainable forest extraction with high returns, as use of communal resources is not reflected in their asset holdings. Further, there are variables such as entrepreneurial and managerial skills that are hard to measure. We have included a few household characteristics only, including whether or not the households run their own business, but there is likely to be household characteristics that are important for future income that we have not captured in the regression model. To the extent this is case, the category "stochastically rich" will be misleading. This is a limitation of the proposed approach when only having access to cross-section data, and we cannot test how well we predict future income.

We also introduced new measures of predicted forest reliance and income, which we think can be useful complements to using measures based on observed figures. Yet a major issue is that we are much less able to predict forest income and forest reliance, and these predictions have therefore received less space in our discussion. In fact, this last group, the stochastically rich, are the ones expected to be the most forest reliant in the longer term, because they are not only forest reliant, they also derive high absolute values of income from forest resources.

4 Conclusions

This paper aimed to explore the implications of alternative income measure and household classifications on frequently asked questions about forest and poverty. Our motivation was, in part, that cross-section studies just give a snapshot of the rural economy, and just using observed incomes give an incomplete picture. We therefore introduced predicted incomes both as new measures and means of household classification. While we fully realize that nothing can replace observing the same households over time, we believe the suggested method can be used to discuss some aspects of poverty, normally confined to analysis of poverty dynamics with long-running panel data. The approach used can therefore be highly valuable given that most datasets are based on one-shot surveys.

Classifying households based on observed income yields the conventional finding that the poorest households are more forest reliant, while the better off use more forests products in an absolute sense, although the differences are not as distinct as found in most other studies (e.g., Angelsen et al. 2014). But this result is sensitive to how we classify households: if classified based on predicted income, the predicted poorest are more forest reliant, but the better-off households do not use more forest products in an absolute sense. The new classification therefore changes a major conclusion in the forest-poverty literature for our case.

The reasons for the changing result can best be understood when we take the classification a step further and categorize households based on both observed and predicted income into four stochastically/structurally poor/rich groups. This separation yields valuable new insights. One group stands out in terms of having both the highest forest reliance and absolute forest income, namely the stochastically rich. These asset poor (land in particular) households have enjoyed a high total income in the survey year, but have also significantly higher forest income. These high forest-users are not classified as poor when using observed income, but are when using predicted. On the other hand, the stochastically poor households, those that are asset rich but happen to have low income in the survey year, are not intensive forest users.

While the study and analysis was not designed to look into the role of forests role as shock absorbers and a possible pathway out of poverty, the results may shed some light on this debate. First, forests did not play any significant role for the asset rich households that experienced an income shortfall. This group seems to have other coping options, and is not the most vulnerable group for the type of income shocks that our analysis suggest. That group would be among the asset poor. Second, the stochastically rich households are able to enjoy a higher than predicted income. Although higher crop income is the main explanation, forest income also contributes to making these households move out of the structurally poor category. Our analysis is not suitable for studying the potential of forest income as a pathway out of poverty. Long-term panel data is needed to study this, but we cannot rule out that at least for some households, commercial forest activities can play a role.

The proposed method enables us distinguish between households that are observed to be poor because they are experiencing a temporary income shortfall and can be expected to recover in the future, and those that are observed to be poor because that is the normal state. This has policy implications for targeting poverty alleviation in general, but also for how vulnerable the different groups are for changes and restrictions in access to forest resources. While the structurally poor can be characterized by high forest reliance, the stochastically poor households have no different pattern of forest resource use compared to the structurally rich, neither when we compare forest

reliance nor absolute forest income. Thus, these households are less likely to be vulnerable than the structurally poor and also the stochastically rich. The focus in the vulnerability analysis should therefore be on the asset poor rather than the observed income poor.

References

Adhikari, Bhim, Salvatore Di Falco, and Jon C. Lovett. 2004. "Household Characteristics and Forest Dependency: Evidence from Common Property Forest Management in Nepal." *Ecological Economics* 48 (2): 245-257.

Ainembabazi, J.H, G Shively, and A Angelsen. 2013. "Charcoal Production and Household Welfare in Uganda: A Quantile Regression Approach." *Environment and Development Economics* 18 (5): 537-558.

Angelsen, A, and S. Wunder. 2003. *Exploring the Forest-Poverty Link: Key Concepts, Issues and Research Implications*. Cifor Occasional Paper No. 40. Bogor, Indonesia: CIFOR Center for International Forestry Research.

Angelsen, A, P. Jagger, R. Babigumira, Brian Belcher, Nicholas J. Hogarth, S. Bauch, Jan Börner, Carsten Smith-Hall, and S Wunder. 2014. "Environmental Income and Rural Livelihoods: A Global-Comparative Analysis." *World Development*. In press.

Angelsen, Arild, Helle Overgaard Larsen, Jens Friis Lund, Carsten Smith-Hall, and Sven Wunder (eds). 2011. "Measuring Livelihoods and Environmental Dependence: Methods for Research and Fieldwork. London and Washington, DC: Earthscan.

Atkinson, A.B., L. Rainwater, and T.M Smeeding. 1995. *Income Distribution in Oecd Countries: Evidence from the Luxembourg Income Study*. Paris: Organisation for Economic Co-operation and Development.

Babulo, Bedru, Bart Muys, Fredu Nega, Eric Tollens, Jan Nyssen, Jozef Deckers, and Erik Mathijs. 2009. "The Economic Contribution of Forest Resource Use to Rural Livelihoods in Tigray, Northern Ethiopia." *Forest Policy and Economics* 11 (2): 109-117.

Carter, Michael, and Christopher Barrett. 2006. "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach." *Journal of Development Studies* 42 (2): 178-199.

Carter, Michael R., and Julian May. 2001. "One Kind of Freedom: Poverty Dynamics in Post-Apartheid South Africa." *World Development* 29 (12): 1987-2006.

Cavendish, William. 2000. "Empirical Regularities in the Poverty-Environment Relationship of Rural Households: Evidence from Zimbabwe." *World Development* 28 (11): 1979-2000.

Cavendish, William. 2002. Quantitative Methods for Estimating the Economic Value of Resource Use to Rural Livelihoods. In Campbell, Bruce M., and Martin K. Luckert (eds) *Uncovering the Hidden Harvest: Valuation Meethods for Woodland and Forest Resources*. London: Earthscan.

Chilongo, Thabbie, and Arild Angelsen. 2014. "Trapped in Forests or Saved by Forests? Forest Reliance and Poverty Transitions in Malawi. Schoold of Economics and Business, Norwegian University of Life Sciences. Unpublished manuscript.

Davis, Benjamin, Paul Winters, Gero Carletto, Katia Covarrubias, Esteban J. Quiñones, Alberto Zezza, Kostas Stamoulis, Carlo Azzarri, and Stefania DiGiuseppe. 2010. "A Cross-Country Comparison of Rural Income Generating Activities." *World Development* 38 (1): 48-63.

Deaton, Angus. 1997. *The Analysis of Household Surveys: A Microeconometric Approach to Development Policy*. Baltimore, US: John Hopkins University Press. 479 pp pp.

Debela, Bethelhem, Gerald Shively, Arild Angelsen, and Mette Wik. 2012. "Economic Shocks, Diversification, and Forest Use in Uganda." *Land Economics* 88 (1): 139-154.

Dercon, Stefan, and Pramila Krishnan. 2000. "Vulnerability, Seasonality and Poverty in Ethiopia." *The Journal of Development Studies* 36 (6): 25-53.

Dove, Michael R. 1993. "Smallholder Rubber and Swidden Agriculture in Borneo: A Sustainable Adaptation to the Ecology and Economy of the Tropical Forest." *Journal of Economic Botany* 47 (2): 136-147.

Duan, Naihua. 1983. "Smearing Estimate: A Nonparametric Retransformation Method." *Journal of the American Statistical Association* 78 (383): 605-610.

Fisher, Monica. 2004. "Household Welfare and Forest Dependence in Southern Malawi." *Environment and Development Economics* 9 (02): 135-154.

Heubach, Katja, Rüdiger Wittig, Ernst-August Nuppenau, and Karen Hahn. 2011. "The Economic Importance of Non-Timber Forest Products (Ntfps) for Livelihood Maintenance of Rural West African Communities: A Case Study from Northern Benin." *Ecological Economics* 70 (11): 1991-2001.

Hulme, David, and Andrew Shepherd. 2003. "Conceptualizing Chronic Poverty." *World Development* 31 (3): 403-423.

Kamanga, Penjani, Paul Vedeld, and Espen Sjaastad. 2009. "Forest Incomes and Rural Livelihoods in Chiradzulu District, Malawi." *Ecological Economics* 68 (3): 613-624.

Mamo, Getachew, Espen Sjaastad, and Pål Vedeld. 2007. "Economic Dependence on Forest Resources: A Case from Dendi District, Ethiopia." *Forest Policy and Economics* 9 (8): 916-927.

Nielsen, Martin Reinhardt, Marième Pouliot, and Riyong Kim Bakkegaard. 2012. "Combining Income and Assets Measures to Include the Transitory Nature of Poverty in Assessments of Forest Dependence: Evidence from the Democratic Republic of Congo." *Ecological Economics* 78 (0): 37-46.

Pattanayak, Subhrendu K, and Erin O. Sills. 2001. "Do Tropical Forests Provide Natural Insurance? The Microeconomics of Non-Timber Forest Product Collection in the Brazilian Amazon." *Land Economics* 77 (4): 595-612.

Rayamajhi, Santosh, Carsten Smith-Hall, and Finn Helles. 2012. "Empirical Evidence of the Economic Importance of Central Himalayan Forests to Rural Households." *Forest Policy and Economics* 20 (0): 25-35.

Shackleton, Charlie M., Sheona E. Shackleton, Erik Buiten, and Neil Bird. 2007. "The Importance of Dry Woodlands and Forests in Rural Livelihoods and Poverty Alleviation in South Africa." *Forest Policy and Economics* 9 (5): 558-577.

Sunderlin, W.D., A.M. Larson, A. Duchelle, E.O. Sills, C. Luttrell, P. Jagger, S. Pattanayak, P. Cronkleton, and A.D Ekaputri. 2010. "Technical Guidelines for Research on REDD+ Project Sites." Bogor, Indonesia: CIFOR - Center for International Forestry Research.

URT. 1997. "Morogoro Region Socio-Economic Profile." Dar Es Salaam, Tanzania: The Planning Commission Dar Es Salaam and Regional Commissioner's Office Morogoro.

URT. 2007. "Morogoro Region Socio Economic Profile." Ministry of planning, economy and empowerment. Dar Es Salaam, Tanzania.

Vedeld, P, A Angelsen, E Sjaastad, and G. K Berg. 2004. "Counting on the Environment: Forest Income and the Rural Poor." *EDP 98*. World Bank, Washington D.C.

Vedeld, Paul, Arild Angelsen, Jan Bojo, Espen Sjaastad, and Gertrude Kobugabe Berg. 2007. "Forest Environmental Incomes and the Rural Poor." *Forest Policy and Economics* 9 (7): 869-879.

Wunder, S., Jan Börner, G Shively, and Miriam Wyman. 2014. "Safety Nets, Gap Filling and Forests: A Global-Comparative Perspective." *World Development*. In press.

APPENDIX

Table A1: Correlation matrix for different measures of total income (TI), value of assets, forest income (FI) and different measures of forest reliance (FR)

	Observed TI	Predicted TI	Value of Assets	Observed FI	Observed FR	Pred/Obs FR	Predicted FR
Observed TI	1.0000						
Predicted TI	0.5641*	1.0000					
Value of Assets	0.2919*	0.5256*	1.0000				
Observed FI	0.0320	0.0070	0.0146	1.0000			
Observed FR	-0.2560*	-0.3047*	-0.1656*	0.7585*	1.0000		
Pred/Obs FR	-0.1225	-0.2657*	-0.1192	0.8923*	0.8841*	1.0000	
Predicted FR	-0.3491*	-0.5425*	-0.2918*	0.3546*	0.5387*	0.5024*	1.0000

Table A2: Comparison of variables across household categories based on observed income and predicted income (log-log model*)

	Structurally poor (70)	Stochastically poor (20)	Stochastically rich (20)	Structurally rich (40)	Test statistics
Income variables (AEU)					
Crops	54 396	69 146	180 542	259 303	F=25.59***
Business	2 429	3 723	0	77 014	F=5.08***
Forest (FI)	12 422	10 389	33 862	16 508	F=6.81***
Firewood	9 910	6 259	10 595	12 674	NS
NTFP	1 756	3 319	7 960	1 737	F=2.94**
Timber/charc.	756	810	15 307	2 097	F=5.05***
Salary	7 295	5 334	16 796	17 354	NS
Non-forest env	5 208	7 118	8 272	14 191	NS
Livestock	1 700	1 783	4 833	6 435	NS
Miscellaneous	578	2 267	4 758	3 895	F=2.98**
Total income (TI)	83 874	97 589	248 660	392 549	F=31.70***
Predicted total inc. (PTI*)	112 460	261 209	142 592	304 095	F=55.66***
Forest reliance measures					
Observed FR (FI/TI)	0.1625	0.1027	0.1781	0.0555	F=5.54***
Long term FR (FI/PTI*)	0.1171	0.0460	0.2410	0.0601	F=8.44***
Predicted forest reliance	0.1567	0.1066	0.1595	0.0729	F=12.61***
Basic household characteristics					
AEU (number)	4.49	3.28	3.90	3.49	F=5.28***
Female headed	0.14	0.10	0.30	0.08	NS
Age (years)	46.70	44.10	46.55	43.80	NS
Education (years)	4.03	4.05	4.15	5.47	F=2.35*
Agricultural land per AEU	0.34	0.76	0.39	0.74	F=18.75***
Value liquid assets	83 310	102 650	188 625	378 325	F=12.55***
Illness hh head	10.24	23.00	10.00	9.20	NS
Illness spouse	7.01	10.70	4.00	8.32	NS
Dist. to village center (min)	119.59	65.40	88.70	62.35	F=4.80***
Share commercial FI	0.03	0.03	0.07	0.01	NS

*Income predicted based on log-log model (variables on log form in the regression model: member groups of household, year education of household head, illness head and spouse, land, farm and household implements, livestock, distance)

Table A3: Comparison of crop prices across household categories

Price of crops (gross value per sack, in TSH)	Structurally poor (73)	Stochastically poor (17)	Stochastically rich (17)	Structurally rich (43)	Test statistics
Maize	27 435	26 125	25 250	25 878	NS
Beans	83 921	82 222	95 180	89 740	NS

PAPER 4

Forest as an employer of last resort and potential impacts of REDD+ in Tanzania

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Abstract

This paper uses household-level data from forest adjacent villages in Tanzania to study income and activity diversification across households. An analytical household model provides the theoretical framework to investigate the linkages between shadow wages, the use of forests and potential impacts of REDD+ projects. The empirical analyses show that income diversification is a key characteristic across households of all income levels, but the share of forest income varies. Asset-poor households have low shadow wages and limited on-farm income generating opportunities. Their share of forest income is high, and extraction of forests products in some ways acts as an employer of last resort. This has implications for how different households are affected and adjust when restrictions on forest use are imposed as part of REDD+ implementation.

Keywords: Forest reliance, poverty, smallholders, income diversification

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1 Introduction

Income diversification is a key characteristic of rural households in developing countries (Banerjee and Duflo 2007). In addition to farming their own land, smallholder households engage in a range of income generating activities to meet their subsistence and cash needs, including income generated from livestock, household businesses and casual wage labor. In addition, incomes from environmental resources in forested and other natural habitats play an important role in rural household economy. In a global-comparative analysis of environmental income, Angelsen et al. (2014) find that forest income on average accounts for more than one fifth of total household income in developing countries. They also confirm the well-established pattern of poverty and higher dependency of resources from the forest, similar to the finding in a meta-analysis of 51 case studies (Vedeld et al. 2007).

In an accompanying paper, analyzing data from the same sample of households as in this paper, we identify *who* the forest reliant households are, and find a strong pro-poor profile of forest reliance (Dokken and Angelsen 2014). The focus of the present paper is to look into *why* some households earn a larger share of their income from forest related activities. A household model based on Barbier (2010) is used as a theoretical framework to discuss the role of shadow wages (measured by marginal returns to aggregate labor endowment) in shaping households activity choices. Welfare maximizing households will allocate their labor so that the marginal returns are the same across different economic activities (Singh et al. 1986). Hence, if a household does not undertake a specific economic activity, this is because their shadow wage exceeds the returns to this activity, and they can earn a higher return by allocating labor to other activities. Contrary to household business and labor market activities, forest activities usually require few skills, little capital and have low entry costs. At the same time, forest activities are labor intensive and the most of the resources extracted are of low market value. We can then predict that the households involved in low return forest activities are the households with the lowest returns to labor.

Angelsen and Wunder (2003) launched the hypothesis of the forest acting as an employer of last resort for asset-poor households. I test this hypothesis by comparing shadow wages, resource endowments and income diversification across households. The empirical results indicates that households that are rich in resources like land, skills and capital for business have relatively higher shadow wages and earn a higher share of their income from on-farm activities, while households with less resources earn a higher share of their income from off-farm activities, particularly forest related activities.

This makes poorer households more vulnerable to deforestation and forest degradation (Barbier 2010). At the same time, they may also be more vulnerable to initiatives to reduce

deforestation and forest degradation if the initiatives restrict the access to the forest without being fully compensated, as poorer households have fewer other income earning opportunities. Within the framework of the household model, we discuss potential impacts of REDD+ initiatives[1] for different groups of households. The nature of REDD+ initiatives in Tanzania is that of integrated conservation and development projects. The focus is not merely to reduce the amount of carbon emitted from forest, but also to conserve forest and improve the livelihoods of forest dwellers (United Republic of Tanzania 2012). The REDD+ policy mechanisms discussed in this paper are restricted access to the forest, payment for environmental services and alternative livelihood opportunities such as providing off-farm labor opportunities.

In the next section I present the theoretical framework and discuss the potential effects of REDD+ initiatives. Section 3 provides a short introduction to the policy context in Tanzania and the data collected and used. The empirical strategy used to estimate household specific shadow wages is described in Section 4. The results are presented and discussed in section 5. The last section concludes.

2 Theoretical framework: the role of shadow wages

Treating the household as a single decision making unit that maximizes welfare subject to its resource constraints and income earning opportunities yields the baseline proposition that the household will allocate its labor time so that the average marginal returns are the same across different economic activities (Singh et al. 1986). In developing economies, labor markets are commonly thin or missing, and only a small share of the work force is engaged in wage labor. In this context of market failures, farm household's production and consumption decisions are nonseparable, and the shadow wage rate is determined within the household (Singh et al. 1986). Jacoby (1993) and Skoufias (1994) show that the shadow wage of self-employed farm laborers is equal to their marginal product of labor estimated from an agricultural production function.

The following model, based on Barbier (2010), demonstrates the role of shadow wages in shaping household's activity choices. Consider a representative household in a rural area without well-functioning markets for land, labor and credit. The main economic activity for the household members is working on their own farm (on-farm). This includes cultivating agricultural land, doing household business and tending livestock. In addition, households can engage in income

[1] Reducing Emissions from Deforestation and Forest Degradation and enhancing forest carbon stock in developing countries.

generating activities outside their own farm (off-farm), such as agricultural wage labor and collect resources from communal forests. The household maximize the following utility function:

$$U = U(c, l^l, s, x; z), \;\; U_i > 0, U_{ii} < 0, \quad i = c, l^l, s, x, \tag{1}$$

where c is the household's consumption of own produced goods, l^l is leisure time, s is consumption of forest products and x is the amount of purchased consumption goods, all conditional on household characteristics, z. These characteristics include household composition, such as gender and age, health and number of dependents.

In addition, the household faces technological, time and budget constraints. The production function is an aggregate output (*y*) from on-farm production, including farming, livestock and household business:

$$y = f(l^h, v, N), \quad f_i > 0, f_{ii} < 0, f_{ij} > 0, \; \lim_{i \to 0} f_i(0) = 0, \;\; i = l^h, v, N, \;\; i \neq j, \tag{2}$$

where l^h is the aggregate household labor (aggregate household labor is treated as homogenous), v is purchased inputs, and *N* is a measure of the quantity and quality of the resource stock available to the household, including land and livestock. Given market failures, the land and livestock allocation is given in the short run.

In addition to labor spent for own production and leisure, some of the household labor may also be allocated to work outside their own farm, l^o. This can take the form of casual wage labor or harvest of resources in the communal forest, either for subsistence or for cash. The household labor constraint is formalized by

$$L = l^l + l^h + l^o, \quad l^l, l^h > 0, \;\; l^o \geq 0, \tag{3}$$

The budget constraint facing the household depends on the purchased consumption goods and inputs, p^x and p^v on the left hand side, and total income on the right hand side. If farm production, y, is larger than household consumption of own goods, c, the marketed surplus is sold at price p^y and added to the budget available for consumption of purchased goods. Total income also includes exogenous non-labor income denoted *R* (remittances, pension etc.) and off-farm income (wage received for any paid work and the value of harvested forest resources), $w^o l^o$. The household budget constraint is then:

$$p^x x + p^v v = p^y (y - c) + w^o l^o + R, \;\; x, v \geq 0, \;\; y > 0, \quad R \geq 0 \tag{4}$$

Maximizing utility (1) subject to production, time and cash constraints (2)-(4) yields the optimal levels of c, l^l, s and x as well as optimal levels of purchased inputs v and labor l^h, l^o. The optimal choices for time allocation, l^l l^h and l^o are governed by the first order conditions:

$$U_{l^l} = \lambda, \quad p^y f_{l^h} = \frac{\lambda}{\mu}, \quad \mu w - \lambda \leq 0, \quad l^o \geq 0, \quad [\mu w^o - \lambda] l^o = 0 \quad \text{or}$$
$$\frac{U_{l^l}}{\mu} = p^y f_{l^h} = \frac{\lambda}{\mu} \geq w^o \tag{5}$$

λ is the shadow value of the total labor and leisure time of the household and μ is the marginal utility of additional income. From (5) it follows that the household will allocate labor to on-farm production activities so that it equates the marginal value of leisure, and further, that the value of this labor is equal to or exceeds the returns received from off-farm labor, either from casual labor or from harvesting forest resources. The reservation wage, w^R, is defined in this equilibrium. If the off-farm wage is higher than the reservation wage, the household will engage in off-farm activities, otherwise not.

$$\frac{U_{l^l}}{\mu} = p^y f_{l^h} = w^R \tag{6}$$

An important difference in this model compared to Barbier (2010) is the role of the market wage. He assumes a perfectly functioning labor market, and compares the market wage rate to the household specific reservation wage. A perfectly functioning labor market is not a reasonable assumption in our setting. The labor market is not equally accessible at all times and across all households. In the synthesis paper by Barrett et al. (2001) on nonfarm income diversification in rural Africa, they find that attractive nonfarm opportunities are only accessible to a limited subpopulation, and typically those with higher endowments of land and human capital. They focus on non-agricultural labor in their study, but access to casual agricultural labor might also vary depending on households' endowments of productive and human assets.

We can include differentiated access to the non-farm jobs by including transaction costs (TC) in the model by assuming that all households are able to access wage labor if they willing to travel far from home. The transaction costs include transport costs, searching costs and costs related to staying away from one's own farm. These costs vary across the households depending on endowments of assets, human capital, network and other household characteristics. Thus, rather than using the market wage, w^m, the wage received by the household is defined as the effective wage, w^e, i.e., the market wage minus transaction costs ($w^m - TC$).

Under the assumption of utility maximizing behavior, the effective wage received from off-farm work must exceed the marginal labor productivity on the farm for a household to participate in the labor market. When the effective wage received is higher than the reservation wage it is optimal

to sell some labor in the market. Then, the optimal allocation of labor, l^{h^*} and leisure, l^{l^*}, is determined by their respective values equated to the effective wage rate. Similarly, if the price of forest resources is higher than the reservation wage rate, it is optimal to allocate some time for harvest of forest resources, and l^{h^*} and l^{l^*} is determined by their respective values equated to the price of forest resources.

Figure 1 illustrates a household's labor allocation. The total time allocated to leisure, labor on-farm and for off-farm activities are depicted on the horizontal axis. The marginal cost of allocating time for labor in terms of foregone leisure is upward sloping because of the decreasing marginal utility of leisure. The marginal return to labor allocated to own production is downward sloping because of decreasing marginal productivity of labor for a given quality and quantity of the resource endowment used by the household. The reservation wage rate is determined by the intersection of the two curves depicting marginal utility of leisure and marginal returns to labor.

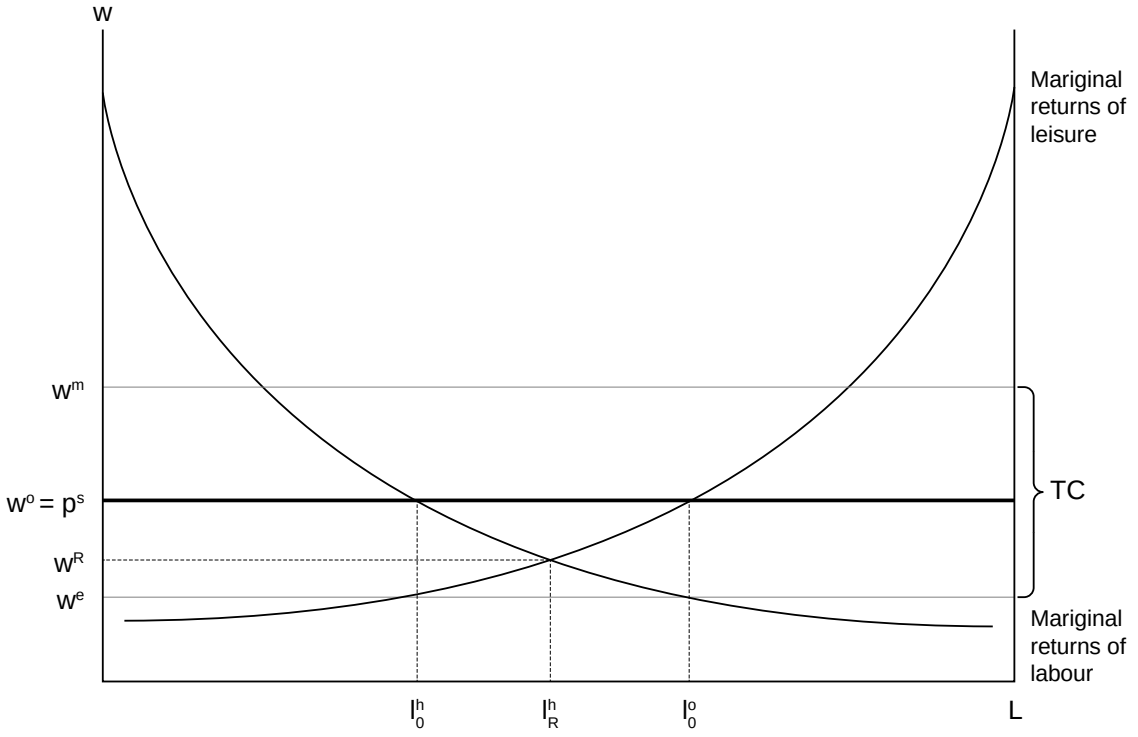

Figure 1 Household labor allocation.

The wage received for off-farm activities, be it from wage labor (w^e) or harvest of forest resources (p^s), is illustrated by w^o. This is the wage the household can receive for off-farm activities, and is determined by the highest value of the w^e and p^s. Thus, if the effective wage rate

received in the market is lower than the value of forest resources, the value of forest resources determines w^o.

If the effective wage the household receives for off-farm activities is lower than the reservation wage, the household will spend l_R^h on own production and $L - l_R^h$ on leisure. If the wage for off-farm activities is higher than the reservation wage, the household will reduce both labor for own production and leisure to engage in off-farm activities. The household will allocate l_0^h labor for own production, l_0^o to off-farm activities and the remaining $L - l_0^h - l_0^o$ to leisure.

The labor allocation choices illustrated in this section is a framework to analyze how a household make labor allocation choices. In reality, household income-generating activities change over the year, depending on the crop season, weather and changes in household needs, and marginal productivity for labor on-farm is likely to vary over the year. Similarly, the effective wage rate is likely to vary depending on seasonal variations in the casual labor market. Such seasonal variations are not taken explicitly into account, rather, the model gives the optimal allocation of household labor at a given point in time.

Income from crops is an important income source for rural households in developing countries and access to land is a key asset that is likely to influence production decisions made by the household (Ellis 2000). The household-specific shadow wage rate will vary across households depending on access to resources, and it will change over the year. In the high season, marginal return to agricultural labor is high, and the household is likely to allocate little labor to other activities, while in the low season, marginal return to agriculture is low and the household will allocate more labor to other activities. Most forest activities can be characterized by low entry costs and few skills and capital requirements, but also by low returns. This makes harvest of forest resources attractive to households with low reservation wage only, and households poorer in income and resources tend to be more reliant on forest income.

REDD+ policies can affect the equilibrium in several ways, depending on the instruments used. Restrictions on forest resource use can be implemented by limiting the amount of forest resources harvested and/or prohibiting access to certain areas completely. Prohibiting access to certain areas may lead to longer walking distance to harvest forest resources, and thus lower the net value of the resources harvested per unit of labor. For households with a low reservation wage, that is, those who allocated some time to forest activities before the restrictions were introduced , will now allocate more time to own production and leisure, at the expense of forest activities. If the new value of forest resources fall below w^e, it may be optimal for the household to allocate some time for wage labor, given that w^e is above the household reservation wage, w^R. If we assume that households with a low reservation wage are also the poorest (to be tested later), then

this REDD policy will also reduce the welfare for the poorest more than for the better-off households.

Paying agents to abstain from harvesting forest resources, such as PES, is another REDD+ policy option. The core of PES is to pay the producers for the environmental services they provide. In this case, it means paying the households that already harvest forest resources for *not* harvesting or for harvesting *less*. PES is a conditional payment, and we can study it within our model in the following way: completely abandoning forest harvesting gives a certain, maximum payment, PES^{max}. The payment is reduced if households harvest some forest resources. This means that the net value of the forest resource is reduced to p^s minus the payment received (transformed into payment per labour units). If the level of that payment is equal to or higher than the difference between the value of forest resources and the household reservation wage rate ($p^s - w^R$), the household will no longer harvest forest resources.

There is, however, an additional income effect to consider. The potential payment, PES^{max}, can be included in the model as an increase in R in Eq. 4. This will reduce the marginal utility of income, and leads to a shift to the left in the curve for marginal utility of leisure. In the new equilibrium, the reservation wage rate is increased, and the time devoted to leisure is increased further, at the expense of time allocated to productive activities, including forest extraction. Including this income effect in the model does also imply that the PES payment can be set lower than ($p^s - w^R$) and still achieve zero harvesting. Further, the payment needed to achieve this would also be household specific. Setting payments such that zero harvesting is achieved at the minimum costs (no overcompensation) entails an enormous informational problem, not discussed further in this paper[2].

Since the household could allocate the labor in exactly the same way as before and receive the same income, the changes implies that the household will also be better off than before REDD+ implementation.

One should also note that these are short-term effects. In the longer term, if the policy successfully reduces deforestation and forest degradation, we can expect an increase in forest quality and higher returns to forest related activities. This can also increase the sustainable levels of harvesting, and may not necessarily need countermeasures.

To test whether this is a useful theoretical framework to discuss REDD+, I first estimate the household shadow wage as the returns to household labor, and then analyze the relationship between households' shadow wage and forest reliance in Tanzania.

[2] The effectiveness and efficiency of PES payments are discussed in Engel et al. (2008).

3 Context and data

A random sample of 150 households in forest adjacent villages is used to test if the theory is applicable to the context. The sample villages are all in Kilosa District in the Morogoro region in Tanzania. The district has an area of 14 245 km^2 and had a population of 488 191 in the latest (2002) census. Agriculture is the main income generating activity, and employs about 85% of the labor force (URT 2007).

The area of land under forest cover in the Morogoro region is approximately 55%[3] (URT 1997). Although all land in Tanzania is held in trust by the president on behalf of the nation (URT 1999), about 10% of the forested land in Tanzania is under some form of community management recognized by statutory law (Sunderlin et al. 2008). There are two main approaches for decentralizing tenure rights to forests in Tanzania that differs in the level of decentralization of rights and responsibility. The first approach, covering the largest area of forested land, is *community based forest management* (CBFM). CBFM takes place on land registered under the Village Land Act (1999) and managed by the village council. Village forest reserves are designated by the village and district government and managed by a village natural resource committee, a group or an individual. The village has ownership and management responsibility and retains all forest-generated revenue. The second approach is a collaborative management approach, called *joint forest management* (JFM). It takes place on national forest reserves or local government reserves. Land ownership remains with the state while forest management responsibility and revenues are divided between the state and the community and formalized through a joint forest management agreement (Blomley and Ramadhani 2006). All villages in our sample have some level of community rights to harvest forest resources in at least a share of the forests within their boundary village boundaries, either by statutory or customary laws. Although village level rules exist, lack of rule enforcement and low compliance is prevalent (Dokken et al. 2014), and the tenure regime resembles that of *de facto* open access.

3.1 Data

The data set is part of the Global Comparative Study on REDD + (GCS-REDD) conducted by the Center for International Forestry Research (CIFOR) and its partners. This is a comprehensive research project on REDD+ projects in nine countries. In this paper, we present research conducted by module 2, which focuses on REDD+ project sites and aims to understand the effectiveness, efficiency, equity and co-benefits of design and early implementation. It involves

[3] The exact number is unknown (URT 2007), and different estimates occur in the literature. This number is estimated based on numbers from 1997 (URT 1997).

collecting both qualitative and quantitative data before and after implementation of REDD+ at the national, project, village and household levels. In selected project sites, we also collect data in control villages. By comparing villages that are part of a REDD+ project (intervention) and non-REDD+ villages (control), both before and after the introduction of REDD+ incentives (referred to as before-after/control-impact design, or BACI), module 2 aims to provide robust empirical evidence of the performance of REDD+ (Jagger et al. 2010).

In this paper, we use GCS-REDD baseline data, collected between March and July 2010, at a very early stage of project implementation. A household survey on a random sample of 30 households in five villages in Kilosa was conducted in 2010. Detailed information on household characteristics was recorded, including detailed income accounting and household level harvest of natural resource from forested and non-forested areas. If possible, both the head of household and the spouse were present if the head of household was married. A one year recall period was used. Total income is defined as the sum of cash income, subsistence income and net gifts/transfers of cash or in-kind. The accounting methods from different sources of incomes draw primarily on Cavendish (2002) and the PEN survey (Angelsen et al. 2011).

From the descriptive statistics in Table 1, we see that agriculture is the main income source. Being self-employed in agriculture is the main activity for the vast majority of the households in the sample; in 97% of the households this is the main occupation of the household head. The same is true for the spouse; in 98% of the households with a spouse, the spouse's main occupation is agriculture. 19% of the households have their own household business. The most common household business is brewing and selling *pombe*, the local beer. In total, 13 out of the 28 households are engaged in this activity. Others are selling fish, meat, agricultural and other consumer goods either in their own shop facilities at home or at the market. Two households also have their own flour milling machine. A quarter of the household also report that one or more household members received salary during the 12 months prior to our visit. The majority of these did casual agricultural labor (33 of 38).

Some goods, particularly environmental goods, are for self-consumption and not traded in a market. We used own reported values to get a more realistic estimate of the 'real' price (value to the household) rather than inflated market prices. Due to lack of data we don't deduct the depreciation of farm implements as a cost of production, but purchased inputs and hired labor[4] is included in the costs. For all agricultural, forest and livestock products, we used a test to identify outliers and checked total values and prices for each product by unit combination, and reviewed outliers manually. In the case of a missing value of an item, the mean village value was used.

[4] In total, 18 of the 150 households hired some labor.

Given restrictions on the harvest in protected areas or of certain products, such as woody material for production of charcoal, some activities are illegal and may be underreported in the household surveys. We are not able to test or control for this potential bias in our data, but tried to limit this during data collection by underscoring to respondents that none in our group of field workers were linked to government or any environmental NGO and that the households' information would remain confidential.

Table 1 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max[2]
Income and cost variables					
Total household net income (in TSH[1])	150	696 925	744 560	-46 900	6 601 200
Share from crops[2]	150	0.6743	0.2614	0.0000	1.8657
Share from forest	150	0.1281	0.1530	0.0000	0.9000
Share from non-forest	150	0.0612	0.1106	0.0000	0.7507
Share from salary	150	0.0574	0.1504	0.0000	1.0326
Share from business	150	0.0571	0.1548	0.0000	0.8184
Share from livestock	150	0.0179	0.0539	0.0000	0.3775
Share from miscellaneous	150	0.0126	0.0397	0.0000	0.3571
Total gross income (in TSH)	150	817 404	1 058 204	74 033	9 801 200
Business costs (in TSH)	150	88 866	403 248	0	2 808 000
Crop costs (in TSH)	150	28 043	64 328	0	392 000
Livestock costs (in TSH)	150	3 571	17 171	0	182 000
Household productive assets and composition					
Total agricultural land used (in ha)	150	1.8077	1.1530	0.4000	6.0705
Business dummy (1 if own business)	150	0.1867			
Salary dummy (1 if receive salary)	150	0.2533			
Adult males	150	1.3600	0.9643	0	5
Adult females	150	1.2733	0.7763	0	4
Elderly	150	0.1933	0.4874	0	2
Young	150	0.8400	0.8520	0	3
Children	150	1.4267	1.3774	0	7
Household characteristics					
Gender household head (1 if female)	150	0.1400			
Age household head (in years)	150	45.5600	14.4070	20	98
Education household head (in years)	150	4.4333	2.9434	0	11
Distance to village center (in min walking)	150	92.9800	87.5679	0	360

[1]Exchange rate July 1st 2010: 1 USD = 1599.0305 TSH (From: http://www.exchangerates.org.uk/USD-TZS-exchange-rate-history-full.html), [2]The mean income shares are calculated by taking the mean income shares for the households, [3] Shares larger than one is due to a negative income from one/several of the other activities.

4 Empirical strategy: estimation of household shadow wage

The estimation of the household specific shadow wage build on the work by Jacoby (1993) and Skoufias (1994). The first step in the empirical strategy is to estimate the production function. The estimates from the production function are then used to estimate the marginal productivity of labor.

Household labor supply is one of the key variables, but this data is not available for our sampled households. Similar to Fisher et al. (2005), assumptions are made regarding different members' labor contribution, and annual hours worked are estimated for each household by summing up total hours worked in all activities over different groups[5].

Given the lack of detailed labor contribution to the different household income generating activities, the aggregated household gross value of production is estimated. Thus, the estimated function is a revenue function. For simplicity, the technology is described by a Cobb-Douglas function. By logarithmic transformation, the Cobb-Douglas revenue function can be estimated as a linear expression:

$$\ln(Y_h) = \ln(\alpha) + \beta_L \ln(L_h) + \beta_N \ln(N_h) + \sum_{h \in H} \beta_V \ln(V_h) + \sum_{h \in H} \beta_Z Z_h + \varepsilon_h \quad (7)$$

where Y_h is the gross output value for household h, measured by their total gross income from all activities, α is total factor-productivity, L is the total number of labor hours available within the household while N is the amount of land in hectares, V is a vector of the monetary value of business inputs and purchased crop and livestock inputs used by household h and Z is a vector of household characteristics, including gender, age, education of the household head and distance to the village center as proxies for skills and management ability. In addition, village dummies are included to control for village fixed effects. The β's are measures of how the amount of output responds to changes in the inputs, and ε is the household specific error term. Many of the

[5] All members are assumed to work 6 days a week (312 days per year), but their labor contribution vary. Adults aged 16-64 are assumed to work 8 a day. Hours worked by different members of the family is similar to the assumptions made by Fisher et al. (2005), with some exceptions. Time use studies from Africa often find that women work longer hours than men (see e.g. Blackden and Wodon 2006), and Fisher et al. (2005) assume that women work 2 hours more than men. Although recognizing the importance of this work, this include housework that is not a direct contribution to the household's measurable output, thus this is disregarded in this model. Elderly aged 65 and above are assumed to work 2 hours. Children and adolescents contribute to household economy. In their study of children's time-use in Tanzania, Kondylis and Manacorda (2012) found that about 60% of children aged 7-14 are engaged in work, and among these the average working hours per week is 26 hours. For the purpose of this study, young girls and boys aged 10-15 are assumed to work 4 hours per day, while children aged 9 and below are assumed to work 2 hour. For each member aged 16 and above, total days of illness in the previous 12 months is subtracted from the estimated labor contribution. In addition, total household labor supply is reduced by 20% for all households, assuming only 80% of total labor hours are spent for productive purposes. Different assumptions regarding household labor is included as a sensitivity analysis.

households do not use purchased inputs. To avoid the problem of observations with the value of 0, 1 is added upon log-transformation for business inputs and purchased crop and livestock inputs.

Household labor endowment is considered exogenous in the model, given that this variable is not the observed labor contribution from the household member. The amount of land used by the households is also considered exogenous in the short term, and (7) is estimated by an OLS model.

The shadow wage, or returns to labor endowment, is directly derived from the first order derivative of (7):

$$\widehat{w}_h = \hat{\beta}_L \frac{\hat{Y}_h}{L_h} \tag{8}$$

The estimated household specific shadow wage rate, $\widehat{w}_h$, is calculated using the Cobb-Douglas revenue function estimates from (7) and $\hat{Y}_h$ denotes the fitted gross output value of household *h*.

An implicit assumption is that all households use the same production technology. This is a reasonable assumption, given that all the households are from the same area and that the main income generating activity for most households. The Cobb-Douglas functional form is commonly used when estimating production functions, but it imposes some assumptions. This includes that the inputs may be substituted for another, and that output elasticities are constant, independent of production level. Further, as briefly discussed in the previous section, household shadow wage is likely to vary over crop season and across household members if there is division of labor and/or variation in skills or physical ability. The shadow wage estimated in this paper is the aggregate household shadow wage, and averaged over a year. Some household variation is captured by subtracting days of illness from total labor supply, but the estimate of household shadow wage is still coarse.

Another weakness of the analysis is that I use shadow wages to explain household's off-farm activity, including participation in the market for casual wage labor. At the same time, off-farm income is included in the model used to estimate household shadow wage. Knowing how much time different household members spend on income generating activities would be very useful and improve the estimation of household specific shadow wages, but data limitations restrict the options available to explore this. A very detailed data set, with time use data for each separate household member for different activities over a year would be preferable, but unfortunately, this data is not available.

5 Results and discussion

To test the hypothesis of the forest as an employer of last resort for resource-poor households in the context in Kilosa, Tanzania, I compare aggregate shadow wages across households to see if asset-rich households have higher shadow wages, and then I test whether households with lower shadow wages are more dependent on forests.

5.1 Shadow wages and household poverty

The results from estimating the revenue function (Eq. 7) are presented in Table 2. Both the dependent and the independent variables are log transformed, and the coefficients can therefore be interpreted as elasticities. Land and household labor are the most important inputs. Everything else equal, a 10% increase in agricultural land used by the household will is associated with a 5.6% increase in total gross income. Similarly, a 10% increase in household labor is associated with a 7.4% increase in income.

Table 2 OLS estimation of the Cobb-Douglas revenue function

Variables	Coefficient (robust std. err)
Log of agricultural land used (in ha)	0.5556*** (0.1665)
Log of total labor hours in the household	0.7391*** (0.1520)
Log of business costs (in TSH)	0.0679*** (0.0130)
Log of total crop costs (in TSH)	0.0236** (0.0117)
Log of livestock costs (in TSH)	0.0503*** (0.0177)
Gender household head (1 if female)	0.1020 (0.1525)
Age of household head (in years)	-0.0265 (0.0187)
Age of household head (squared years)	0.0003* (0.0002)
Education household head (in years)	0.0554*** (0.0179)
Distance from household to village center (in minutes walking)	-0.0015** (0.0006)

Cont. Table 2

Village 1	-0.0302
	(0.1684)
Village 2	-0.4313**
	(0.1889)
Village 3	-0.2573
	(0.1867)
Village 4	-0.1329
	(0.1753)
Constant	6.2457***
	(1.2205)
R-squared	0.5318
N	150

* p<0.10, ** p<0.05, *** p<0.01. The Cobb-Douglas specification was tested for omitted variables using the Ramsey regression specification-error test (Ramsey 1969). The model cannot be rejected by this test (p= 0.1213).

As described in Eq. 8, the estimated coefficients presented in Table 3 are used to calculate the household specific shadow wage (return to labor) per hour and the mean hourly shadow wage is 96 TSH (Table 3).

Table 3 Estimated shadow wage based on coefficients from the revenue function

	Mean	Std.deviation	Min	Max
Shadow wage	96.1173	70.6828	23.5306	372.6274

The shadow wage differs across households, but is positively correlated (0.55) with household total income (Appendix A1). The positive correlations are even stronger when correlating shadow wage with income per adult equivalent (0.62). The importance of agricultural land as a productive asset in our study site is evident from Table 2, and it is also positively correlated with total household net income (0.40) and household shadow wage (0.45). Figure 2a and b illustrate the correlation between shadow wage and (a) total income and (b) agricultural land, with a fitted quadratic regression line. From these, we see that households poorer in income and agricultural land have lower shadow wages.

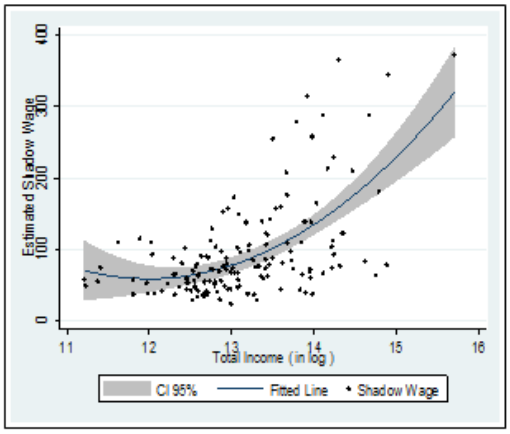

Figure 2a Relationship between shadow wages and household net income

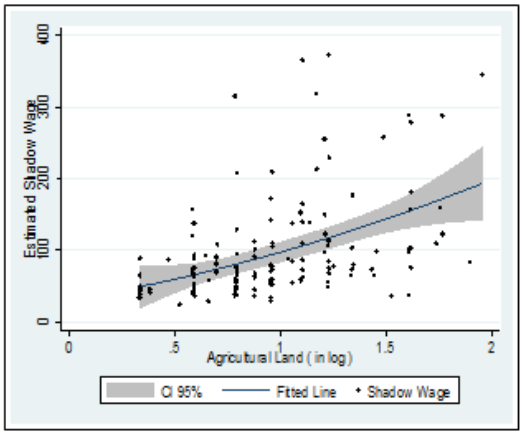

Figure 2b Relationship between shadow wages and agricultural land used

5.2 Shadow wages and activity choices

Agricultural land is found to be a key asset that influence production decisions made by rural households in developing countries (Ellis 2000). By dividing the sample in quintiles based on land holdings per adult equivalent, we can compare income diversification across different segments of the sample depending endowments of an important productive asset (Table 4). The largest share of household income is from on-farm activities, defined as income from crops, business, non-forest environmental income[6], livestock and miscellaneous income. On average, on-farm sources account for 81% of total income, while the off-farm activities forestry and salary income account for 19% of total income. The on-farm share is larger in the higher quintiles; they have a larger share of their income from both crops and from business. The lower quintiles derive a significantly higher share of their income from off-farm activities. This difference is driven by the fact that the lower quintiles earn a higher share of their income from forest activities compared to the highest quintile.

[6] This is included as on-farm income because the households who report this kind of income report they harvest these resources on private land, not from communal areas. This income is from goods harvested in non-cultivated areas that are not forested, and includes fruits, thatch, mushroom, firewood etc.

Table 4 Comparison of income shares and shadow wages across land holding quintiles

	Quintiles						
	1	2	3	4	5	Total	F-test[1]
On-farm	0.7637	0.7497	0.7992	0.8426	0.8794	0.8079	F=2.09*
Crops	0.6615	0.5936	0.6635	0.7303	0.7231	0.6743	NS
Business	0.0429	0.0226	0.0604	0.0586	0.0965	0.0571	NS
Non-forest env.	0.0441	0.0845	0.0673	0.0331	0.0722	0.0612	NS
Livestock	0.0107	0.0374	0.0112	0.0099	0.0193	0.0179	NS
Miscellaneous	0.0088	0.0115	0.0026	0.0109	0.0277	0.0126	NS
Off-farm	0.2363	0.2503	0.2008	0.1574	0.0903	0.1854	F=3.49***
Forest	0.1831	0.1738	0.1291	0.0822	0.0747	0.1281	F=3.43**
Salary	0.0532	0.0765	0.0717	0.0752	0.0156	0.0574	NS
Shadow wage	54	65	100	94	160	96	F=14.69***

*, **, *** significant at 0.1, 0.05 and 0.01 respectively. [1]One-way ANOVA

The importance of income from crops is also evident when looking at how income shares are correlated. A simple correlation matrix with households' shares of income from different sources show that the crop income share is negatively correlated with the other income sources (Appendix A1). Similarly, the forest income share is negatively correlated with the business income share, meaning that the higher share a household earn from business, the smaller is the share of income from the forest, indicating that households with relatively more business income are less forest reliant across households independent of relative income poverty.

To see how this income diversification is related to shadow wages, household specific shadow wage is correlated with the income shares from different sources (Table 5).

Table 5 Correlation shadow wage and income shares

Income share	Correlation value with shadow wage
Crop	0.0981
Livestock	0.0245
Business	0.4520*
Forest	-0.2225*
Non-forest	-0.1652*
Salary	-0.1469
Miscellaneous	-0.0005

* 5% significance

The shadow wage is not correlated significantly with the crop income share. This is not surprising, as the crop income share differ very little across households. For the activities that do differ across households, forest and business, we see that shadow wage is positively correlated with the share of income from business. This indicates that households with higher shadow wages have

access to better income earning opportunities compared to the households with lower shadow wages.

Given the low returns to harvesting forest activities, we expect households collecting more forest resources relative to their total income are households with lower shadow wage, and this is what we find. The shadow wage is negatively correlated with shares of income from both forests and non-forested areas. This supports the hypothesis that households with lower shadow wages are more dependent on forests and other communal resources than households with higher shadow wages. Thus, it seems like the forest and other communal resources act as an employer of last resort for many of the poor households without access to other income generating opportunities. The negative relationship between shadow wage and forest income share is further illustrated in Figure 3.

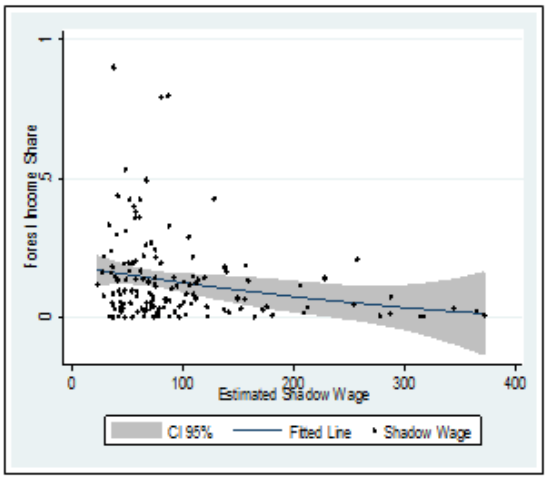

Figure 3 Relationship between shadow wages and forest income share

5.3 Shadow wages and market wages

We know from the descriptive statistics that in total, 38 household have some income from salary and with the exception of five of the households, they were all engaged in casual agricultural labor (Table 6). Assuming they prefer working on their own farm (i.e., disutility related to working for someone else compared to on own farm), we expect these households to have insufficient productive resources to cover their needs. This is captured in low shadow wage. Thus, households with lower shadow wage are expected to have a larger share of their income from wage labor. When looking at the correlation coefficient, it has the expected negative sign, but the negative correlation is not large enough to be significant.

Most of households were paid by task, and not on an hourly/daily basis, and thus it is not possible to compare the received wages across the households. We did, however, ask for the daily market wage rate for casual labor at the village level from key informants in each village. To compare, the hourly shadow wage is multiplied by eight, assuming an eight-hour working day. Time allocated for own-farm activities is expected to be spent less efficiently compared to when taking on casual labor. Because of this, total household labor supply was reduced by 20% before household shadow wage is calculated. Still, the daily wage rate for casual labor is higher than the mean shadow wage rate in all the villages. Both Jacoby (1993) and Skoufias (1994) find that the observed wages are higher than household shadow wages, and one of the few studies estimating household shadow wage in Tanzania find a similar result. Using data from 2008-2009, Nerman (2012) finds that average daily shadow wage for agricultural household is TSH 1260, while average daily wage rate for agricultural casual wage labor is TSH 3133.

Table 6 Comparison market wage rate and estimated shadow wage

Village	Households participating in the labor market[1]	Reported village daily wage rate[2]		Estimated mean daily shadow wage[3]
		High season	Low season	
1	16 of 30	2000	1500	557
2	1 of 30	2322	1021	1014
3	18 of 30	3000	2500	798
4	2 of 30	2000	1000	503
5	1 of 30	6000	3000	974
Total	38 of 150	3064	1804	769

[1]Yes if any in the household receive salary, [2]Male and female wage different in Village 2, otherwise they are reported to be the same, thus the average of male and female daily wage is reported, [3]Based on an 8 hours working day.

We cannot directly compare the price level of forest resources and the wage for casual labor to identify whether the off-farm wage rate available to the households as discussed in section 2 (w^o) is determined by the returns to harvest of forest products or the effective wage rate from casual labor. But wage labor activities across households can give an indication. Although the daily wage rates in the area are several times higher than the estimated shadow wage, few households are engaged in casual wage labor, and the average share of income earned is low. This indicates that harvest of forest resources is a more viable option for the households.

From economic theory, we expect a higher participation in the market for unskilled agricultural labor if the market wage is higher than household shadow wage. In his model, Barbier (2010) assumes that households will seek outside employment is the market wage exceeds the household shadow wage, and that the market wage for hired labor will decline if the supply of

labor exceeds demand. There are at least three possible explanations as to why shadow wages are well below the market wages.

One possible explanation is cooperative behavior and solidarity mechanisms among peasants in rural communities as discussed by Fafchamps (1992) and further explored by Basu (1997). In a study of the Indian village labor market, Kaur (2013) found that nominal wages for casual agricultural labor increase in the case of a positive shock, but does not decrease in the case of a negative shock, and that nominal wages remain high after a positive shock. He suggests that the reason why wages does not fall is that nominal wage cuts are perceived as unfair, both by workers and employers and that cuts in nominal wages are perceived to lower workers' effort.

The second potential explanation is discussed in section 2. Transaction costs can explain the difference between the market wage rate and the household shadow wage, and why households resort to the forest rather than casual wage labor. The presence of transaction costs are also recognized by Jacoby (1993) and Skoufias (1994). Transaction costs can arise from searching costs, travel costs and costs related to staying away from one's own farm. There are potentially large gains to be made by decreasing these transaction costs in terms of reducing the pressure on communal natural resources. If transaction costs can be reduced, and casual labor made available to more households, this is likely to shift the adjustment from engagement in forest activities to casual labor. Further, individuals are not necessarily willing to take on agricultural wage work even though the wage they would receive is higher than their shadow wage and/or the return from forest resources. One reason could be preferences for working on their own farm or at least as self-employed in the forest, and attach a high disutility to wage work. This is not the same as transaction costs per se, but it implies the same; the household would "demand" a higher wage than their shadow wage to take on wage work.

A third explanation is that the estimated shadow wage is underestimated. A more detailed dataset with activity data across different household members over a year would be preferable, but this is not available. The assumptions made about household labor supply do not differentiate across different households. It might be that households with lower returns work less and allocate relatively more time for leisure than households with higher returns to labor. As a sensitivity analysis, the shadow wage is calculated with alternative assumptions of labor available in the household (Appendix). First, labor supply of the 20% most land poor households is reduced by 20% and secondly, labor supply of the 20% most income poor households is reduced by 20% relative to the assumptions made in the 'base' estimate. Shadow wage is also estimated using the same estimates as Fisher et al. (2005), where adult women are assumed to work two hours more than adult men. As a sensitivity analysis, I also estimate shadow wage based on the assumption that

women work no longer than men, both groups work 8 hours a day. As expected, increasing the number of labor hours in the household decreases the shadow wage, whereas decreasing the number of labor hours increases the shadow wage rate. Although the absolute value of shadow wages change, the patterns across groups of households remain the same. Households with more total income and more agricultural land have higher shadow wages, even when labor supply of the poorest households is reduced. With respect to the mix of activities the household engage in, shadow wages are positively correlated with business and negatively correlated with activities related to environmental income from the use of forest and other communal resources.

6 Conclusion

Income diversification is a key characteristic of the households in rural areas in developing countries, and also in our study area. The diversification cuts across poverty status, and what differs between poor and less poor households is the share derived from off-farm income. The poorer households earn a significantly higher share of their income from forests, and this paper demonstrates that the forest act as an employer of last resort for some households. The most forest reliant households have lower shadow wages, in line with the hypothesis promoted by Angelsen and Wunder (2003).

The results of the empirical analysis are broadly in agreement with the household model presented in section 2. The model provides a useful framework for discussing potential impacts of REDD+. Higher restrictions on forest use is likely to harm the poorest households more, as these households are more resource poor and have few other livelihood opportunities to cover their livelihood needs. Payment for environmental services (PES) is one way of compensating forest reliant households for reduced access to and use of forests. Another option is to increase on-farm and non-forest off-farm income generating opportunities for the poorest households. The fact that the market wage is higher than the shadow wage, but still few households participate, suggests that gains can be made from expanding the opportunities for rural poor to access the market for casual labor.

The implications for REDD+ implementation in this context, is that proponents and policy makers need to take into account that households use the forest differently, and that this is driven mainly by access to other productive assets, such as land and capital and skills for household business. If opportunities for off-farm labor and household business are part of the REDD+ initiative, proponents should focus on accommodating improvements for the resource-poor households.

References

Angelsen, A, and S. Wunder. 2003. *Exploring the Forest-Poverty Link: Key Concepts, Issues and Research Implications*. Cifor Occasional Paper No. 40. Bogor, Indonesia: CIFOR Center for International Forestry Research.

Angelsen, A, P. Jagger, R. Babigumira, Brian Belcher, Nicholas J. Hogarth, S. Bauch, Jan Börner, Carsten Smith-Hall, and S Wunder. 2014. "Environmental Income and Rural Livelihoods: A Global-Comparative Analysis." *World Development* In press.

Angelsen, Arild, Helle Overgaard Larsen, Jens Friis Lund, Carsten Smith-Hall, and Sven Wunder (eds). 2011. "Measuring Livelihoods and Environmental Dependence: Methods for Research and Fieldwork. London and Washington, DC: Earthscan.

Banerjee, Abhijit V., and Esther Duflo. 2007. "The Economic Lives of the Poor." *The Journal of Economic Perspectives* 21 (1): 141-168.

Barbier, Edward B. 2010. "Poverty, Development, and Environment." *Environment and Development Economics* 15 (Special Issue 06): 635-660.

Barrett, C. B., T. Reardon, and P. Webb. 2001. "Nonfarm Income Diversification and Household Livelihood Strategies in Rural Africa: Concepts, Dynamics, and Policy Implications." *Food Policy* 26 (4): 315-331.

Basu, Kaushik. 1997. *Analytical Development Economics: The Less Developed Economy Revisited. Chapter 9: Unemployment and Surplus Labor*. Cambridge, MA and London: The MIT Press.

Blackden, C. Mark, and Quentin Wodon (eds). 2006. "Gender, Time Use, and Poverty in Sub-Saharan Africa. World Bank Working Paper No. 73. Washington DC: World Bank.

Blomley, Tom, and H Ramadhani. 2006. "Going to Scale with Participatory Forest Management: Early Lessons from Tanzania." *International Forestry Review* 8 (1): 93-100.

Cavendish, William. 2002. Quantitative Methods for Estimating the Economic Value of Resource Use to Rural Livelihoods. In Campbell, Bruce M., and Martin K. Luckert (eds) *Uncovering the Hidden Harvest: Valuation Meethods for Woodland and Forest Resources*. London: Earthscan.

Dokken, Therese, and Arild Angelsen. (2014). *Forest Reliance Across Poverty Groups in Tanzania*. Ås, Norway: School of Economics and Business, Norwegian University of Life Sciences. Unpublished manuscript.

Dokken, Therese, Susan Caplow, Arild Angelsen, and William D. Sunderlin. 2014. "Tenure Issues in REDD+ Pilot Project Sites in Tanzania." *Forests* (5): 234-255.

Ellis, Frank. 2000. *Rural Livelihoods and Diversity in Developing Countries*. Oxford: Oxford University Press.

Engel, Stefanie, Stefano Pagiola, and Sven Wunder. 2008. "Designing Payments for Environmental Services in Theory and Practice: An Overview of the Issues." *Ecological Economics* 65 (4): 663-674.

Fafchamps, Marcel. 1992. "Solidarity Networks in Preindustrial Societies: Rational Peasants with a Moral Economy." *Economic Development and Cultural Change* 41 (1): 147-174.

Fisher, Monica, Gerald E. Shively, and Steven Buccola. 2005. "Activity Choice, Labor Allocation, and Forest Use in Malawi." *Land Economics* 81 (4): 503-517.

Jacoby, Hanan G. 1993. "Shadow Wages and Peasant Family Labour Supply: An Econometric Application to the Peruvian Sierra." *Review of Economic Studies* 60 (1993): 903-921.

Jagger, P., E. Sills, K. Lawlor, and W.D Sunderlin. 2010. A Guide to Learning About Livelihood Impacts of Redd+. In *Occasional Paper 56*. Bogor, Indonesia: CIFOR - Center for International Forestry Research.

Kaur, Supreet. 2013. "Nominal Wage Rigidity in Village Labor Markets". CDEP-CGEG WP No. 2. Columbia, NY: Center for Development Economics and Policy and Center on Global Economic Governance.

Kondylis, Florence, and Marco Manacorda. 2012. "School Proximity and Child Labor: Evidence from Rural Tanzania." *Journal of Human Resources* 47 (1): 32-63.

Nerman, Måns. 2012. "Households' Income-Generating Activities and Marginal Returns to Labor in Rural Tanzania." *Working Papers in Economics, no. 547*. Department of Economics, University of Gothenburg, Sweden.

Ramsey, James Bernard. 1969. "Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis." *Journal of the Royal Statistical Society. Series B (Methodological)*: 350-371.

Singh, Inderjit, Lyn Squire, and John Strauss (eds). 1986. "Agricultural Household Models. Baltimore: Johns Hopkins University Press.

Skoufias, Emmanuel. 1994. "Using Shadow Wages to Estimate Labor Supply of Agricultural Households." *American Journal of Agricultural Economics* 76 (2): 215-227.

Sunderlin, W., J. Hatcher, and M. Liddle. 2008. *From Exclusion to Ownership? Challenges and Opportunities in Advancing Forest Tenure Reform*. Washington, DC: Rights and Resources Initiative.

United Republic of Tanzania. (1999). *The Village Land Act, 1999*.

United Republic of Tanzania. 2012. "National Strategy for Reduced Emissions from Deforestation and Forest Degradation (REDD+). Second Draft, June 2012." Dar Es Salaam, Tanzania: The Vice President's Office.

URT. 1997. "Morogoro Region Socio-Economic Profile." Dar Es Salaam, Tanzania: The Planning Commission Dar Es Salaam and Regional Commissioner's Office Morogoro.

URT. 2007. "Morogoro Region Socio Economic Profile." Dar Es Salaam, Tanzania: Ministry of planning, economy and empowerment.

Vedeld, Paul, Arild Angelsen, Jan Bojo, Espen Sjaastad, and Gertrude Kobugabe Berg. 2007. "Forest Environmental Incomes and the Rural Poor." *Forest Policy and Economics* 9 (7): 869-879.

Appendix

Table A1 Correlation matrix income shares and shadow wage

	Total income	Share crop	Share livestock	Share business	Share forest	Share non-forest	Share salary	Share misc.	Shadow wage
Total income	1								
Share crop	-0.0480	1							
Share livestock	0.0003	-0.2277*	1						
Share business	0.3492*	-0.3976*	-0.0411	1					
Share forest	-0.2510*	-0.4033*	0.0948	-0.1683*	1				
Share non-forest	-0.0929	-0.2988*	-0.0394	-0.0620	-0.1267	1			
Share salary	0.0227	-0.4183*	-0.0151	-0.1109	-0.1216	-0.0145	1		
Share misc.	-0.0303	-0.0658	0.0337	-0.0535	-0.0023	-0.0821	-0.0604	1	
Shadow wage	0.5454*	0.0981	0.0245	0.4520*	-0.2225*	-0.1652*	-0.1469	-0.0005	1

Table A2 Sensitivity analysis

		Correlation values				
Assumption about household labor	Shadow wage	Income	Land	Forest share	Business share	Non-for env.inc
Base *	96	0.55	0.45	-0.22	0.45	-0.17
Women work 10 hrs	68	0.54	0.45	-0.23	0.44	-0.16
Adults work 8 hrs	73	0.55	0.45	-0.22	0.45	-0.16
Land poor 20% less	88	0.54	0.38	-0.20	0.45	-0.17
Income poor 20% less	103	0.58	0.45	-0.21	0.49	-0.17

*Base: Adult women and men work 8 hours a day, elderly aged 65 and above work 4 hours a day, adolescents aged 10-15 work 4 hours a day, while younger children work 2 hours a day. Days of illness are deducted for the adults. Then, total household labor is reduced by 20%.