Forests and Livelihoods in Malawi: Looking Beyond Aggregate Income Shares

Skog og levekår i Malawi: Mer enn bare aggregerte inntektsandeler

Philosophiae Doctor (PhD) Thesis

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Dedication

*To **Maxwell II**, my son; **Margaret**, my mum; **Maxwell I**, my dad; and the rest of my family.*

*To **Paul Mwale**, my uncle, who inspired and supported me to be what I am today when all hope seemed lost.*

*To my grandma **"Mamo" Elizabeth Dondashe Mwale**, and my Grandpa **"Tata" Felix Anderson Mwale**, you shaped my life in many positive ways. This thesis will forever be part of your legacy.*

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Ås, 2014

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Introduction

Introduction

Forests and Livelihoods in Malawi: Looking Beyond Aggregate Income Shares

Thabbie Chilongo

1 Introduction

1.1 The Problem

Forests play very critical roles in Malawi. Over 90% of the country's energy requirements is fuel wood-based. In addition, forests meet the nation's requirements poles and for most of the timber required for construction, joinery and board manufacture. The rural dwellers, which make up the majority of the population (over 90%), rely to a large extent on forests for their needs in the form of fuel wood, bush meat and other foods, construction materials, agricultural tools and medicinal plants (Government of Malawi, 1996).

However, Malawi, like most Sub-Saharan African countries, presents a case of policy dilemma in sustainable forest management. With its growing population and the resultant contraction of per capita land area, coupled with the ever increasing fuel wood demand, the challenge is to sustainably manage the forests without alienating the majority of local communities whose livelihoods heavily depend on the forests. There is therefore a need to fully understand the forest-reliant people if the goal of sustainable forest management is to be achieved. While much forest research has been on the biological aspects, the social aspect side has not received much attention (Jumbe, 2005). Furthermore, Oksanen et al. (2003) observe that although the importance of forests on livelihoods is widely recognized, there is general lack of mainstreaming of forests in poverty reduction strategy papers due to, among others, weak understanding of links between forest reliance and poverty. This assertion is also supported by Cavendish (2000) who noted that despite the considerable economic significance of environmental resources to rural households, environmental income is quite often either ignored or captured 'in passing' in national income surveys. Therefore, understanding what characterizes forest reliance vis-à-vis livelihood status of rural households is an important step in contributing to effective mainstreaming of forest in policy decision-making and eventually sustainable forest management. This thesis contributes to filling that information gap by assessing the role and determinants of forest reliance on livelihoods of rural households surrounding Chimaliro and Liwonde forest reserves in Malawi.

1.2 Status of Malawi Forests and Policy

Malawi's forest cover is about 34% of the total land area or about 32,000km^2 (World Bank, 2014a). The forested area is made up of about 90 protected forest reserves with an estimated area of 10,000km^2 (the study areas of Chimaliro and Liwonde reserves are part of these protected forests), national parks and game reserves (9,680km^2), and about 12,000km^2 of woodland on customary land (Department of Forestry, 2004; World Bank, 2014a).

There is an inverse relationship between forest cover and population distribution across Malawi. The Northern Region, with 13% of the national population, has 45% of the total national forest cover. On the other hand, the most populous Southern Region contributes only 20% of forest cover despite having 45% of the population. The remaining 35% of forest cover are located in Central Region, which accounts for 42% of the population (Government of Malawi, 1996; National Statistical Office (NSO), 2008). Consequently, the pressure on forests in Malawi is highest in the South and least in the North (Government of Malawi, 2001; Gowela and Masamba, 2002). The two study sites capture some of these regional differences. Liwonde Forest is in Southern Region while Chimaliro Forest is in the Central Region on the border with the Northern Region.

Malawi has one of the highest deforestation rates in Southern Africa (Government of Malawi, 1996; Walker, 2004; World Bank, 2014a). Malawi's forest cover declined from about 41% in 1990 to 34% in 2011 (Figure 1). Although Malawi's forest cover is still above the Sub-Saharan Africa average, it is below all its three neighbours of Tanzania, Mozambique and Zambia (Figure 1). This deforestation is a result of both land clearance for agriculture and over-exploitation of trees, which mostly emanates from population growth pressure (Government of Malawi, 2001; Marsland et al., 2003).[1]

Malawi Forest Policy of 1996 and the Forest Act of 1997 are the main current guiding frameworks for forest management. The two replaced the old forest policy and Act dating back to colonial times. Before the 1997 Act, Malawi was using a 1942 Forest Act it inherited from colonial era (Government of Malawi, 1996; Government of Malawi, 2001). The weaknesses and the obsolete nature of the old Act necessitated the formulation of a new policy in 1996, which was enacted in the following year as the Forest Act of 1997. Among other things, the new frameworks promote participation of local communities in forest management by allowing them to have regulated and monitored access to some forest products (Government of Malawi, 1996; Gowela and Masamba, 2002; Department of Forestry, 2004; Blaikie, 2006; Kamoto, 2007). The two study sites of Chimaliro and Liwonde were designated as pilot sites of Forest Co-

[1] Malawi's population growth rate of 2.8% per annum is among the top-20 in the world (National Statistical Office (NSO), 2008; World Bank, 2014b).

management (FCM) programme – a form of community forest management, which was possible due to the amended forest policy and Act. The new policy and Act also facilitated collection of some forest use data from households, which would have otherwise not been possible under the old policy regime due to the illegal nature associated with forest product use.

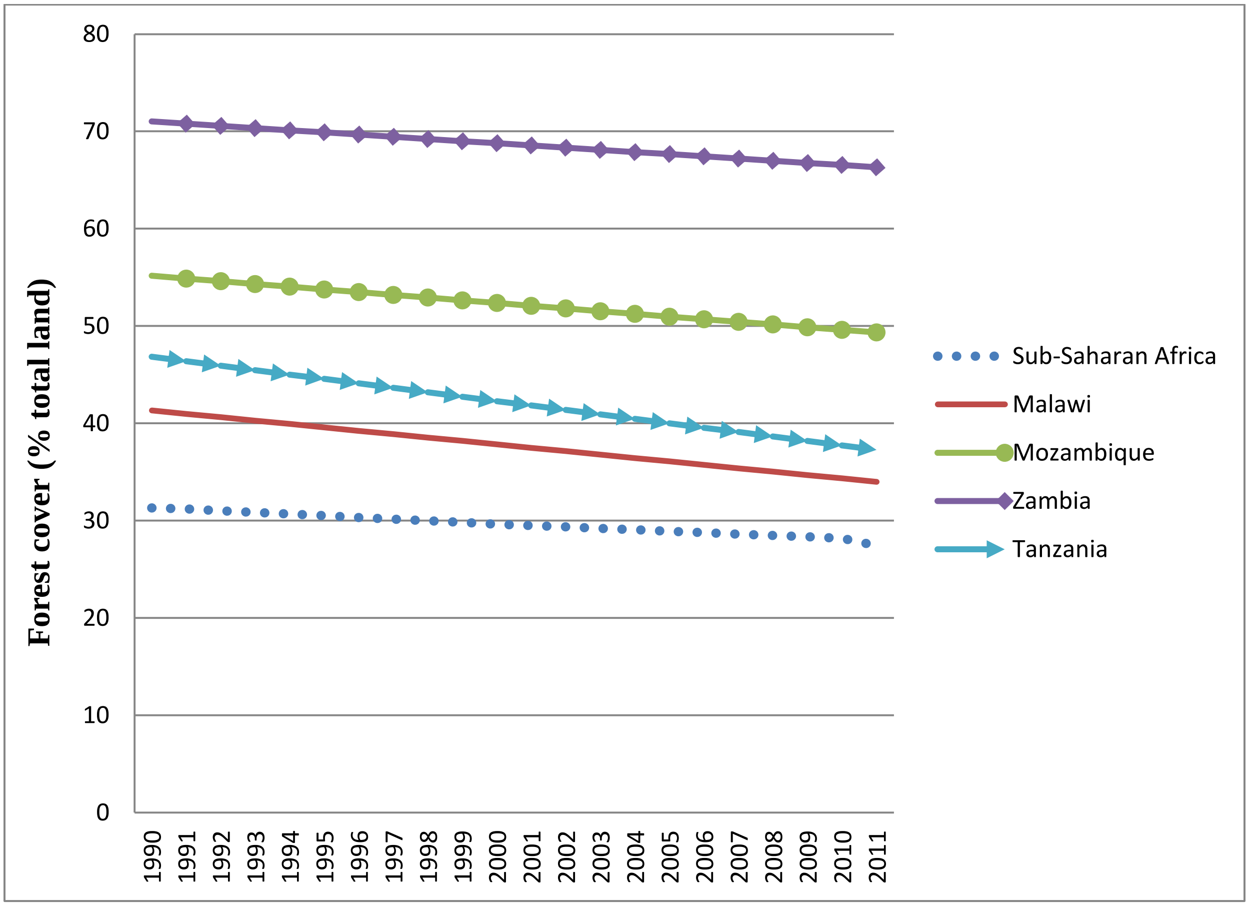

Figure 1: Forest Cover for Malawi, Its Neighbouring Countries and Sub-Saharan Africa from 1990 to 2011
Source: World Bank (2014a)

1.3 Thesis Objectives

A number of previous studies have assessed the different aspects of the forest co-management programme in Chimaliro and Liwonde. These include ecological and biological studies (e.g., Chanyenga and Kayambazinthu, 1999; Makungwa and Kayambazinthu, 1999; Kayambazinthu, 2000), programme evaluation (e.g., Kayambazinthu, 2000; Banda, 2001; Kayambazinthu and Locke, 2002), and forest utilization studies (e.g., Abbot and Lowore, 1999; Ngulube, 1999). Later on socioeconomic studies complimented the assessment of the FCM programme (Botha, 2003; Jumbe and Angelsen, 2006; Jumbe and Angelsen, 2007). This thesis compliments these previous studies but takes a slightly different focus. The thesis does not focus on the FCM programme, *per se*, but incorporate it, where necessary, as one of the cross-cutting issues. Instead, the thesis studies the forest reliance-livelihood link by focusing on those areas that have not received much attention in the past studies such as seasonality and time-dimension of forest reliance. Like the previous studies, the thesis targets smallholder rural households hence the forest products under consideration are non-timber forest products (NTFPs).

The thesis is a collection of the following four related papers:

- Paper I: Livelihood Strategies and Forest Reliance in Malawi
- Paper II: Employer of Last Resort? Shadow Wages and Forest Reliance in Malawi
- Paper III: Forest Reliance, Seasonality and Income Gap Filling Potential in Malawi
- Paper IV: Trapped in Forests or Saved by Forests? Forest Reliance and Poverty Transitions in Malawi

The papers have the following objectives:

1. To identify the main livelihood strategies in the study areas. (Paper I).
2. To assess the determinants of the livelihood strategies. (Paper I).
3. To compare the livelihood outcomes for the different livelihood strategies. (Paper I).
4. To investigate the relationship between forest use and household labour productivity. (Paper II)

5. To assess the role of forest income in filling seasonal income gaps and other external shocks. (Paper III).
6. To assess the role of forest income in movements in and out of poverty. (Paper IV).
7. To assess the role of forest income as a safety net when households fall into poverty or face shocks. (Paper IV).

2 Conceptual Framework

The thesis is based on the livelihoods framework, sometimes also referred to as the sustainable livelihoods framework. The framework looks at the complex inter-linked relationships among assets, conditioning factors, livelihood strategies and outcomes (Carney, 1998; Scoones, 1998; Ellis, 2000). The asset status of the households is important to understand options open to them, their chosen livelihood strategies and their vulnerability to adverse shocks and trends (Ellis, 2000). Forest reliance may form part of activities under the chosen livelihood strategies. Figure 2 presents an adapted livelihoods framework with the four papers placed where they fit in the framework.

Figure 2 shows key feedbacks and interactions (arrows (a) to (g)). The livelihood assets determine which livelihood activities a household engages in (a). Households are normally engaged in a portfolio of these activities forming their livelihood strategies leading to different livelihood outcomes (d). Access to the livelihood assets is influenced by other conditioning factors such as markets, prices and local institutions (b), which in turn affect the livelihood activities/strategies employed (arrow (c)).

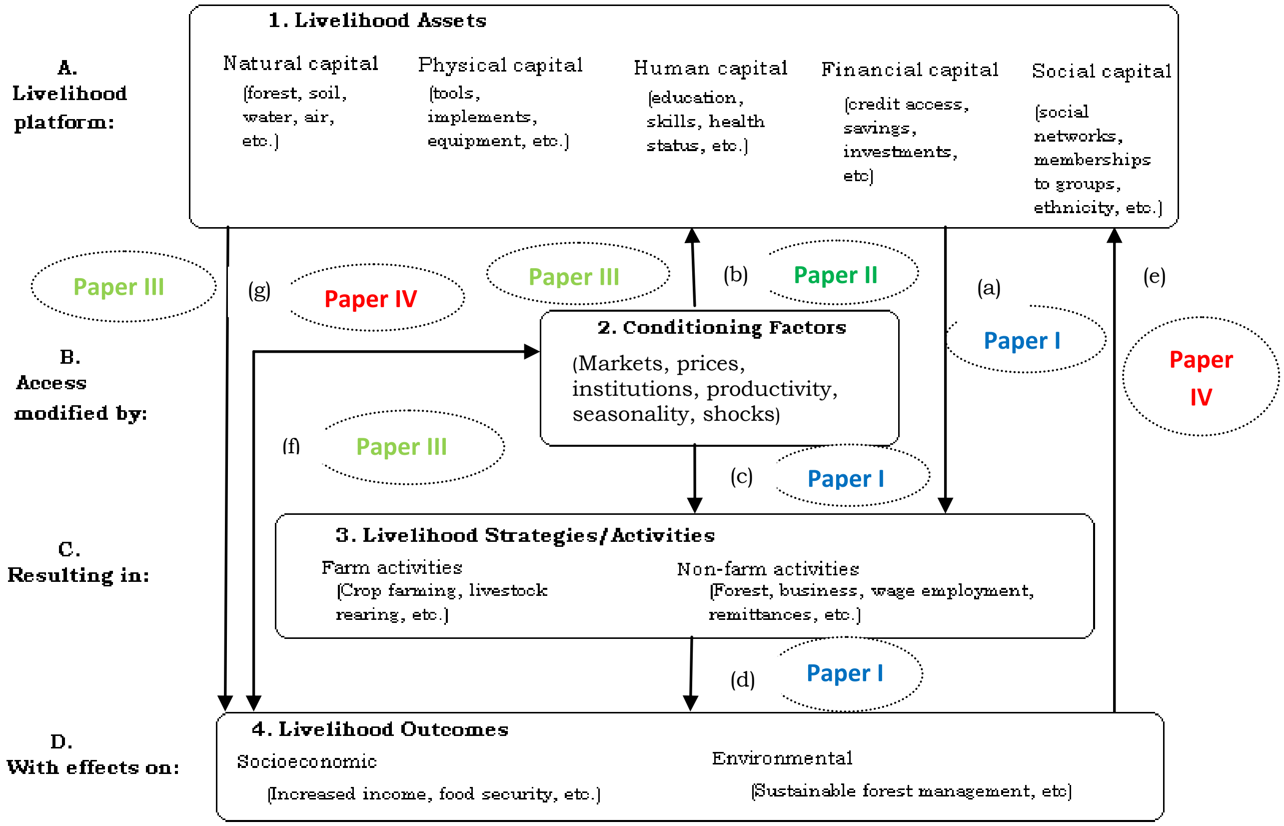

Figure 2: Livelihood Framework

Source*: adapted from Carney (1998), Scoones (1998), Ellis (2000) and Babulo et al. (2008)*

The framework also includes dynamic feedback loops as shown by arrows (e), (f) and (g). The livelihood outcomes can have direct consequence on the access and availability of future livelihood assets (e). For example, if forest reliance leads to forest degradation, this may eventually lead to reduced forests thereby lower the available natural capital. Institutions can therefore emerge to regulate resource use. Typical examples for this are the study sites where forest co-management (FCM) – a form of community forest management – was introduced to sustainably manage the forests. It is also possible for livelihood assets to directly influence livelihood outcomes (g).

The four papers in this thesis cover different aspects of the framework as portrayed in Figure 2. In addition to the livelihoods framework some papers used theories for specific elements within the livelihoods frameworks (e.g. consumption smoothing for Paper III and poverty-forest dynamics in Paper IV) to support the general livelihoods framework. Such details are found in the individual papers. This section describes the overall livelihoods framework with reference to the four papers.

Paper I assesses how livelihood assets influence livelihoods strategies and the activities therein (a). Forest reliance forms one such livelihood activity. The livelihood strategies are also influenced by the conditioning factors such as local institutions, market availability, prices, among others (c). The livelihood strategies chosen will in turn have a bearing on the livelihood outcomes.

Paper II mainly deals with the interaction between conditioning factors and livelihood assets (b). Specifically, the paper seeks to understand how labour productivity and labour markets affect utilization of natural capital endowments (land and forests). *Ceteris paribus*, when household's marginal labour productivity is higher than alternative off-farm employment, there will be more incentive for households to exploit their natural resources and vice versa (Barbier, 2010). In other words, lack of viable off-farm employment may lead to high reliance on forests (Coxhead et al., 2002; Angelsen and Wunder, 2003; Fisher et al., 2005; Barbier, 2010).

Paper III also looks at how the conditioning factors, specifically seasonality and shocks, affect the livelihood assets (b) and eventually livelihood outcomes (g). It is also possible for the seasonal variation to directly affect livelihood outcomes. The paper therefore, assesses the role of forest and other sources of income in filling the seasonal income gaps from the main incomes sources, which is crop income for most households in the study areas. Theoretically, the diverse nature of forest products (e.g. mushrooms during the lean rainy season) makes them potential candidates for seasonal income gap filling.

Paper IV presents a chicken-egg problem. With reference to forest reliance, poverty can either be exogenous or endogenous (Angelsen and Wunder, 2003). While there is a consensus that the majority of people that rely on forests are poor (See for example, Cavendish, 2000; Campbell et al., 2002; Cavendish, 2002; Cavendish and Campbell, 2008; Babulo et al., 2009; Debela et al., 2012), the debate is which one comes first: forest reliance or poverty comes. Are the households poor because they depend on forests (implying a poverty trap and that poverty is endogenous to forest reliance)? Or, do households depend on forests because they are poor (implying a safety net and that poverty is exogenous to forest reliance)? Paper IV is therefore premised on those arguments. The paper assesses whether forest reliance can be a poverty trap or safety net. From Figure 2, the poverty trap path can be traced through arrow (g): the expectation is that over-reliance on forests could lead to poverty as a livelihood outcome. On the other hand, as a safety net, due to 'bad' livelihood outcomes, the households are expected to fall back on forests (natural livelihood asset) as a coping mechanism (e).

3 Study Area and Data Collection Methods

3.1 Description of Study Areas

The study population consists of households living in villages surrounding the Chimaliro and Liwonde forest reserves in the central/northern and southern regions of Malawi respectively (Figure 3). The reserves cover 160 000 ha (Chimaliro) and 274 000 ha (Liwonde), and both are categorized as semi-deciduous and evergreen natural *miombo* woodlands. Both forests were pilot sites for a forest co-management (FCM) programme (Jumbe and Angelsen, 2006). Unlike the earlier policy on total government forest control, under FCM the communities surrounding the forests co-managed the forests with the government. Being pioneer FCM sites, therefore, provided an opportunity to collect information on forest usage that would otherwise not have been easy to collect. For both sites, firewood, mushrooms and thatching grass are the three most commonly collected forest products. The forest products are mostly used for subsistence.

The sites are over 400 km apart and have distinct geographical, social and agro-ecological differences as noted by Jumbe and Angelsen (2007). Chimaliro is relatively flat compared with Liwonde, which is hilly. Chimaliro lies in one of the most productive agricultural zones of Malawi. Tobacco, which is Malawi’s major export earner, is the main cash crop of the area. Liwonde, on the other hand, is in an area of less agricultural potential. Like most of southern Malawi, Liwonde is characterised by high population densities resulting in small landholding sizes, averaging less than one hectare per household. Liwonde is ethnically heterogeneous with many tribes, while Chimaliro is homogenous with the population dominated by one tribe called *Tumbuka*. These ethnic composition differences theoretically have a bearing on the sustainable management of the forests. *Ceteris paribus*, the more homogenous a group, the more likely it is to collectively manage common pool resources (Baland and Platteau, 1996). Studies have indeed shown that the Chimaliro forest is better managed than the Liwonde forest (Makungwa and Kayambazinthu, 1999; Jumbe and Angelsen, 2007), although there could be other factors behind these outcomes.

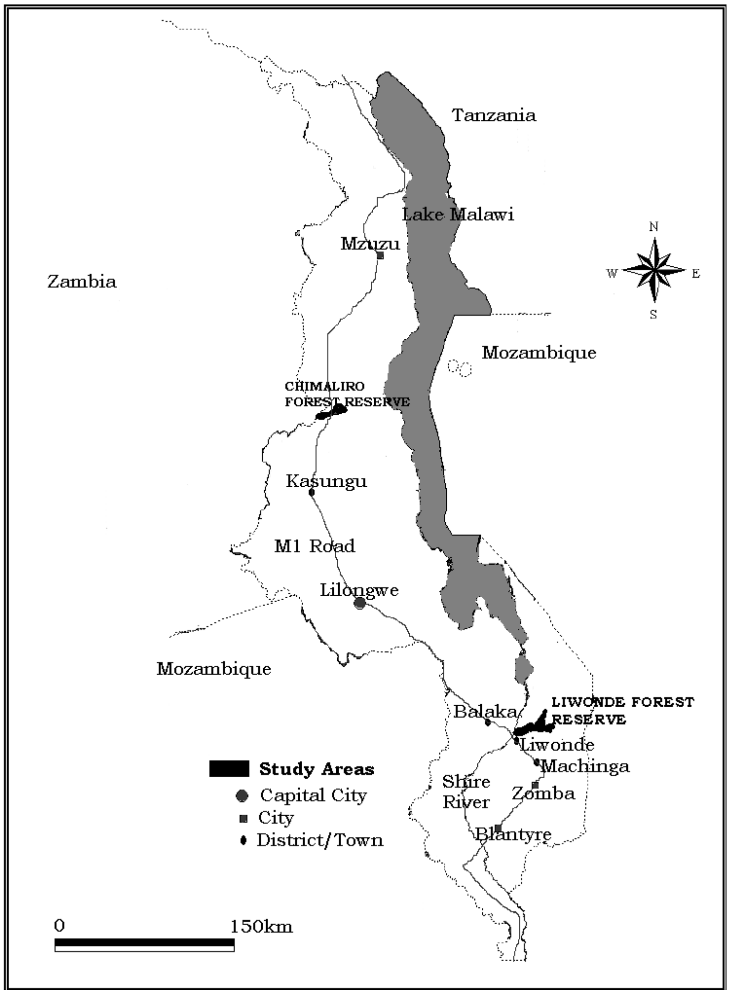

Figure 3: Map of Malawi Showing the Study areas

In terms of location and market access, Chimaliro is relatively remote compared with Liwonde. Although both are along the main Malawi north-south highway, Liwonde is at a crossroads of major towns and trading centres. Chimaliro is not only far from towns and trading centres but even those that are closer are smaller than those in the vicinity of Liwonde. The closeness to major towns in Liwonde could exert more pressure on forests due to a high demand of forest products. On the positive side, the increase in forest demand means forests can potentially be a stepping stone out of poverty if well managed.

3.2 Data Collection and Paper Organization

The main source of data for this thesis was the CIFOR's Poverty and Environment Network (PEN) surveys of 2006/07 in Malawi. PEN was a CIFOR's initiative that collected forest socioeconomic data at global scale using standard questionnaire, which could be slightly adapted to suit different contexts.[2] In addition, one paper also used data from the same households collected during an earlier survey in 2002 (Jumbe, 2005; Jumbe and Angelsen, 2006; Jumbe and Angelsen, 2007).

A total of 404 households were sampled: 205 from Chimaliro and 199 from Liwonde. The sampling followed the same households as in 2002. Out of the 2002 initial sample of 404 households, 267 households could be matched with certainty, giving an attrition rate of 34%. The 2006/07 survey replaced the 137 households with new ones to maintain the sample size at 404. This was necessary because the objective of the 2006/07 survey was beyond just creating a longitudinal dataset. For details on the 2002 survey, we refer to Jumbe (2005) or Jumbe and Angelsen (2007). Paper IV details how the two datasets were harmonized.

The 2006/07 data collection, for which I was the field supervisor, consisted of several surveys: four quarterly surveys (Q1-Q4), two annual household surveys (A1 and A2), two village surveys (V1 and V2) and two attrition and temporary absence surveys (ATA1 and ATA2). Table 1 presents a summary of the contents of each of the surveys.

[2] Details about PEN surveys can be obtained on this link http://www.cifor.org/pen.

Table 1: Surveys, Their Timing and Main Contents

Timing	Surveys	Content
August-September 2006	V1	Geographic and climate variables, demographics, infrastructure, forest and land cover/use, forest resource use, forest institutions and forest user groups.
	A1	Household demographics, land, assets and savings, forest resource base, forest user groups.
	Q1	Income (Quarterly)
January 2007	Q2	Income (Quarterly)
April 2007	Q3	Income (Quarterly)
	ATA1	Reasons for dropping out
July 2007	V2	Geographic and climate variables, risk, wages and prices, forest services.
	A2	Crisis and unexpected expenditures, forest services, forest clearing.
	Q4	Income (Quarterly)
	ATA2	Reasons for dropping out

The ATA survey questionnaire was administered to a neighbour or any other person in the village who knew the household that was interviewed in an earlier phase but was absent in the subsequent survey. In general, the ATA surveys were supposed to be conducted from the second to last phases. However, the decision to come up with ATA surveys came after we had already conducted the second phase. Thus, two instead of three ATA surveys were conducted.

Only households that participated in at least three quarterly surveys were included in the dataset. This left us with 366 out of the 404 households. The other 28 households (9%) had for various reasons missed more than one quarter.[3] However, as will be noted, since each of the four papers in this thesis had its own requirements, a sample of 366 households was not used in every paper. For example, Paper IV necessitated that only those households that were available in both 2002

[3] Some of the reasons given were respondent fatigue (“they simply did not want to be interviewed), death of a household head and temporary migration for casual labour work in nearby plantations (this was the case during second quarter in Liwonde).

and 2006/07 surveys are included while for Paper III, only households that participated in all the quarters were used. Figure 3 presents a summary how the papers utilized the datasets.

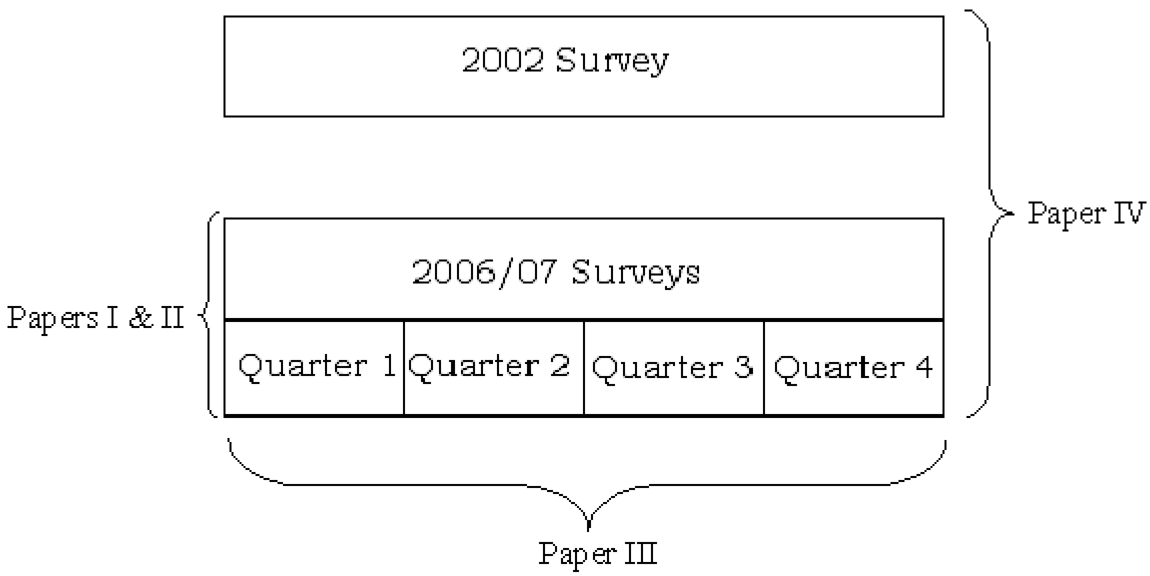

Figure 4: Paper Distribution by the Survey Data

Figure 4 shows that by income data usage, the four papers can be categorized into whether they used annual data aggregates or not, and whether they were based on cross sectional or longitudinal data sets. Three of the four papers (I, II, and IV) used annual while Paper III used individual quarterly income data. Papers I and II were solely cross sectional-based using 2006/07 data. Papers III and IV used a panel data approach; the former with a four-period balanced panel of the 2006/07 quarterly surveys while the latter was based on a two-period balanced panel of the 2002 and 2006/07 aggregated annual incomes. In all the four papers, additional variables were provided by the annual and village surveys.

4 Summary of Main Findings

This thesis is a collection of four interlinked papers each tackling specific objectives outlined in Section 1 and specific linkages in the overall livelihoods framework. This section presents a synthesis of the individual papers.

Paper I: Livelihood Strategies and Forest Reliance in Malawi

Research Questions/Objectives: How do forests contribute to rural livelihoods, and how does forest use differ across different types of livelihood strategies? Using household survey data from Chimaliro and Liwonde forest reserves in Malawi, I address these questions by investigating three relationships regarding forest reliance in the sample. First, what are the main livelihood strategies of the households? Second, what shapes these livelihood strategies? Third, how do the outcomes of these livelihood strategies compare with the degree of household forest reliance?

Conceptual Framework: The study is guided by the general livelihoods framework. Specifically the paper assesses how livelihood assets (natural, physical, human, financial and social) and conditioning factors, such as markets, prices and institutions, influence households' choice of livelihood activities (strategies). I pay particular attention to how forest reliance differs across the livelihood strategies.

Empirical Approach: To identify livelihood strategies, the data is subjected to principal component analysis (PCA) and the subsequent PCA scores are used as input in cluster analysis. I use shares of main income sources (food crop, tobacco, livestock, forest, wage business and other sources) as inputs for PCA. However, unlike previous studies, I split the sectoral incomes into subsistence and cash income shares to distinguish between commercially and subsistence oriented livelihood strategies. The identified livelihood strategies are then used as dependent variables in a multinomial logit (MNL) model to assess the determinants of the livelihood strategies. In addition, I descriptively compare level of forest reliance among the identified livelihood strategies. Finally, a stochastic dominance test is used to compare the income distributions of the livelihood strategies. In this way, I was able to check the hypothesis that high forest-reliant households' income distributions have inferior income distributions compare with low forest-reliant households.

Main Findings: Four livelihood strategies were identified on each study site. In general, the forest reliance-dominated strategies were associated with low income. In Liwonde however, there was one special livelihood strategy that had both highest income and highest forest reliance. This finding was contrary to most findings in literature that there is an inverse relationship between forest reliance and level of income. However, the stochastic dominance test revealed that the livelihood strategies with more forest reliance were inferior to those strategies with less forest reliance. This was true even for the said strategy in Liwonde. Findings in this paper therefore, generally agree with previous similar studies that it is the vulnerable poor households that rely more on forests. The policy implication of this finding is that for sustainable forest management, there is need to strike a balance between forest protection and forest use, especially by the vulnerable poor households.

Main Contributions: The paper makes two contributions to the literature. First, the cash-subsistence sector income split provides a more nuanced approach to identifying and defining livelihood strategies. Second, the paper provides a comparative study of two forest-reliant communities with quite different socioeconomic and agro-ecological characteristics.

Paper II: Employer of Last Resort? Shadow Wages and Forest Reliance in Malawi

Research Questions/Objectives: Is forest reliance an employer of last resort? This paper investigates the conditions surrounding forest reliance in low-income settings. Using survey data from households living adjacent to two forest reserves in Malawi we measure the relationship between forest use and household labour productivity. Specifically, we compare the households' marginal labour productivity with the average wages offered in outside employment. We estimate household shadow wages, which are used as a proxy to household productivity.

Conceptual Framework: Following Barbier (2010), we develop a theoretical model that demonstrates that households' reliance on forests and other natural assets, such as land, could be due to lack of other viable livelihood alternatives. In that theory it is argued that household's dependence on natural resource endowment-based production activities is due to low wages in outside employment relative to households' shadow wages. The starting point is that a household will only engage in outside employment if the wage from such employment is more than the household's reservation wage. We further argue that this is exacerbated by imperfect labour market, which is mostly characterized by outside employment. This job scarcity coupled with increasing demand of the same, may lead to households' clinging to their own production activities (which includes relying on forests) as an employer of last resort even when the households' reservation wages are low.

Empirical Approach: We use a two-step method to estimate shadow wages associated with a composite agriculture-forest output. We then use the labour elasticities from the estimated function to calculate shadow wages. The estimated shadow wages are then compared with outside employment wages and how they relate with forest reliance and level of income.

Main Findings: Despite that the market wage rate exceeds, the average household shadow wage, the low-incidence of off-farm employment in the sample suggests strong rationing in the labour market. This means households continue to depend on self-provisioning activities, implying eventual negative consequences for the local agricultural and forest resource base. The policy implication from this finding is that the environmental conservation initiatives should go hand in hand with attempts to provide alternative livelihood activities. An example would be the already existent public works programs. Our study however, did not go into details of the public works programs. This is another potential area where future studies may look into the relationship between these programs and natural resource exploitation.

Main Contributions: The paper was one of the few attempts in literature to link forest reliance to household productivity (shadow wage) and of alternative employment availability. Again the presence of two sites with different agro-ecological characteristics provided an opportunity to assess contextual differences of forest reliance patterns.

Paper III: Forest Income and Seasonal Gap-Filling in Malawi

Research Questions/Objectives: We investigate the role forest products in filling the seasonal income gaps using quarterly income survey data from households surrounding Chimaliro and Liwonde forest reserves in Malawi. We address two questions: First, does forest income play a 'seasonal gap-filling' (SGF) role in the sense that quarterly forest income varies negatively with crop and other major sources of household income? Second, (how) does the (potential) SGF role vary across groups of households? For example, is this role more important for households that are poor, pursue certain livelihood strategies or have other particular demographic characteristics?

Conceptual Framework: This paper falls within the broader literature of income and consumption smoothing. Given the poor functioning or absence of markets, especially the financial (insurance and credit) and labour markets, income smoothing becomes a major element of the livelihoods strategy of rural households in developing economies (Morduch, 1995). Average incomes are not only low but also volatile emanating from seasonality fluctuations due to overdependence on agriculture (Paxson, 1993; Morduch, 1995; Kochar, 1999; Rose, 1999; Rose, 2001; Chaudhuri and Paxson, 2002). This seasonality of income and consumption means that there are always some “hunger months” within the year. Households therefore strive to smooth out their incomes and hence also consumption. Some of such responses include depleting assets, relocating some labour to off-farm income-generating activities and diversifying economic activities (Chaudhuri and Paxson, 2002). Forest resource extraction forms both part of off-farm activity and as a diversification strategy (Rosenzweig and Binswanger, 1993; Morduch, 1995; Kochar, 1999; Rose, 2001; Chaudhuri and Paxson, 2002).

Empirical Approach: In general, we measure seasonal gap filling by assessing the covariance between forest income and other main sources of income. A necessary condition for forest to be a potential seasonal gap filler is for it to negatively correlate with other main sources of income. The paper introduces a new seasonal gap filling measure that separates seasonal and inter-household income variation, as opposed to what the commonly used measure does. We make a distinction between *Overall Correlation*, which is a standard correlation based on deviations from overall sample mean, and *Within-Household Correlation*, which accounts for inter-household income differentials because it is based on individual household income deviations. We argue that the *Overall Correlation* may lead to a mix up of two phenomena: a seasonality pattern and inter-household pattern. A negative correlation however, may not always indicate forest income gap filling as it may also occur when forest income is very low (or even close to zero) and the other sources' incomes are high. Our main interest is a situation when, in a given quarter, a household increases forest income when income from other main sources decline. We therefore also construct a forest gap filling indicator, which is assigned one if the interaction between forest income and another income source is negative conditional on forest income being above the annual mean. Otherwise, the indicator is assigned zero. Treating each quarter as a panel, we then use a random effects panel probit model to assess factors that increase or decrease the probability of forest income being a gap filler.

Main Findings: The study shows that forest products play a seasonal gap-filling role for the low-income households and those households where forest forms one of the main livelihood activities. Empirically, the paper demonstrates that using the overall correlation can mask the potential role of forests or other forms of income as seasonal gap fillers.

Main Contributions: The paper introduces a new measure to assess the seasonal gap filling (SGF). Our new SGF measure (the *Within-Household Correlation*) takes into account the large variation of incomes (sectoral and overall) across households by considering the household-specific seasonal income variation, as opposed to looking at overall variation across seasons and households simultaneously. Indeed the results show that using the 'overall income variation' approach masks the role of forest as a seasonal gap-filler.

Paper IV: Trapped in Forests or Saved by Forests? Forest Reliance and Poverty Transitions in Malawi

Research Questions/Objectives: What role does forest income play in movements in and out of poverty? This study uses a balanced panel from Chimaliro and Liwonde forest reserves in

Malawi, with data collected in 2002 and 2006/7. The paper assesses whether high forest reliance is likely to perpetuate poverty (hence 'trapped' in forests) or whether forest income acts as a safety net for those that experience income shortfall or face other shocks (hence 'saved' by forests).

Conceptual Framework: The study combines the concepts of time dimensions of poverty, forest reliance and livelihoods. The time dimension of poverty is best captured by assets rather than income or consumption, which are stochastic in nature (Carter and Barret, 2006). In this paper however, due to data the type of data available, we use income data to assess the role forest reliance plays income poverty transitions. We draw lessons from several empirical studies in literature about the general link between forest reliance and poverty.

Empirical Approach: In testing the 'trapped' part, we ask the question whether forest forest reliance is one of the determinants of poverty and income growth. A multinomial logit (MNL) model is used to test whether households with high initial forest reliance are more likely to be poor or not. The dependent variables are the four poverty transitions: chronic poor, falling into poverty, escaping poverty, and never poor. The effect of forest on income growth is tested by an OLS regression of change in income within the period (2002 and 2006/07) on initial (2002) incomes (including forest income), assets and demographic characteristics. The 'saved' part is assessed by an OLS regression of change in forest income on household characteristics as the previous regression plus poverty transition and shock dummies. The aim was to check if forest use increases with particular poverty transition statuses or shocks.

Main Findings: Are forest-reliant people trapped in forests? We find no evidence to support that hypothesis. Are the people then saved by forests? The study provided both 'yes' and 'no' as answers to this question. Yes, because we find some evidence that forests function as a safety net when households fall into poverty. No, because there was no evidence that forest reliance could be a pathway out of poverty apart from the safety net role played.

Main Contributions: The paper's main contribution is the use of panel data, which has not been much explored so far in discussion of environmental (forest) income and poverty. In addition, as is the case with the other papers in this thesis, with data coming from two distinctly different areas, the study also provides an opportunity to investigate how the poverty dynamics differ between the two sites, including how the contrasting state of the forest ecosystem and the market access in the two sites shapes the forest-poverty dynamics.

5 Conclusions and Perspectives

5.1 Methodological Contributions

As the thesis title suggests, the aim of my work was to move beyond just looking at aggregate income shares by providing some new methods and approaches to study an old topic. While many earlier studies have, of course, gone beyond simple calculations of forest income shares, the four papers of this thesis also include new methodological elements. Paper I uses a cash-subsistence income split to identify livelihood strategies, which provides a more disaggregated analysis and can yield insights into the different roles cash and subsistence income may play in rural livelihoods. Paper II uses labour productivity (shadow wages) to predict forest reliance, and test the theory that high forest reliance reflects poor alternative income opportunities (forests as an "employment of last resort"). Paper III explores to what extent forest income serve as a seasonal gap-filler, by introducing two new measures to test for this. And finally, Paper IV uses a panel data set to test how high forest reliance affects movements in an out of poverty, and vice versa, a question hardly addressed in the forest-poverty literature due to lack of panel data sets. These are approaches to analyze the forest-livelihoods (poverty) nexus that have so far not received much attention. It is my hope that the papers, apart from the contribution through their results, will generate debate and motivate further studies and methodological developments.

5.2 Key Findings

The papers of this thesis produced several important findings but as an overall conclusion, I want to highlight two:

A. "*The low-value fruits are low-hanging while the high-value fruits are high-hanging*."

This is the metaphor that can sum up the findings from all the four papers. The relative ease of access (hence low-hanging) of most forest products makes them strong candidates to serve as coping mechanisms or safety nets, e.g., when other livelihood activities fail to meet the income requirements (Paper I); in absence of other better off-farm employment activities (Paper II); when faced with seasonal income fluctuations (Paper III); and when households permanently or temporarily fall into poverty due to stochastic income fluctuations (Paper IV). But, the forest products relative low values mean that the probability of them be a pathway out of poverty is severely limited (Paper IV). Most 'high-hanging' fruits of forests (e.g., timber products), with high potential to become a pathway out of poverty, are beyond the reach of most poor households.

B. The ecological fallacy

The papers also demonstrate the importance of "ecological fallacy", or rather possible pitfalls of aggregated analysis. The term "ecological fallacy" refers to when group characteristics are wrongly assumed to infer to the individuals belonging to that group. It can also relate to inferring from conclusions made for the full sample to sub-samples. In the various analyses of these theses, there were often more insights about forest reliance when I looked at sub-groups than at the aggregate level. For example in Paper I, the clustering of households into livelihood strategies revealed a pattern of forest reliance that is rarely reported in literature, i.e., that both forest reliance and total income moved in same direction for some groups of households. Similarly in Paper III, analysis by income and livelihood strategies revealed the potential of forest income as a seasonal gap filler, which was otherwise masked when studied at aggregate level. And, while we find limited evidence for forests being as a seasonal gap-filler when considered at the level of the full sample, it clearly has such a role for households pursuing livelihood strategies that have forest income as a significant component.

These are lessons that can guide future similar studies. The fact that forests on the aggregate may not be critically important should not prevent us from investigating its potentially important role for particular groups.

5.3 Shortcomings and Possible Future Research Areas

Like any study, this thesis has shortcomings, and some of these have been elaborated in the individual papers. Here I focus on some crosscutting shortcomings. First, the design of the surveys meant that during the second and third surveys only income data were collected. This however resulted in missing information for some key variables. For example, information on shocks was only collected at the end of the surveys (the last quarter). This could be one of the reasons why most results on shocks had low significance or had unexpected signs. My speculation is that if data on shocks were collected quarterly, they would have related much better with the seasonal income composition. Further, the quarterly collection of some of these variables would have enabled using other econometric methods, such as fixed effects models, which only require time-varying variables. Future similar studies should therefore, collect information on such variables during the quarterly surveys, in addition to incomes.

Second, in Paper II, labour supply was a key variable, but not measured directly in the surveys. We therefore had to make rough and uniform (across households) assumptions, which can raise questions about the robustness of the results. While labour data are not easy to collect from smallholder households that rarely keep records and find it hard to recall the exact labour inputs into various activities, future studies should still attempt to collect labour supply data. In the literature there are several examples of studies that managed to collect such information.

Finally, another direct way of measuring income seasonality is to directly link it to consumption smoothing, i.e., making consumption a function of seasonal income and other variables (e.g., Paxson, 1993; Jacoby and Skoufias, 1998; Dercon and Krishnan, 2000; Khandker, 2009). The distinction between income and consumption in rural areas of developing countries is not as sharp as in developed countries (since a high proportion of the income is subsistence). Yet, having information on seasonal variation in both variables (and also changes in assets) can yield additional insights in how households cope with the seasonal variation in income. Future studies should attempt to collect income data side by side with consumption data if they want to investigate this issue further.

Finally, some of the new methods developed and used in this thesis would be interesting to apply on data sets from other locations, in order to test how we can generalize the conclusions reached from the two research sites in Malawi. There is a high risk of errors when generalizing results from location specific case studies. Just as I warned against the “ecological fallacy”, we also need to be aware of what could be termed “the case-study fallacy”.

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Paper I

Livelihood Strategies and Forest Reliance in Malawi[1]

Thabbie Chilongo*

Abstract

How does household forest use differ across different types of livelihood strategies? This paper investigates rural livelihood strategies in Malawi and the role forests play in these strategies. Data from a survey of 366 households living around Chimaliro and Liwonde forest reserves in Malawi are used. Principal component and cluster analyses identify four livelihood strategies at each site. The findings suggest that some households turn to forest and other non-agricultural activities to compliment inadequate agricultural income. The results underscore the importance of knowing the types of households that rely upon forests. This information can help policy makers achieve sustainable forest management by balancing forest protection with household needs. (JEL O13, Q23)

Key words: livelihoods, household economy, use value, smallholder, non-timber forest products (NTFP), community participation.

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[1] Accepted in *Forests, Trees and Livelihoods*

1 Introduction

A livelihood strategy is a household's mix of income-generating activities, based on its evolving assets and the changing circumstances it faces (Ellis 2000). Rural households in Malawi, as elsewhere in the developing world, depend on a broad portfolio of activities for their livelihoods. This diversification may occur due to missing markets that compel the self-provision of goods and services for own consumption, synergies among distinct activities, and diminishing returns on certain activities (Brown et al. 2006). Diversification may be a deliberate household strategy (Stark 1991), an involuntary way to manage a short-run crisis mitigation (Davies 1996), or a combination of both. Patterns of diversification can reflect seasonal variation and different skills within a household.

Ellis (2000) observes that this livelihood diversification often poses challenges to socioeconomic analysis and policy prescriptions; a common tendency among researchers and policy makers is to identify people's place in the economy according to their main occupation and then develop a body of theory and policy around that activity. This is the case for Malawi, where the greatest emphasis is placed on farming, which is the main occupation, with little attention paid to other livelihood activities (Rubey 2005; Droppelmann et al. 2012; Posthumus 2013), such as forest use in this case. Specifically, the agricultural policy is biased towards maize and tobacco as is reflected in the farm input subsidy programme (FISP), which mainly targets maize and tobacco (Rubey 2005; Posthumus 2013). However, this 'main-occupation bias' may lead to sub-optimal policy prescriptions because other smaller yet important activities are ignored (Ellis 2000).

Furthermore, reliable information about environmental income-reliant people is rare (Oksanen et al. 2003; Colchester et al. 2006). Without this clear information on how poor people make a living, Colchester et al. (2006) argue that it is difficult for policy makers and development agencies to adopt contextually relevant pro-poor approaches. Moreover, this lack of information can lead one to overlook the interests of households that rely on environmental resources in general, and forests in particular, when designing policy interventions aimed at sustainable environmental management.

This paper investigates rural livelihood strategies and the role forests play in these strategies. Using household survey data from Chimaliro and Liwonde forest reserves in Malawi, it addresses one overall question: how do forests contribute to rural livelihoods, and how does forest use differ across different types of livelihood strategies? I address these questions by investigating three sub-questions. First, what are the main livelihood strategies of the households? Second, what factors determine these livelihood strategies? Third, how do the outcomes of the different livelihood strategies relate with the degree of household forest reliance (share of forest income in total household income)?

I employ principal component analysis (PCA) and cluster analysis to identify livelihood strategies. Similar approaches (Botha 2003; Babulo et al. 2008; Tesfaye et al. 2011; Soltani et al. 2012) have been used to identify livelihood strategies by splitting total income into aggregate sectoral incomes. In this paper, however, instead of simply splitting income into different sectors to identify different livelihood strategies, I further split each sector into cash and subsistence income components. The cash-subsistence split leads to more homogenous livelihood clusters than a split based solely on aggregate sectoral incomes. Having identified livelihood strategies, I use the livelihood strategies as dependent variables in a multinomial logit model to identify the determinants of the strategies. Finally, I use a set of stochastic dominance tests to compare the income distributions of the livelihood strategies, thereby checking whether relatively high forest-reliant strategies are dominated by (and, hence, inferior to) low forest-reliant strategies.

The paper makes two key contributions to the literature. First, the cash-subsistence sector income split provides an alternative approach to identifying and defining livelihood strategies. Second, the paper provides a comparative case study of two forest-reliant communities but with different socioeconomic and agro-ecological characteristics.

2 Conceptual Framework and Hypotheses

I apply the livelihood framework to understand factors that influence a household's livelihood strategy. The framework suggests that a household's livelihood strategy is influenced by assets at its disposal, conditioned by its vulnerability context and institutions. The chosen livelihood strategy will result in a particular outcome, defined in terms of income or food security (Carney 1998; Scoones 1998; Ellis 2000). Figure 1 illustrates the framework.

Figure 1 shows key feedbacks and interactions (arrows (a) to (g)). In real life, there is a large number of feedbacks and complex interactions between components (Ellis 2000). The livelihood assets determine which livelihood activities a household engages in (a). Households are normally engaged in a portfolio of activities, which together form their livelihood strategies, leading to different livelihood outcomes (d). Access to the livelihood assets is influenced by other conditioning factors, such as markets, prices and local institutions (b), which in turn affect the livelihood activities employed (arrow (c)).

The framework also includes dynamic feedback loops as shown by arrows (e), (f) and (g). The livelihood outcomes can have direct consequences for the access and availability of future livelihood assets (e). For example, if forest reliance leads to forest degradation, it may eventually lead to reduced forests and may necessitate changing the existing institutions to address the problem. Typical examples for this are the study sites, where forest co-management (FCM) – a form of community forest management – was introduced to sustainably manage the forests. It is also possible for livelihood assets to directly influence livelihood outcomes (g).

The framework stipulates many interdependencies within and among the components (Boxes 1 – 4). Due to data limitations, however, it is not always possible to isolate and measure all these interdependencies in one study. As observed by Ellis (2000):

> ‘The apparent information requirements accompanying with the framework in its entirety are much too large for project and policy purposes. Budgets would get swallowed up in information gathering rather than being used in direct or indirect support to improvements in livelihoods’ (Ellis 2000: p. 47).

Thus, while even the framework in Figure 1 is a simplification of reality, it is too complex to handle quantitatively in a single study. This study focuses on specific elements of this framework, with the following three objectives:

1. To identify how livelihood activities are combined to form livelihood strategies of the households;

2. To assess the determinants of these livelihood strategies (a) and (c); and

3. To compare the livelihood outcomes of the strategies (d).

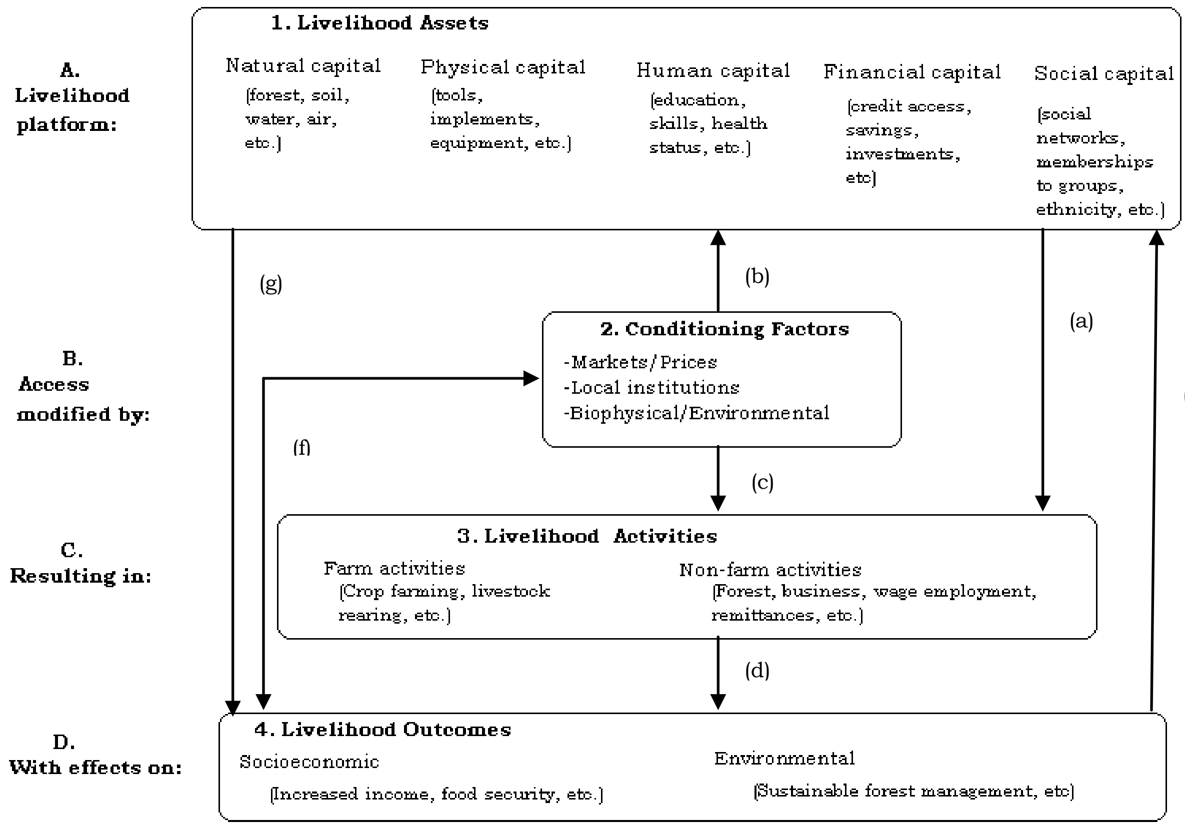

Figure 1. Livelihoods framework

Source: Adapted from Carney (1998), Scoones (1998), Ellis (2000) and Babulo et al. (2008)

Narrowing the focus to forest reliance, studies suggest that households rely on forests as an employer of last resort (Shively 2001; Coxhead et al. 2002; Angelsen & Wunder 2003). Shively (2001) and Coxhead et al. (2002) argue that forests are an important potential source of livelihood for those households that are not gainfully employed, i.e., either underemployed or those with unskilled labour. Angelsen and Wunder (2003) further argue that the characteristics of most non-timber forest products (NTFPs), such as low or medium returns to labour, low capital and skill requirements, and open or semi-open resource access, favour the poor who have no or limited markets for skilled labour and, hence, have low labour productivity. Therefore, these authors postulate that households with poor asset endowment resort to low-return activities – such as forest or other 'last resort' activities – while those with better opportunities find employment elsewhere. Specifically for this context, therefore, the paper hypothesises that households following livelihood strategies with low livelihood outcomes (measured as income) are more reliant on forests than those following strategies with high livelihood outcomes.

3 Study Area, Data and Estimation Methods

3.1 Study area

The study population are households living in villages surrounding the Chimaliro and Liwonde forest reserves in the central/northern and southern regions of Malawi, respectively. Both forests were pilot sites for a forest co-management (FCM) programme. Unlike the earlier policy on total government forest control, under FCM the surrounding communities co-manage the forests with the government. Being pioneer FCM sites, they therefore provided an opportunity to collect information on forest usage that would otherwise not have been easy to collect due to the illegality associated with forest product use and access under the previous policy regime (total government control of forests). For both sites, firewood, mushrooms and thatching grass are the three most commonly collected forest products and the products are mostly used for subsistence (Chilongo & Angelsen 2013).

The sites are over 400 km apart and have distinct geographical, social and agro-ecological differences as summarised in Table 1. Chimaliro is relatively flat compared with Liwonde, which is hilly. Chimaliro lies in one of the most productive agricultural zones of Malawi. Tobacco, which is Malawi's major export earner, is the main cash crop of the area. Liwonde, on the other hand, is in an area of less agricultural potential. Like most of southern Malawi, Liwonde is characterised by high population densities resulting in small landholding sizes, averaging less than one hectare per household. Liwonde is ethnically heterogeneous with many tribes, while Chimaliro is homogenous with the population dominated by one tribe called *Tumbuka*. These ethnic composition differences theoretically have a bearing on the sustainable management of the forests. All other things being equal, the more homogenous a group, the more likely it is to collectively manage common pool resources (Baland & Platteau 1996). Indeed studies have shown that the Chimaliro forest is better managed than the Liwonde forest (Makungwa & Kayambazinthu 1999; Banda 2001; Jumbe & Angelsen 2007), although there could be other factors behind these outcomes.[2]

Table 1. Comparison of the study sites

Characteristic	Chimaliro	Liwonde
Forest area (sq. km)	160	274
Location	Far from major cities and towns	Near major cities and towns
Ethnic composition	Homogenous	Heterogeneous
Main family system	Patrilineal	Matrilineal
Population density per sq. km	80	130
Altitude (m asl)	1100 - 1800	800 - 2080
Rainfall (mm/year)	800 - 1600	500 - 800
Agricultural income share (%)	73	51
Crop income share (%)	56	43
Livestock income share (%)	16	8
Non-agricultural income share (%)	27	49
Wage income share (%)	6	12
Business income share (%)	3	9
Other incomes share (%)	18	29

The less agricultural potential is reflected in agricultural income contribution according to this study's survey data: agriculture contributed 73% of income in Chimaliro while it only contributed 51% in Liwonde. Tobacco and groundnuts are major cash crops in Chimaliro, while Liwonde also relies on cassava and rice, the latter mainly grown as a cash crop (Chilongo &

[2] Although most of the institutional studies conducted to assess the effectiveness of the FCM fell short of giving counterfactuals on whether the better forest management in Chimaliro started before or after introduction of the programme, there is a general consensus that the programme in Chimaliro performed much better than in Liwonde (e.g., Banda 2001; Kayambazinthu & Locke 2002).

Angelsen 2013). The proximity to towns potentially provides more opportunities for off-farm work in Liwonde, and wage and business income contributed to about 21 % of total income, compared with 9% in Chimaliro.

The two sites also differ in their inheritance and family systems. In Chimaliro, inheritance is patrilineal through (the oldest) male children, wives normally move to the husband's village, and husbands dominate in making key household decisions. In Liwonde, however, inheritance is matrilineal through (the oldest) female children, and husbands normally reside in their wives' village. Although the husband is traditionally considered the household head, consent from the wife is important in undertaking household investment decisions (Botha 2003; Jumbe & Angelsen 2007). Place et al. (2001) hypothesize and find some evidence of husbands in matrilineal societies being less interested in long term investments in agriculture and forestry, as they have less control over decisions and feel less ownership to these resources.

In terms of location, Chimaliro is relatively remote compared with Liwonde. Although both are along the main Malawi north-south highway, Liwonde is at a crossroads of major towns and trading centres, while Chimaliro is not only far from towns and trading centres but even those that are closer are smaller than those in the Liwonde vicinity. The closeness to major towns in Liwonde could exert more pressure on forests due to a high demand of forest products. On the positive side, the increase in forest demand means forests can potentially be a stepping stone out of poverty if well managed. It is therefore expected that the livelihood options available to the households in the two sites are influenced by these differences.

3.2 Data

Data for this study come from household surveys conducted under the Poverty and Environment Network (PEN) program of the Centre for International Forestry Research (CIFOR). For this paper, a total of 366 (203 and 163 in Chimaliro and Liwonde, respectively) households were involved. The main data sources were four quarterly surveys conducted between August 2006 and July 2007. The quarterly surveys collected data on all possible sources of household income, including forest income. The quarterly surveys were complemented by two annual household and two village surveys. The annual household surveys collected households' demographic information, while the village surveys collected village level data.

Valuing subsistence income, such as from firewood, is a major challenge in rural household surveys (Wunder et al. 2011). Most forest products, although mainly used for subsistence, were also traded within the villages, so local market prices for the forest products were used. In other cases, subsistence products were exchanged between households in barter trade, and households did not face major problems in putting the equivalent cash price on them.[3] For the remaining and small minority of products, we used prices reported by the household based on its own valuation of the product.

3.3 Methods

Principal component analysis (PCA) and cluster analysis

The first step in the analysis was to determine a criterion for categorising the household livelihood activities into livelihood strategies. There are different ways of doing this in the literature. One of the most commonly used method is grouping households by shares of income earned from different sources (Dercon & Krishnan 1996; Ellis 2000; Babulo et al. 2008). In a related study, Babulo et al. (2008) placed households into four groups based on shares of forest income in total income (<=20%, 20-40%, 40-60% and above 60%). These particular categories were difficult to apply to our data, as the forest income shares were relatively small, leading to

[3] For example, NTFPs such as mushroom exchanged for agricultural products, etc.

skewed categorisations.[4] The paper therefore uses principal component analysis (PCA) combined with cluster analysis to group households with similar activities (to identify a set of livelihood activities) (Brown et al. 2006; Salehi et al. 2010; Tesfaye et al. 2011).

PCA generates few linear combinations (principal components) of variables according to variation in the data (Johnson & Wichern 2007; Rabe-Hesketh & Everitt 2007). Like most similar studies (Babulo et al. 2008; Tesfaye et al. 2011; Soltani et al. 2012), the paper uses shares of main income sources (food crop, tobacco, livestock, forest, wage business and other sources) as inputs for PCA. However, unlike these previous studies, we further split the sectoral incomes into subsistence and cash income shares to distinguish between commercially and non-commercially oriented livelihood strategies. Scores from the principal components were then used for cluster analysis. Alternatively, the cluster analysis could directly use income shares from the various sources, thereby skipping the PCA analysis. Tesfaye et al. (2011) observes that this might lead to multicollinearity.

Cluster analysis is a set of exploratory data analysis techniques that seek to uncover groups in data (Rabe-Hesketh & Everitt 2007). These techniques are broadly divided into partition and hierarchical cluster analysis methods (Anderberg 1973). The former methods break the observations into a distinct number of non-overlapping groups. The latter creates hierarchically related sets of clusters.[5] The hierarchical method is further subdivided into divisive and agglomerative methods. I apply the agglomerative hierarchical method. Each observation is considered a separate group (N groups of size 1). The two closest groups are combined, and this

[4] More than 90% (Chimaliro) and 75% (Liwonde) of the households had forest income shares of less than 20%.

[5] For details about these methods, we refer the reader to Johnson and Winchern (2007) and Rabe-Hesketh and Everitt (2007).

process continues until all observations belong to a group, thereby creating a hierarchy of clusters (Anderberg 1973).[6] This approach yielded four distinct livelihood strategies for each site.

I also calculated a Simpson diversification index as a measure of livelihood activity diversification for the households. The following formula was used for the diversification index (Simpson 1949; Vedeld et al. 2007):

$$Diversity\ index = 1 - \sum_{i=1}^{n} (s_i)^2 \qquad (2)$$

where S_i is the share (proportion) of income source *i* relative to total household income, and n is the number of households. The index ranges from zero (no diversification) to one (infinite number of income sources). Note that the index is sensitive to classification, e.g., splitting agriculture into crop and livestock produces a different index value than when agriculture is treated as a single sector. Thus, care must be taken when comparing across studies.

To profile the poverty status of the households, poverty head count ratio was calculated using the two sites' respective regional poverty lines adapted from a national integrated household survey (National Statistical Office (NSO) 2005). The poverty lines were MK12,952 (USD PPP 539) and MK10,964 (USD PPP 456) per annum per adjusted adult equivalent (aae) for Chimaliro and Liwonde, respectively.[7]

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[6] With divisive hierarchical clustering, all observations initially begin as one group. This group is then split to create two groups, three groups, and so on until all observations are their own separate groups (Anderberg 1973).

[7] Purchasing Power Parity (PPP) exchange rate: USD1 = MK24.05 in 2006 (Heston et al. 2009).

Determinants of livelihood strategies

From the livelihoods framework in Figure 1, I investigate the relationship of livelihood strategies (LS) as a function of livelihood assets (LA) and conditioning factors (CF), as represented in Equation (1). For the conditioning factors, I concentrate on market distances partly due to data limitations and partly because others (e.g., local institutions and biophysical/environmental factors) had limited variation within sites due to the relatively small geographical areas.

$$LS = f(LA, CF) \qquad (1)$$

The relationship in Equation (1) was empirically tested using a multinomial logit (MNL) model. Specifically, the MNL model was used to assess what determines the livelihood strategies. The dependent variables are the four livelihood strategies (for each site) identified through PCA and cluster analyses.

4 Results and discussion

4.1 Overall livelihood activities

The income sources were broadly categorised into farm and non-farm income (Table 2).[8] Households in Chimaliro derived most of their income (73%) from farming, while in Liwonde the farm and non-farm incomes roughly provided equal shares of income.[9] While all households

[8] We follow a working definition as proposed by Brown et al. (2006), who made a distinction between 'non-farm versus farm' and 'on-farm versus off-farm'. They noted that these terms, though sometimes used interchangeably, can be misleading. While the 'farm/non-farm' revolves around sectoral classification, the 'on-farm/off-farm' reflects the spatial distribution of incomes, with off-farm income generated away from one's farm. Our case reflects much of sectoral rather than spatial distribution, hence the use of 'farm/non-farm'.

[9] Note that the income shares in Table 2 are averages of individual household shares. As such, they are not necessarily mean incomes divided by total incomes in the table, e.g., the share of farm income in Chimaliro is not equal to (14,359/18,022)*100.

in Chimaliro had at least crop income as one of their sources, approximately 15% of their counterparts in Liwonde did not have any crop income at all. Also included in Table 2 are income means for 'earning' households, i.e., only households earning from that income source. Although the income distribution pattern across the income sources remains the same (i.e. for overall and 'earners' only mean incomes), the overall mean incomes underestimated the means for those income sources pursued by few households. The difference is particularly noticeable for tobacco in Chimaliro and for business in Liwonde.

Table 2. Income source characteristics

Income source	Chimaliro (n = 203)					Liwonde (n = 163)				
		Mean Income (MK/aae)		Income share (%)			Mean Income (MK/aae)		Income share (%)	
	hh	All	Earners	All	Earners	hh	All	Earners	All	Earners
Farm income	***203***	***14,359***		***72.5***		***163***	***5,322***		***50.9***	
Food crop	203	7,902	7,902	50.7	50.7	138	4,718	5,572	43.4	51.2
Tobacco	37	2,265	12,425	5.3	29.2					
Livestock	183	4,193	4,651	16.5	18.2	112	604	879	7.5	10.9
Non-farm income	203	***3,664***		***27.5***			***3,893***		***49.1***	
Forest	203	1,050	1,050	9.5	9.5	162	1,195	1,203	15.7	15.8
Wage	132	700	1,077	6.1	9.4	117	931	1,297	11.8	16.4
Business	94	362	785	2.9	6.2	81	772	1,553	8.8	17.7
Other	188	1,551	1,675	9.0	9.7	144	996	1,128	12.9	14.6
Total Income	203	***18,022***		***100.0***		163	***9,216***		***100.0***	

Note: hh = number of households earning income from an income source;
aae = adjusted adult equivalent;
Other non-farm income includes remittances, support from government, NGOs or similar organisations and gifts/support from friends and relatives.

Despite being remotely located, households in Chimaliro enjoyed absolute incomes that were about double those of Liwonde. This is mainly due to differences in farm income (Table 2). Agriculture in Liwonde was not a high-return activity as it is in Chimaliro. Although Liwonde had better potential for non-farm income than Chimaliro, it was insufficient to offset the farm income differentials between the two sites. The absolute non-farm incomes were comparable for the two sites – a sign that the non-farm incomes in Liwonde were as low-paying as those in Chimaliro.

Forest income contributes a significant share to the total income for both Chimaliro and Liwonde. In Chimaliro, it comes third after food crops and livestock, while in Liwonde it is second to food crop income.[10] This is an income source that is mostly ignored in conventional income surveys, thereby underestimating household income (Cavendish 2000). The picture indicated by Table 2 is that forest income is one of the major income sources and, hence, needs special attention.

Farming is generally considered the main source of income of all rural households in Malawi. The results from Table 2, however, suggest that this is not always the case. Looking at the farm and non-farm income contributions, this seems to be true for Chimaliro, while for Liwonde, based on income sources, it is not correct to simply categorise all households as "farmers". However, as will be seen in the subsequent sections, even for Chimaliro the picture is not as uniform as portrayed in Table 2.

4.2 Identified livelihood strategies

The PCA yielded five and four principal components (i.e., those with *Eigenvalues* of more than one) for Chimaliro and Liwonde, respectively (Table 3).

[10] The food crop category was used mainly to differentiate the rest of the crops from tobacco, which is a special crop because it is the only crop that is solely grown as a cash crop. Otherwise, not all the crops in the food crop category are strictly subsistence. Crops such as groundnuts and rice are mostly grown as cash crops in addition to being used for own household consumption.

Table 3. PCA analysis of income shares

Components	Chimaliro			Liwonde		
	Eigenvalues	Proportion of variation	Cumulative variation	Eigenvalues	Proportion of variation	Cumulative variation
Comp1	1.81	0.20	0.20	1.63	0.20	0.20
Comp2	1.52	0.17	0.37	1.43	0.18	0.38
Comp3	1.24	0.14	0.51	1.25	0.16	0.54
Comp4	1.11	0.12	0.63	1.01	0.13	0.66
Comp5	1.07	0.12	0.75	0.99	0.12	0.79
Comp6	0.92	0.11	0.85	0.88	0.11	0.90
Comp7	0.83	0.09	0.94	0.80	0.10	1.00
Comp8	0.50	0.05	1.00			

The principal components accounted for at least 66% of the household income variation at both sites. Scores from the principal components were used for cluster analysis, which led to the identification of four livelihood strategy clusters at each site (Table 4). The one-way ANOVA test for equal variance of various income sources across the clusters was strongly rejected for all income sources at both sites. This implies that the distributions of income portfolios for the different livelihood strategies are statistically distinct. The cluster composition at each site reflected the differences for the two sites. Consequently, comparing clusters across sites is problematic. The clusters are labelled based in their income characteristics.

Livelihood strategies in Chimaliro

The majority (54%) of households in Chimaliro belonged to the *Food Crop* livelihood strategy, followed by the *Food Crop-Livestock* mixed strategy (Table 4). There was also a special cluster of 13 households that had tobacco as their main source of income. This *Tobacco-Food Crop* mixed strategy was by far the richest and, as hypothesised, had the lowest forest reliance. Furthermore, this tobacco-reliant strategy was the least diversified, as indicated by the lowest Simpson Diversity Index of 0.25. Apart from tobacco, having livestock was another characteristic of rich households. The *Food Crop-Livestock* strategy, which obtained the highest share of livestock income, was the second richest. Not surprisingly, the tobacco and livestock dominated strategies (*Tobacco–Food Crop* and *Food Crop-Livestock*) had high cash income shares of 67% (57% from tobacco) and 60% (29% from livestock), respectively. In summary, in Chimaliro, a greater reliance on farm income was associated with high incomes, while the poorest clusters depended more on non-farm income. This suggests that non-farm income was being used to supplement the inadequate farm incomes.

Table 4. Distribution of sectoral incomes by livelihood strategy clusters

	Chimaliro						Liwonde					
	Food crop (Cluster 1)	Tobacco-food crop (Cluster 2)	Food crop-livestock (Cluster 3)	Food crop-forest (Cluster 4)	*Site Total*	*One-way ANOVA F-test of equal variance across clusters*	Food crop-non-farm (Cluster 1)	Wage-livestock-forest (Cluster 2)	Forest-business (Cluster 3)	Food crop (Cluster 4)	*Site Total*	*One-way ANOVA F-test of equal variance across clusters*
Farm income share	71.2	90.4	82.8	50.0	72.5	38.13***	33.0	39.5	14.0	75.6	50.9	80.54***
Food crop share	61.2	28.5	41.9	36.3	50.7	27.82***	29.3	16.5	6.1	68.4	43.4	101.16***
Subsistence	55.1	27.5	27.8	27.9	42.6	41.89***	26.1	13.8	3.5	52.8	34.6	39.94***
Cash	6.1	1.0	14.1	8.4	8.1	8.41***	3.2	2.7	2.7	15.8	8.8	8.17***
Tobacco share (Cash)	0.9	57.3	4.0	1.1	5.3	275.03***						
Livestock share	9.1	4.6	36.9	12.6	16.4	52.96***	3.7	23.0	7.9	5.1	7.5	29.98***
Subsistence	5.0	2.1	7.5	7.3	5.8	4.21***	2.8	16.2	6.2	3.0	5.1	22.63***
Cash	4.1	2.5	29.4	5.3	10.6	47.60***	0.9	6.8	1.7	2.1	2.4	6.16***
Non-farm income share	28.8	9.6	17.2	50.0	27.5	38.13***	67.0	60.5	86.0	26.6	49.1	80.54***
Forest share	9.9	3.8	5.8	17.6	9.5	13.24***	19.7	20.0	31.7	8.7	15.7	10.73***
Subsistence	9.3	3.6	5.3	15.3	8.7	13.59***	18.1	15.9	6.5	6.7	11.7	9.01***
Cash	0.6	0.1	0.5	2.4	0.8	3.92***	1.6	4.1	25.2	2.0	4.0	26.37***
Wage share (Cash)	9.1	1.0	2.4	3.5	6.1	10.77***	12.1	31.6	2.7	6.7	11.8	33.82***
Business share (Cash)	0.9	1.5	2.4	12.1	2.9	52.15***	3.9	4.8	47.2	6.8	8.8	45.33***
Other income share (Cash)	8.9	3.3	6.6	16.7	9.0	10.36***	31.3	4.1	4.3	4.2	12.9	63.56***
Total income (MK/aae)	12,578[a]	43,436[b]	26,138[b]	10,143[a]	18,022	12.30***	8,978[ab]	4,900[b]	11,492[ab]	11,148[a]	9,216	5.64***
Total cash income share	30.6	66.7	59.5	49.6	42.9		53.0	54.1	83.9	37.9	48.8	
Simpson Diversity Index	0.52	0.25	0.54	0.65	0.53		0.61	0.66	0.49	0.46	0.54	
Number of households	110	13	52	28	203		52	24	13	74	163	
Proportion of households (%)	54.2	6.4	25.6	13.8	100.0		31.9	14.7	8.0	45.4	100.0	
Poverty head count ratio (%)	65.5	7.7	42.3	75.0	57.1		76.9	95.8	69.2	58.1	70.6	
Inequality (Gini coefficient)	0.39	0.36	0.50	0.42	0.49		0.49	0.38	0.32	0.36	0.43	

***significant at 1%

Note: Bonferroni multiple comparison test of total income across the clusters within a site: the same superscript letters indicate that the means are not significantly different at the 5% level. Different letters indicate a significant difference at 5%.

Table 5, which shows more characteristics of the clusters, mostly confirms the patterns observed in Table 4 for Chimaliro. As expected, households in richer clusters had more assets than the poorer clusters. For example, the rich *Tobacco-Food Crop* and *Food Crop-Livestock* strategies had at least four times the asset values of the relatively poor strategies *Food Crop* and *Food Crop-Forest*.

Table 5. Livelihood assets by livelihood strategies

Variable	Chimaliro				Liwonde			
	Food crop (Cluster 1)	Tobacco -food crop (Cluster 2)	Food crop-livestock (Cluster 3)	Food crop-forest (Cluster 4)	Food crop-non-farm (Cluster 1)	Wage-livestock -forest (Cluster 2)	Forest-business (Cluster 3)	Food crop (Cluster 4)
Human Capital								
Age of hh head (years)	49.5	40.2	50.2	46.2	47.5	41.2	41.4	42.9
Female-headed households (%)	14.6	0.0	3.9	17.9	34.6	8.3	7.7	23.0
Education of hh head (years)	5.6	7.8	6.4	6.4	3.7	5.2	7.4	4.7
Household size (headcount)	5.9	5.9	6.4	5.6	4.6	5.0	5.3	5.1
Household size (aae)	3.9	4.0	4.3	3.7	3.2	3.5	3.6	3.4
Dependency ratio	1.6	1.1	1.3	1.6	1.4	1.2	1.2	1.4
Physical Capital								
Asset value (excl. land) (MK/aae)	21371	87271	125189	16939	3654	6432	9484	8121
Implements (MK/aae)	757	4873	4926	826	960	1052	4910	1629
Livestock (MK/aae)	20613	82398	120262	16113	2694	5379	4574	6492
Livestock (TLU/aae)	0.61	2.08	2.77	0.52	0.10	0.18	0.13	0.24
Land size (ha/aae)	0.84	0.95	1.17	0.69	0.37	0.22	0.54	0.29
Financial Capital								
Savings (MK/aae)	28	462	491	40	80	83	98	81
Social Capital								
FCM membership (%)	46.4	46.2	46.2	32.1	25.0	16.7	0.0	27.0
Main ethnic group (%)	86.4	100.0	82.7	92.9	69.2	83.3	76.9	52.7
When hh formed (years)	23.6	15.6	23.3	22.2	20.5	14.3	17.6	17.5
Natural Capital								
Distance to forest (km)	2.1	1.8	1.8	1.8	0.7	0.7	0.4	0.6
Woodlot ownership (%)	50.0	46.2	44.2	39.3	32.7	25.0	46.2	32.4
Conditioning Factors								
Average distance to market (km)	24.1	26.1	23.8	22.6	3.4	2.1	2.4	4.8

Note: TLU = Tropical Livestock Unit from FAO, as quoted by Jahnke (1982): camel = 1, donkey/horse = 0.8, cattle = 0.7, pig = 0.25, goat/sheep = 0.1, poultry = 0.01.

Although the tobacco-dominated livelihood strategy (*Tobacco-Food Crop*) had the highest income, it was not the most endowed with assets. Instead it was the livestock-dominated cluster that had the highest value of assets. The tobacco cluster may have arguably been the richest, but it was the livestock cluster that could be most resilient to stochastic income fluctuations owing to the latters' high asset stock, which could act as a buffer in times of income shocks or other shocks.

Livelihood strategies in Liwonde

Non-farm income dominated in three out of four livelihood strategies in Liwonde (Table 4). This result serves to emphasise the differences in relative importance of farm and non-farm income sources for Liwonde and Chimaliro. Three of the four identified livelihood strategies in Liwonde had at least 60% of their income coming from non-farm sources. Only the *Food Crop* strategy had over three-quarters of its income from farming activities. However, the majority of households (45%) still belonged to the *Food Crop* strategy. The other 55% of the households were split among the remaining three strategies. The *Food Crop-Non-farm*, *Wage-Livestock-Forest*, and *Forest-Business* strategies had relatively high forest reliance compared with the *Food Crop* strategy. Unlike in Chimaliro, where high livestock income was associated with high income, in Liwonde this was the opposite. Households in the highest livestock-reliant *Wage-Livestock-Forest* strategy were the poorest. Only 4% of the households were above the poverty line (Table 4). This result had to do with the type of livestock involved. The livestock in Chimaliro was of high value, e.g., cattle, while in Liwonde it was mostly poultry, which is of low value.

The *Forest-Business* strategy in Liwonde deserves special mention. This strategy was counter-intuitive to the generalisation that more income is associated with less forest reliance. The households in this strategy had both highest income and highest forest reliance. They obtained most of their income (47%) from business, followed by forest (32%). The business orientation of this strategy was reflected in having the highest share of cash income of 84%. Inequality was lowest in this strategy (Table 4). Ironically, none of the households in the *Forest-Business* strategy belonged to the community forest management group – FCM (Table 5).

4.3 Forest products, crops and livestock distribution for the livelihood strategies

Firewood and mushrooms were consistently the top two forest products for all clusters and both sites. All households (except one from Liwonde) had firewood as one of their products.[11] This was as expected because firewood is the main source of cooking energy in Malawi (more so in rural areas). Almost all forest products were in their raw form except wooden utensils/tools. Wooden utensils/tools had more potential to bring in cash than the other raw products, all things being equal. However, the reliance on these wooden utensils was relatively low for both sites. Even the more cash-oriented *Forest-Business* strategy in Liwonde mostly depended on firewood (all households) and mushrooms (77% of the households). Only three households indicated wooden utensils as one of their forest products in Liwonde's *Forest-Business* strategy.

[11] Given that firewood is the main, and in most cases only, source of energy for cooking, it means this household used firewood from sources other than forests. We defined forest products as those that strictly came from forests.

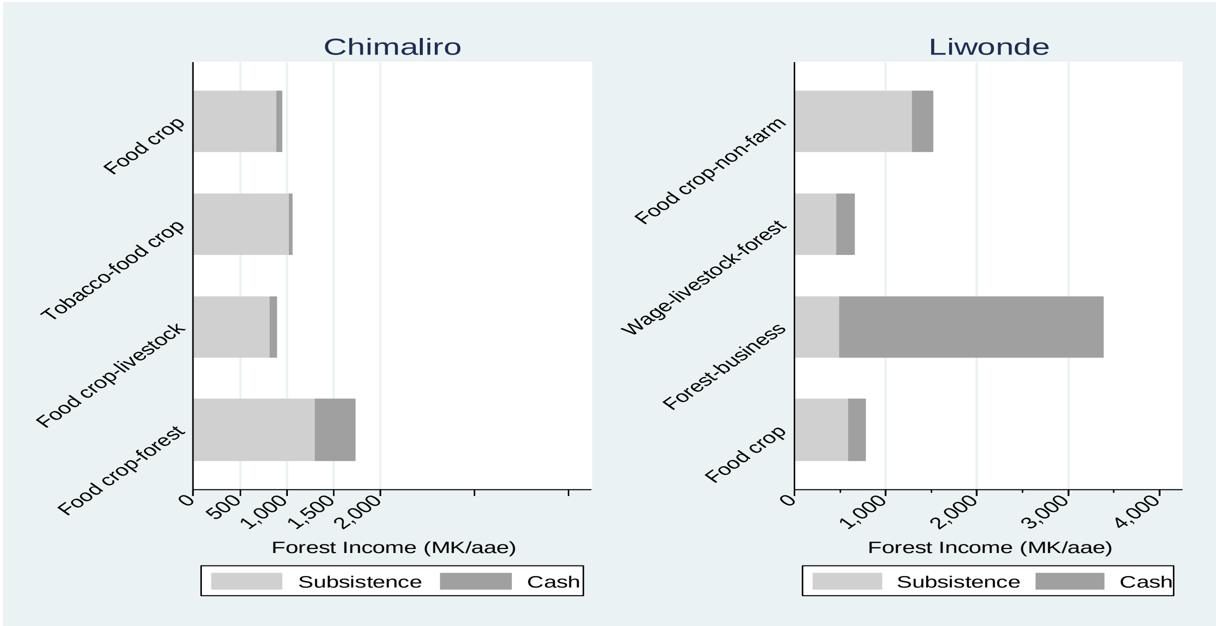

Figure 2. Forest income by livelihood strategy

Other interesting, but unobvious, patterns emerged. The more forest-reliant livelihood strategies in Chimaliro (*Food Crop-Forest*) and Liwonde (*Forest-Business*) not only had the highest forest income shares (Table 4) but also the highest absolute forest incomes (Figure 2). Therefore, the general finding that forest reliance is inversely related to income levels (Cavendish 2000; Babulo et al. 2009) has exceptions. In Liwonde, the *Forest-Business* strategy was even more special: the strategy had forest income that was at least double that of the other three strategies in Liwonde.

While maize was the most common crop for both sites, the other main crops were different. In Chimaliro, the other main crops were groundnuts, soya and tobacco, while Liwonde had rice and cassava. For both sites, maize was mainly grown for subsistence. The other crops were either grown solely for cash (e.g., tobacco) or for both cash and subsistence (groundnuts, soya, rice and cassava). Chimaliro had more cash sources from crops than Liwonde, which was one of the possible reasons for having higher incomes than Liwonde. Of particular importance was tobacco, which was dominated by the *Tobacco-Food Crop* strategy in Chimaliro, and households in this strategy were consistently the richest.

The distribution of livestock was also one of the distinguishing features of the livelihood clusters, especially in Chimaliro. Chicken was the most common livestock type for both sites. At least 73% of the households in all the clusters owned chickens. However, it was cattle that made a large difference in income levels. Cattle was nearly absent in Liwonde (of the sampled households, only one owned cattle). This was a very large contrast to Chimaliro, where at least 19% of households in every livelihood strategy owned cattle.

4.4 Determinants of livelihood strategies

Livestock was one of the critical assets that determined livelihood strategy outcomes in Chimaliro (Table 6). Livestock was associated with high income (low forest-reliant) strategies of *Tobacco-Food Crop* and *Food Crop-Livestock*, while the low income (high forest-reliant) *Food Crop* and *Food Crop-Forest* strategies were associated with having less livestock. Most likely as a potential source of labour, a high adult equivalent (household size) increased the probability of a household following the *Food crop-Livestock* mixed strategy and the tobacco-dominated strategy *Tobacco-Food Crop* (though not significant in the latter ($p = 0.19$), possibly due to the small sample). This makes sense, as both tobacco farming and crop-livestock mix are some of the most labour-demanding enterprises. It is also intuitive that household heads in the *Tobacco-Food Crop* strategy were young compared with those in other strategies, as is reflected in both Tables 4 and 5. All things being equal, younger household heads would cope better with the tobacco labour demands than the older ones.

The conditioning factors also had a significant influence on the livelihood strategies in Chimaliro (Table 6). Households in the *Food Crop* strategy were associated with being far from markets for forest products and agriculture but closer to the district market. Bearing in mind that there was no proper market *per se* for forest products and that the main road mostly serves as forest market, one might infer that households in the *Food Crop* strategy were those located away from the main road. Although the households in the *Food Crop* strategy were the second most forest reliant in Chimaliro, they mostly used forest products for subsistence purposes (Figure 2). It is therefore unsurprising that they were located away from markets for forest products. Moreover, these households were located away from the forest, according to the positive *Distance to forest* coefficient. The *Tobacco-Food Crop* strategy was also characterised by being away from the district market.

Several variables were significantly associated with some livelihood strategies in Liwonde (Table 6). The business-oriented *Forest-Business* strategy was associated with having more household implements, unlike the *Food Crop-Non-farm* and *Wage-Livestock-Forest* strategies, which were characterised by a low value of the implements. There was a negative relationship between the supposedly richest livelihood strategy (*Forest-Business*) and livestock. In other words, this cluster depended less on livestock. Indeed, from Table 4, livestock contributed only approximately 8% of the total income for households in the *Forest-Business* strategy. These findings demonstrate how the same assets can have different impacts on livelihoods in different settings. For business to be successful, some education is required. Intuitively, therefore, education was only positively significant in the *Forest-Business* strategy. This is also reflected in Table 5, where the household heads of the *Forest-Business* strategy had the highest average education of 7.4 compared with a range of 3.7 to 5.2 for the other three strategies.

Although Liwonde is relatively ethnically heterogeneous compared with Chimaliro, the *Yao* are the main ethnic group and the original inhabitants of the area. Other tribes are recent settlers who mostly settled there through marriage and business. Therefore, all things beings equal, the main ethnic group should have more say regarding forest usage than the settlers. The results in Table 6 (again agreeing with Table 5) suggest that the more-forest dependent strategies of *Food Crop-Non-farm*, *Wage-Livestock-Forest* and *Forest-Business* had household heads that mostly belonged to the main ethnic group, *Yao* (although only significant for the *Forest-Business* strategy), as opposed to the *Food Crop* strategy, where belonging to the main ethnic group had a negative influence. Thus, while ethnicity had some significant influence on the livelihood strategies in Liwonde, such was not the case in Chimaliro. Chimaliro was more ethnically homogenous for the variable on ethnicity to have any influence, i.e., there was little variation in the ethnicity variable in Chimaliro.

Distance to markets (especially the forest market) indirectly measured remoteness from the main road. All the high forest-reliant livelihood strategies in Liwonde (*Food Crop-Non-farm*, *Wage-Livestock-Forest* and *Forest-Business*) were negatively related to distance to a forest market (although only significant for the *Wage-Livestock-Forest* strategy), unlike the least forest-reliant *Food Crop* strategy, which was positively related to distance to a forest market (Table 6). In other words, the less remote a household was, the less likely it was to pursue a more crop-dependent livelihood. Indeed, crop production is mostly concentrated away from the main roads. In addition, unsurprisingly, the least agricultural-dependent strategy, *Forest-Business* (only 14% of its income came from agriculture – Table 4), was associated with being away from agricultural markets (Table 6). In short, proximity to forest markets combined with low agricultural production capacity encouraged households to rely more on forests in Liwonde.

Table 6. Multinomial logit (marginal effects) results for determinants of livelihood strategy

Variable	Chimaliro				Liwonde			
	Food crop (Cluster 1)	Tobacco-food crop (Cluster 2)	Food crop-livestock (Cluster 3)	Food crop-forest (Cluster 4)	Food crop-non-farm (Cluster 1)	Wage-livestock-forest (Cluster 2)	Forest-business (Cluster 3)	Food crop (Cluster 4)
Human Capital								
Age of hh head (years)	0.002 (0.71)	-0.004 (-2.29)**	0.001 (0.39)	0.001 (0.68)	0.005 (1.63)	0.001 (0.37)	-0.002 (-0.81)	-0.003 (-1.06)
Female-headed households (1/0)	0.247 (0.01)	-0.540 (-0.01)	0.180 (0.01)	0.113 (0.02)	-0.013 (-0.12)	-0.154 (-1.65)	0.032 (0.56)	0.134 (1.27)
Education of hh head (years)	-0.016 (-1.56)	0.006 (1.10)	0.005 (0.60)	0.005 (0.66)	-0.006 (-0.47)	-0.001 (-0.14)	0.018 (2.19)**	-0.011 (-1.00)
Household size (aae)	-0.040 (-1.55)	0.020 (1.33)	0.054 (2.47)**	-0.034 (-0.1.61)	-0.033 (-0.98)	-0.012 (-0.45)	0.031 (1.36)	0.014 (0.40)
Physical Capital								
Implements (log MK/aae)	-0.004 (-0.84)	0.001 (0.47)	-0.001 (-0.36)	0.004 (1.17)	-0.017 (-2.99)***	-0.011 (-1.73)*	0.032 (1.98)**	-0.003 (-0.35)
Livestock (log MK/aae)	-0.105 (-8.25)***	0.034 (2.69)***	0.096 (5.88)***	-0.025 (-4.07)***	0.006 (0.85)	0.009 (1.40)	-0.009 (-2.49)**	-0.006 (-0.90)
Land size (ha/aae)	0.043 (0.94)	0.001 (0.09)	0.036 (1.15)	-0.079 (-1.78)*	0.096 (0.62)	-0.156 (-1.11)	0.065 (0.63)	-0.005 (-0.03)
Woodlot ownership (1/0)	0.144 (2.16)**	-0.037 (-1.15)	-0.099 (-1.77)*	-0.007 (-0.14)	0.011 (0.14)	-0.028 (-0.48)	0.030 (0.78)	-0.012 (-0.15)
Social Capital								
FCM membership (1/0)	0.071 (1.02)	0.036 (1.07)	-0.045 (-0.77)	-0.062 (-1.14)	0.194 (0.03)	0.149 (0.01)	-0.688 (-0.02)	0.344 (0.02)
Main ethnic group (1/0)	-0.232 (-0.01)	0.608 (0.01)	-0.436 (-0.01)	0.060 (0.01)	0.010 (0.13)	0.056 (0.85)	0.110 (2.04)**	-0.176 (-2.29)**
Natural capital								
Distance to forest (km)	0.036 (1.77)*	-0.001 (-0.14)	-0.017 (-0.98)	-0.017 (-1.10)	0.058 (1.17)	0.012 (0.32)	-0.028 (-0.72)	-0.042 (-0.74)
Conditioning factors								
District Market (km)	-0.008 (-1.72)*	0.005 (2.22)**	0.004 (1.00)	-0.001 (-0.25)	0.021 (0.73)	0.009 (0.37)	-0.003 (-0.20)	-0.026 (-0.94)
Agricultural market (km)	0.016 (2.23)**	-0.001 (-0.28)	-0.003 (-0.41)	-0.015 (-2.17)**	-0.021 (-0.77)	0.014 (1.22)	0.011 (2.01)**	-0.003 (-0.12)
Forest Market (km)	0.016 (1.90)*	-0.010 (-1.84)*	-0.005 (-0.70)	-0.002 (-0.33)	-0.008 (-0.28)	-0.046 (-2.30)**	-0.012 (-0.84)	0.066 (2.43)**
	Chimaliro				*Liwonde*			
Number of observations	*203*				*163*			
Log likelihood	*-166*				*-142*			
LR Chi-square	*126****				*109****			
Pseudo R^2	*0.28*				*0.28*			

Note: Figures in parentheses are z-statistics
aae = adjusted adult equivalent
***significant at 1%, **significant at 5%, *significant at 10%

4.5 Livelihood outcomes and forest reliance

Finally, the study wanted to confirm whether forest reliance was indeed high for the low-income livelihood strategies. A stochastic dominance test was used to check whether income distributions of low forest-reliant (high income) livelihood strategies dominated the high forest-reliant (low income) livelihoods. Assuming we have two distributions A and B whose cumulative density functions (CDF) are denoted by CDF_A and CDF_B, then distribution B first order stochastically dominates A if and only if, for any argument *y*, $CDF_A(y) \geq CDF_B(y)$ (Davidson 2006). In other words, a distribution first order stochastically dominates another if for every income level it has a lower CDF than the other (Whitmore & Findlay 1978).

There was no strict first order stochastic dominance for the clusters as evidenced by the crossing of the respective CDF curves in Figure 3. Nevertheless, some general patterns could be isolated. For Chimaliro, relatively high forest-reliant livelihood strategies (*Food Crop* – Cluster 1 and *Food Crop-Forest* – Cluster 4) were mostly dominated by the relatively low forest-reliant strategies (*Tobacco-Food Crop* - Cluster 2 and *Food Crop-Livestock* – Cluster 3), i.e., the CDFs for the latter strategies were mostly below (to the right of) the CDFs for the former strategies. The exception was after MK50,000/aae, where *Food Crop* CDF crosses *Food Crop-Livestock* CDF. With average incomes of approximately MK12,500 and MK26,000 for the *Food Crop* and *Food Crop-Livestock* strategies, respectively, (Table 4) in Chimaliro, incomes above MK50,000 (especially for the *Food Crop* strategy) should be considered outliers. Thus, the results generally confirm that households with low incomes relied more on forests than the high income households.

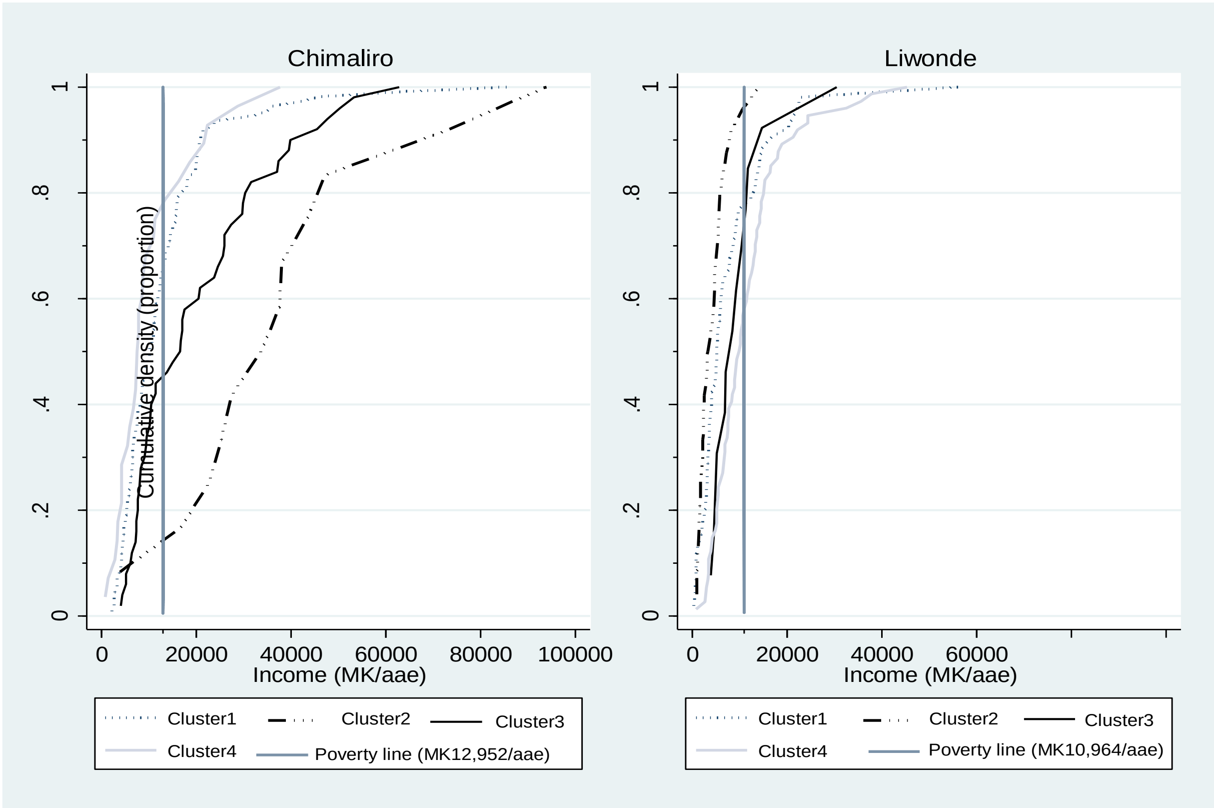

Figure 3. Income cumulative distribution for livelihood clusters

In Liwonde, the relatively high income strategies *of Food Crop-Non-farm* – Cluster 1, *Forest-Business* – Cluster 3 and *Food Crop* – Cluster 4 dominated the low income *Wage-Livestock-Forest* – Cluster 2 strategy (Figure 3). In turn, despite having the nominally highest average income compared with the *Food Crop-Non-farm* and *Food Crop* strategies, the *Forest-Business* strategy was mostly dominated by the *Food Crop* strategy (except for incomes above MK40,000 and below MK500). The story is generally the same: the more forest-reliant a livelihood strategy is, the more inferior the income distribution is compared with the less forest-reliant strategy. This implies that poor households are associated with high forest reliance.

4.6 Discussion

Identification of livelihood strategies: cash versus subsistence sectoral incomes matter

The splitting of income sources into their cash and subsistence components is one of the unique features of this paper compared with previous studies. The majority of these previous studies (Botha 2003; Babulo et al. 2008; Tesfaye et al. 2011; Soltani et al. 2012) used aggregate sectoral incomes to identify livelihood strategies. I also tried using aggregate sectoral incomes. Although both methods generally produced similar livelihood strategy clusters (by main income source composition), the splitting of the income sources into subsistence and cash led to more homogenous livelihood strategies than when aggregate sectoral incomes were used instead. Given that the households mostly earn their living through subsistence farming, any amount of direct cash income earned makes a difference in distinguishing such households from the rest. Indeed this was the case for tobacco and livestock-oriented strategies (*Tobacco-Food Crop* and *Food Crop-Livestock* strategies) for Chimaliro and the *Forest-Business* strategy in Liwonde.[12]

Determinants of livelihood strategies and contextual issues

In Chimaliro, labour and livestock were critical assets. Intuitively, the high labour-demanding *Tobacco-Food Crop* and *Food Crop-Livestock* strategies were associated with more household members than the other strategies. Cattle owners were among the richest households in Chimaliro. Apart from playing an economic role, cattle are culturally a source of prestige, as they are used for paying bride prices. During key informant interviews, we were told that there was at least a cattle market once every month where cattle were either sold for cash or farmers could

[12] In Chimaliro, for example, using the aggregate sectoral incomes, the *Tobacco-Food Crop* strategy had 19 households, but after splitting into sectoral cash and subsistence incomes, only 13 households remained while the other six households were pushed to the general *Food Crop* cluster. Similar household reorientations were also observed in Liwonde, especially for the *Forest-Business* strategy.

exchange older cattle for younger ones and vice versa depending on need. In short, cattle were a highly liquid and valuable asset in Chimaliro.

The type of livestock in the two areas could also be linked to socio-cultural differences. Liwonde is mainly a Muslim area, while Chimaliro is mainly Christian. As expected, none of the sampled households in Liwonde reported keeping pigs, while in Chimaliro pigs were the third most common domestic animal, after chickens and goats. This result highlights how socio-cultural norms can be a barrier to some livelihood activities.

Tobacco farming was another important characteristic of high-income livelihood strategies. Tobacco is a main cash crop of Malawi, and Chimaliro lies along a major tobacco-producing belt. Tobacco in Malawi is marketed through an auction system. There are four auction floors in Malawi: one in the south, two in the centre and one in north. Being on the boundary between the central and northern regions, Chimaliro has access to both auction floors in the centre and the one in the north. The strategic position of Chimaliro gives it good access to the tobacco markets.

Another contextual elaboration that needs to be made is the relationship between tobacco farming and forest reliance. The general expectation was that tobacco farming would be associated with high forest reliance due to the curing process. The results however, have shown that tobacco farming was concentrated in households with low forest reliance (Table 4). The possible explanation for this could be that in Malawi smallholder farmers mainly grow burley tobacco, which is air-cured, while flue-cured tobacco (which requires firewood for curing) is almost exclusively grown by estates.[13] This study only involved smallholder farmers. It was therefore plausible that there was no positive association between forest reliance and tobacco

[13] To mitigate the possible consequences for forests, estates by law are required to set aside at least 10% of their land for planting trees in Malawi.

farming. However, Chibwana et al. (2012), in their study in the same areas, noted demand for trees to construct sheds for tobacco as a potential negative impact to forests.

Complex links between forest reliance and low income livelihood strategies

In Chimaliro, the answer to the above question is yes. Agreeing with previous findings (Cavendish 2000; Babulo et al. 2008; Babulo et al. 2009; Tesfaye et al. 2011; Debela et al. 2012), the results in Table 4 for Chimaliro suggest that low income levels were associated with high forest reliance and vice versa. The lowest and second lowest income strategies of *Food Crop-Forest* and *Food Crop* had the highest and second highest forest reliance, respectively. Correspondingly, the higher the poverty levels, the higher the forest reliance.

In Liwonde, however, the answer to the above question is both yes and no. If we exclude the *Forest-Business* livelihood strategy, yes, high forest reliance is associated with low income livelihood strategies, as reported in the literature. However, the PCA and cluster analysis allow this study to identify a livelihood strategy (*Forest-Business*) that was exceptional to the inverse forest reliance – income relationship in that it had both the highest income and forest reliance. Although this cluster was only for 12% of the households in Liwonde, it tells an important story that the income level-forest reliance relationship may not be as straightforward and predictable as is mostly portrayed in literature.

The existing literature generally agrees that poor households have higher relative forest income (reliance) than rich households, but the rich households have more absolute forest income than the poor (Cavendish 2000; Babulo et al. 2009). However, this paper's findings show that the low income livelihood strategies had both the highest relative and absolute forest incomes in Chimaliro. In Liwonde, the highest income strategy had both the highest relative and absolute forest incomes. These results do not necessarily mean that the study sites are unique compared with other sites found in literature, but they should be interpreted within the context of the methodology used in this paper. When households are not categorised into livelihood clusters, the relationships hold where the absolute forest and relative incomes are, respectively, directly and inversely related income levels. However, as already noted, the PCA and cluster analysis resulted in more homogenous household clustering, thereby revealing some characteristics that would have been hidden otherwise.

In summary, households in Chimaliro not engaged in tobacco and/or livestock keeping were those that were likely to have forest-dominant livelihood strategies. In addition, because of its high agricultural potential and partly due to its remote location, the livelihood strategies in Chimaliro were more farm-oriented than non-farm-oriented. In Liwonde, the livelihood strategies were oriented more toward non-farm activities than farm activities. Only households in the *Food Crop* strategy obtained more than half their income (76%) from farming (Table 4). For the remaining strategies, the contribution of farming to income ranged from 14% to approximately 40%. With forest reliance being one such non-farm activity, this result could explain why forests were under more pressure in Liwonde than in Chimaliro. Furthermore, Liwonde's closeness to major towns and trading centres provides a potential market for forest products.

High reliance on non-farm income is commonly assumed to be related to high total income. That was not the case in our study. Although in Liwonde the highest income came from a non-farm-dominated livelihood strategy (*Forest-Business*), the stochastic dominance test showed that it was the farm income-dominated strategy (*Food Crop*) that was better off. In Chimaliro, the pattern was very clear: the greater the farm-income dominance, the higher the income and vice versa. Thus, for both study areas, agriculture was the dominant source of income. A lack or inadequacy of agricultural opportunity was characterised by low incomes. This was more evident in Liwonde, with its low agricultural potential. Therefore, low agricultural capacity indirectly signalled high reliance on forests and other non-farm activities.

5 Conclusions

This study has provided evidence that forest reliance differs across different types of livelihood strategies and these are partly determined by the local context. Despite the two sites representing two contrasting environments, the general pattern of forest reliance was the same for both sites: the more forest-dominant strategies were characterised by lower returns (income) than the less forest-dominant livelihood strategies. Furthermore, stochastic dominance tests revealed that the more forest-reliant livelihood strategies had an inferior income distribution compared with those with less forest reliance. Even in Liwonde, where the highest average income came from the cluster with the highest forest reliance, the stochastic dominance tests showed that the least forest-reliant livelihood strategy (with second highest income) had a superior income distribution compared with the nominally highest income strategy. Another unique feature of households following forest-dominated livelihood strategies was that they were more diversified than those with low forest reliance. The diversification was, however, on low-return alternatives of which forest reliance was one, which should be understood as a coping mechanism rather than a poverty exit strategy.

Like previous similar studies, this study has shown that it is the vulnerable poor households that rely more on forests. The policy implication of these results is that policy makers should aim for a sustainable forest management that strikes a balance between forest protection and forest use, especially by vulnerable households. One-sided protection is likely to hurt the most vulnerable segments of the surrounding villages, while uncontrolled use might undermine the long-term benefits that forests provide to these groups.

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Paper II

Employer of Last Resort? Shadow Wages and Forest Reliance in Malawi

Thabbie Chilongo* and Gerald Shively*

Abstract

This paper investigates the conditions surrounding forest reliance in low-income settings. Using survey data from households living adjacent to two forest reserves in Malawi we measure the relationship between forest use and household labor productivity. We test the hypothesis that the forest is an employer of last resort. We use a two-step method to estimate shadow wages associated with a composite agriculture-forest output. Despite that the market wage rate exceeds, the average household shadow wage, the low-incidence of off-farm employment in the sample suggests strong rationing in the labor market. This means households continue to depend on self-provisioning activities, implying eventual negative consequences for the local agricultural and forest resource base. Findings underscore that policies directed at investing in agriculture and expanding rural employment are likely to simultaneously support poverty-alleviation and environmental conservation objectives. (JEL Q23, J22, O13)

Key words: labor productivity, forest reliance, shadow wages, rural livelihoods

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1 Introduction

Many rural people in developing countries depend heavily on forests (Cavendish, 2000; Oksanen et al., 2003). This heavy reliance on forests has led to environmental degradation mainly emanating from unsustainable exploitation of forests. As a result, understanding the motivations and behaviors of rural households has become a prerequisite for promoting sustainable forest management in low-income settings. In this paper we contribute to the literature linking economic incentives and environmental outcomes by focusing on forest-use by the rural poor in Malawi. We specifically assess the role of labor productivity in triggering environmentally damaging behavior, asking to what extent the forest serves as an employer of last resort.

Empirical evidence led Barbier (2010) to conceptualize the underlying mechanisms at play that lead to forest as an employer of last resort. Barbier notes that given the poor's overdependence on natural resources, one is tempted to conclude that it is poverty that is a major driver of environmental degradation. He emphasizes that such a conclusion is likely too simplistic. The relationship between poverty and natural resource reliance, and the role of the rural poor as agents of environmental degradation are very complex. Barbier postulates that overdependence on natural resources by the poor may be a symptom of constraints they face: one such constraint being an inability to engage in outside employment, even when doing so would generate returns to labor that exceed those from natural resource-based activities. He argues that, *ceteris paribus*, when market wages fall below a household's labor productivity for self-provisioning or resource extraction, incentives will favor the continued exploitation of natural resources (e.g., land and forests). In this paper, we further argue that labor market failures, including employment rationing and high transaction costs, result in situations in which observed wages may exceed the marginal product of labor, but households continue to rely on natural resources.

Several empirical studies support the assertion that forest extraction is an employer of last resort. Shively (2001) and Coxhead et al. (2002) find that forests are an important source of livelihood for those households that are not gainfully employed, especially those with unskilled labor. Fisher et al. (2005) conclude that there are more incentives to degrade forests when returns to forest use are high. In another related study, Chilongo (2014) finds a positive correlation between low agricultural income and high forest reliance. It appears households turn to forest use to complement their inadequate incomes from the main livelihood activity, which is mostly agriculture for developing countries. Angelsen and Wunder (2003) sum up the characteristics that favor the poor's reliance on non-timber forest products (NTFPs): low or medium returns to labor, low barriers to entry, modest capital and skill requirements, and open or semi-open access.

In this paper we use survey data from a group a rural households residing near two forest reserves in Malawi. Following a theoretical model suggested by Barbier (2010), we test the narrative that the forest is an employer of last resort. Specifically, we compare households' marginal labor productivity with the average wages offered in outside employment. In the study areas, the main sources of outside employment are provision of casual labor and government and NGO-initiated public works programs (PWP). Following an empirical strategy suggested by Jacoby (1993) and previously implemented in a range of settings (e.g., Skoufias, 1994; Shively and Fisher, 2004; Fisher et al., 2005; Ainembabazi, 2012), we estimate household shadow wages, which we then use as a proxy for household labor productivity in self-provisioning. This forms the basis for comparisons with market wages and an analysis of activity choice.

2 Theoretical Framework

We adapt the following model from (Barbier, 2010) to conceptualize the role of shadow wages in determining household's choice of livelihood activities. Consider a rural low-income household living on marginally-productive land. The household's agricultural productivity is very low, perhaps due to low inherent soil fertility, past land degradation, and/or lack of skill or inadequacy of inputs. The household also faces general market failures, especially in the financial sector, leading to lack of access to formal credits, capital and insurance. The household's main livelihood activities can be broadly categorized as falling into one of two categories: direct self-provisioning (e.g. combining labor with locally-available natural resources such as land, forests or water) or outside employment at a market-determined wage, w^m. We recognize that households combine these activities and that individuals within households may specialize. We abstract from these considerations below.

We assume the household seeks to maximize the following utility function:

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

where c is the household's consumption from own production activities including collection of forest products, x represents consumption of market-purchased goods, and l^u is leisure. The utility is maximized subject to the following production, labor and full income constraints:

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

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

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

Equation (2) is an aggregate production function where y is the household's output from own production, such as agricultural production and forest products.[1] The aggregate production is a function of household labor (l^h), purchased inputs (v), and N denoting quality and quantity of household's natural resource endowment, which includes agricultural land and any other accessible and exploitable natural resources, like forests, fisheries, wild flora and fauna, and water sources. The household's total labor endowment (L) can be split among own production activities (l^h), outside employment (l^w) and leisure (l^u) (Equation 3).

Equation (4) is the household's full income constraint where the left-hand side represents cash purchases and the right-hand side is income. The household faces market prices p^x, p^v and p^y for the corresponding commodities and a market wage rate, w^m. The household either sells its surplus production (if $y > c$) or buys to fill its consumption deficit (if $y < c$). If a household uses hired labor, it is included in v, in which case p^v effectively becomes a vector of input prices that includes the wage rate, w^m. The household may have other non-labor income sources, such as remittances, support from relatives and friends, or other transfers (M).

The choice variables for the above maximization problem are consumption levels (c, x, and l^u) and inputs (l^h, l^w and v). The first order conditions yield the following expressions for the optimal allocation of labor (l^h, l^u and l^w):

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

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[1] Barbier (2010) notes that it is possible to separate agricultural production from other natural resource activities. However, doing so simply complicates the model without changing the qualitative results significantly.

$$\frac{U_{l^u}}{\mu} = p^y f_{l^h} = \frac{\lambda}{\mu} \geq w, \tag{5}$$

where λ is the shadow value for households total labor value and leisure time, μ is the shadow value of additional cash income. From (5) it therefore follows that the household compares its marginal value of leisure with that of labor allocated for production activities. In other words, the household compares the outside employment wage (w^m) with its reservation wage (w^R). The reservation wage is expressed as:

$$w^R \equiv \left[\frac{U_{l^u}}{\mu} = p^y f_{l^h} \right]_{l^{w*}=0} \tag{6}$$

Barbier (2010) assumes a frictionless off-farm labor market. With unlimited availability of outside employment the wage rate is the main determinant of whether a household allocates labor to an outside activity. In reality, however, rural labor markets in most developing countries function imperfectly (Morduch, 1995; Byron and Arnold, 1999; Rose, 2001; Chaudhuri and Paxson, 2002). Moreover, Barret et al. (2001) note that there is often a positive correlation between nonfarm activities (which include outside employment) and household wealth. The implication of this positive wealth-nonfarm correlation may suggest that the poor are rationed out of the labor market. In recognition of these empirical features, we relax this assumption by introducing transaction costs (TC) to the model. Such transaction costs could be explicit (e.g. search costs, transport costs, disutility of wage work, or costs associated with staying away from one's family); or implicit (e.g. barriers to entry, discrimination based on religion, ethnicity or political affiliation, or government distortion of the labor market through direct or indirect interventions). Therefore, it makes sense to refer to the wage faced by the household an "effective" wage, w^e rather than market wage, w^m. The effective wage is the difference between the market wage and transaction costs ($w^m - TC$) such that in absence of transaction costs, the market wage would equal the effective wage. By extension, a negative effective wage is possible, for example if transaction costs exceed the market wage itself. Thus, it is possible to observe households not engaged in outside employment despite that the market wage exceeds the shadow wage.

Denoting the respective optimal labor allocations with an asterisk (*) superscript, from the above discussion and Equations (5) and (6), we adapt the following propositions from Barbier (2010):

Proposition 1: $l^{w*} > 0 \;\; iff \;\; w^e > w^R, \;\; and \; l^{w*} = 0 \;\; iff \;\; w^e \le w^R.$

The household will engage its labor in outside employment if and only if the effective wage received is more than the household's reservation wage. In contrast, the household will forgo outside employment if the effective wage is equal to or less than the reservation wage. Adapting the proposition specifically for our case, we postulate that forest reliance will be one of the employers of last resort when the effective wage is not high enough to attract some labor force outside extractive production activities (which includes agriculture in general).

Proposition 2*: If* $w^e > w^R$ *then* $U_{l^u} / \mu = w^e$ *is the equilibrium defining* l^{u*} *and* $p^y f_{l^h} = w^e$ *is the equilibrium defining* l^{h*}

If the effective wage is high enough to attract household participation in outside employment, the household determines the optimal labor and leisure allocations by equating their respective values with the market wage rate.

The above propositions are graphically illustrated in Figure 1. The figure depicts the relationship between wage rate and household labor allocation decisions.

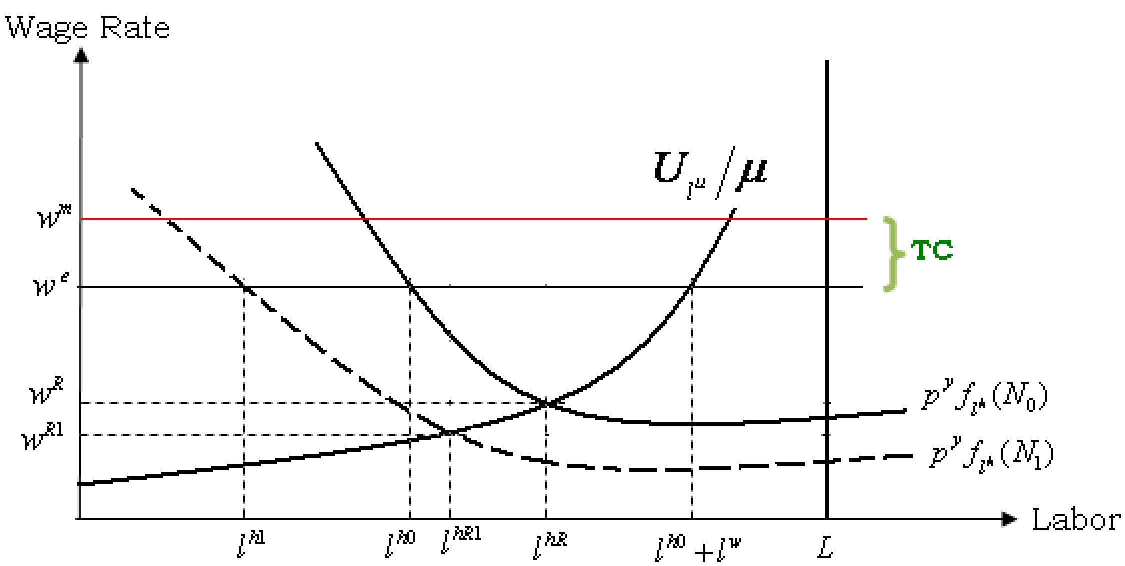

Figure 1: Rural Household Labor Allocation
***Source*: Adapted from Barbier (2010)**

Holding constant the quantity and quality of the natural resource endowment, e.g., N_0, the marginal value of household labor to its own production, $p^y f_{l^h}(N_0)$, is downward slopping due to diminishing marginal productivity of labor. On the other hand, the opportunity cost of forgone leisure, U_{l^u}/μ, is upward slopping due to decreasing marginal utility of leisure. The household faces market wage rate w^m and transaction costs TC and hence the effective wage rate w^e. According to Equation (6), the intersection of the two curves defines the reservation wage, w^R, where the household allocates l^{hR} amount of labor to own production activities on natural resource endowment, which includes forests. The remaining $L-l^{hR}$ is allocated to leisure. From Proposition 1, at any effective wage rate up to and below w^R, the household will allocate all its labor to own production activities and leisure but none to outside employment. At an effective wage rate of w^e, the household allocates some labor, l^w, to outside employment and reduces both production and leisure labor allocations to l^{h0} and $L - l^{h0} - l^w$ respectively. This reduction of labor on natural resource endowments, *ceteris paribus*, also means reduced pressure on the natural resources including forests.

With time the household production activities lead to both land and forest degradation. This therefore, reduces household's productivity to say, N_1. As shown in Figure 1, this reduces both the reservation wage to w^{R1} and labor allocated to production activities to l^{h1}. The reduction of the reservation wage means that the household is willing to allocate more labor to outside employment at relatively low market wage rates.

Introducing transaction costs into the model generates some unexpected outcomes. We demonstrate this in Figure 2.

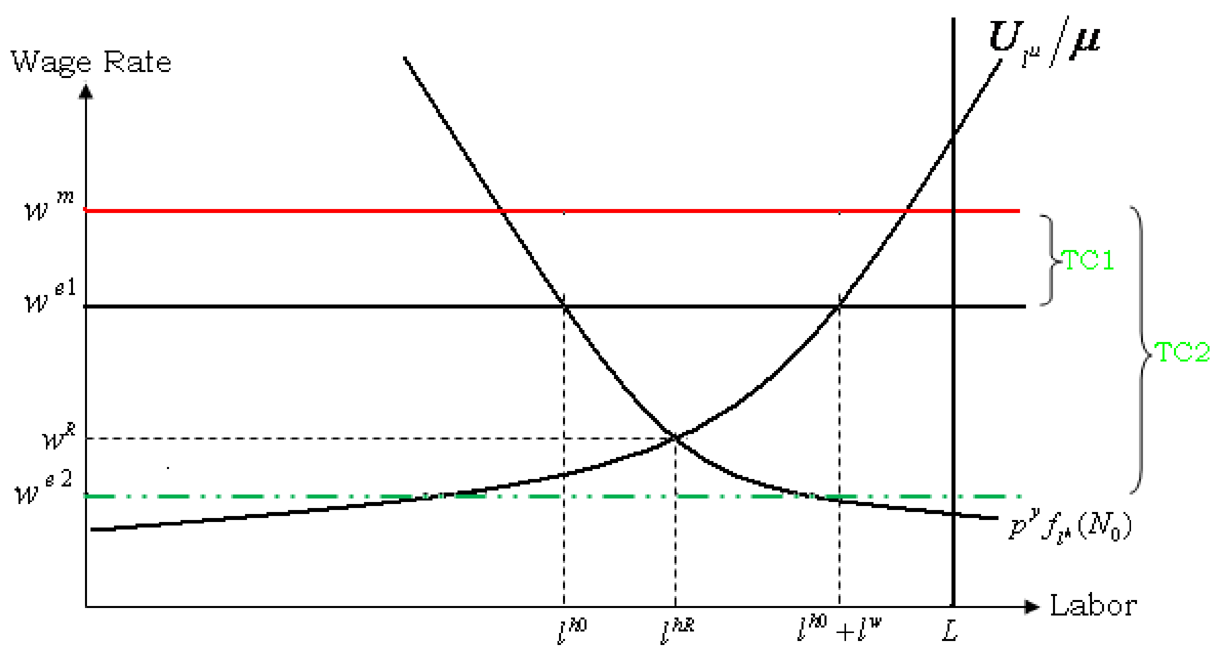

Figure 2: Effects of Transaction Costs on Rural Household Labor Allocation
***Source*: Adapted from Barbier (2010)**

Figure 2 presents two possible scenarios with transaction costs. The first scenario is when the transaction costs (*TC1*) are such that they still result in an effective wage rate (w^{e1}) that is above the household reservation wage (w^{R}). The household will therefore allocate l^{h0} and l^{w} to household production and outside employment respectively. It is also possible in the second scenario to have large transaction costs (*TC2*) that lead to an effective wage (w^{e2}) that is less than the reservation wage. Thus although the market wage appears to be far higher bigger than the reservation wage, it is possible to find households not participating in outside employment. As a result the household only allocates up to l^{hR} to own production and allocates the remaining $L - l^{hR}$ to leisure.

An example of the second scenario could be the case of public works programs (PWP). The paradox is that despite the high demand for outside employment and scarcity of the same, the wage rate that is set is significantly higher than both the average household income and the official rural minimum wage rate. For example, at the time of this study (2006-2007), the PWP wage rate of MK200/day (USD PPP 4.17/day) was higher than the rural minimum wage rate of MK170/day and 15% greater than average monthly cash outlays for food (Beegle et al., 2012).[2] Thus, despite an apparently high outside employment and low household shadow wages, not many households are expected to be engaged in outside employment. This may point to high

[2] MK = Malawi Kwacha (currency of Malawi), PPP = Purchasing Power Parity; PPP 2006 Exchange rate: USD1 = MK48.74 (World Bank, 2014).

transaction costs, or that households are labor constrained. It also means that a higher market wage may not necessarily be a panacea to reducing pressure on forests and natural resources in general.

3 Estimation Strategy

3.1 Data

Data for this study come from household surveys conducted under the Poverty and Environment Network (PEN) program of the Centre for International Forestry Research (CIFOR). For this paper, a total of 366 households (203 and 163 in Chimaliro and Liwonde, respectively) were involved. The main data sources were four quarterly surveys conducted between August 2006 and July 2007. The quarterly surveys collected data on all possible sources of household income, including forest income. The quarterly surveys were complemented by two annual household and two village surveys. The annual household surveys collected households' demographic information, while the village surveys collected village level data.

The sites are over 400 km apart and have distinct geographical, social and agroecological differences. Chimaliro lies in one of the most productive agricultural zones of Malawi. Tobacco, which is Malawi's major export earner, is one of the main cash crops of the area. Liwonde, on the other hand, is in an area of less agricultural potential. Like most of southern Malawi, Liwonde is characterised by high population densities resulting in small landholding sizes, averaging less than one hectare per household. More description of the study areas can be found in other past similar studies on the sites (e.g., Jumbe, 2005; Chilongo, 2014; Chilongo and Angelsen, 2014b; Chilongo and Angelsen, 2014a).

3.2 Estimation of Marginal Productivity of Labor (Shadow Wages)

An empirical test of the propositions suggested by the theoretical section requires us to compare the marginal productivity of labor inside the household to the market wage. In a perfect market situation, the opportunity cost of labor is exogenously determined by the labor market (Jacoby, 1993; Skoufias, 1994). However, given the labor market failures observed, the opportunity cost of labor is endogenously determined within a household, and the marginal productivity of labor measures the opportunity cost of labor, i.e. the shadow wage.

The first step in estimating shadow wages is to estimate a production function. However, in our case, since we are estimating a composite household output composed of agricultural (crop and livestock), wages, business and forest products, we use a hybrid function that is mostly (but not completely) a revenue function in which some inputs are measured as quantities and others are measured as values.[3] The function takes a Cobb-Douglas form:

$$Y_i = \alpha L_i^{\beta_L} N_{ik}^{\beta_{Nk}} \tag{7}$$

where Y_i is the composite household output value; L and N are labor hours and other k inputs respectively for household i; α and β are parameters to be estimated.[4] For this study, our main

[3] From experience (and by PEN survey design), for most inputs, households remember easier amounts used to purchase the inputs than the quantities used.

[4] Estimation of the shadow wage requires household labor supply data as one of the key variables. In the PEN survey, data necessary to allocate labor to specific uses were not collected. Admittedly, such data are very challenging to collect among rural households. When faced with a similar data challenge, Fisher *et al.* (2005) made several simplifying assumptions in order to estimate household annual labor supply. We follow their example here. We assume a total of 312 working days per year, and that an adult household member (15-64 years) works for six hours a day. Children (10-14 years) and adults over 65 are assigned three hours per day. Children (0-9) are assumed not to work.

focus is on β_L, which is later used to estimate the shadow wages. We estimate equation (7) by transforming it into a linear-in-logarithm form:

$$\ln(Y_i) = \ln(\alpha) + \beta_L \ln(L) + \beta_{Nk} \ln(N) + \varepsilon_i \qquad (8)$$

Other input costs in model are land, and all the other inputs, which we aggregated into one variable based on their values. Combining other inputs was required because most of them were used by few households thereby compromising their usefulness as single variables.

Due to endogeneity of these inputs, equation (8) cannot be directly estimated using OLS (Jacoby, 1993; Skoufias, 1994; Sills et al., 2003; Fisher et al., 2005; Ainembabazi, 2012). We therefore employed an instrumental variable (IV) estimation technique. The inputs were instrumented by *characteristics of the household head* (age, sex and education); *household characteristics* (number of household members (male, female and dependents), household members - except head - with lower primary education, upper primary education and post-primary education); and *village characteristics* (average input prices, average daily wage and average distance to markets). As noted earlier, owing to considerable differences between the two sites, we estimated the functions separately for Chimaliro and Liwonde. In each case, as a standard rule, all the instruments that were strongly correlated with the dependent variable, Y_i, were excluded. The presence of more instruments than the instrumented independent variables can give rise to over-identification concerns. However, the Sargan's identification test (Sargan, 1958) showed that in our case the equation is not over-identified.

The point estimates for labor from equation (8) were subsequently used to calculate shadow wages using the following expression (Jacoby, 1993):

$$w_{ij}^{s} = \frac{\beta_{Lj}\hat{Y}_i}{L_i} \tag{9}$$

where w^s is the shadow wage rate, $\hat{Y}_i$ is the predicted household output value, and L_i denotes total household labor hours. Below we compare the estimated shadow wages with market wages and assess how they relate to forest reliance and levels of income. The PEN surveys included a question on wage levels from outside employment. For comparison purposes, we complement this information with other reports at national level (e.g., Chirwa et al., 2004; Beegle et al., 2012).

4 Descriptive Statistics

Table 1 presents a summary of key variables for this paper. Household in Chimaliro have larger labor endowments, on average, than those in Liwonde. The average household size for Chimaliro is 6 while that of Liwonde is 5.2 (Chilongo and Angelsen, 2014b). Besides, although the southern region of Malawi where Liwonde is located is generally more populated than the central and northern regions where Chimaliro is, the 2008 national census show that population is growing faster in Northern Region (3.3%) and Central Region (3.1%) than the Southern Region (2.4%) (National Statistical Office (NSO), 2008). This agrees with the bigger household sizes in Chimaliro than Liwonde.

Table 1: Summary Statistics of Key Household Variables

Variable (Per household)	Chimaliro *(n = 203)*	Liwonde *(n = 163)*
Total production value (MK)	58691	26826
Agricultural output value (MK)	51038	17936
Forest output value (MK)	3600	3591
Wage income (MK)	2729	2844
Business income (MK)	1323	2454
Forest income share (%)	9.5	15.7
Labor hours	9535	7882
Land area (ha)	3.3	1.0
Inorganic fertilizer cost (MK)	5899	1688
Seed cost (MK)	1047	183
Livestock input cost (MK)	809	320
Other input costs (MK)	1412	252
Average off-farm working days/month	13.1	13.2

Overall, both outputs and inputs in Chimaliro are greater than those in Liwonde. This is intuitive given that Chimaliro is in an area with more agricultural potential than Liwonde. The output level differences are reflected in forest income shares: although absolute forest incomes are about MK3600 in both sites, in Liwonde this accounts for about 16% of the total income as opposed to about 10% in Chimaliro. Chimaliro has on average more than three times land size than Liwonde. These land sizes reflect the regional characteristics of the respective sites. Chimaliro is found in the relatively land-abundant Central Region while Liwonde is found in the land-scarce Southern Region of Malawi (Chilongo and Angelsen, 2014b).

We conducted several diagnostic checks on the validity of the estimation methods and variables. Since the analysis is OLS-based, the most basic check is to make sure that there are no zeroes in the dependent variable. This condition is satisfied as every household had at least an output. Next, we carry dependent-independent variable pair wise checks. Appendix Figures A1 and A2 present Kernel Densities of dependent and independent variables for Chimaliro and Liwonde respectively while Figures A3 and A4 present the dependent-independent variable bivariate plots. Both the Kernel Densities and the bivariate plots confirm that the dependent variables (household output value) have no zero values and that they are roughly normally distributed. However, except for *Land* and *Labor*, the rest of the inputs are not individually used by all households. That is demonstrated by the bimodal Kernel Densities (Figures A1 and A2) with one peak concentrated around zero inputs. The bivariate plots (Figures A3 and A4) also capture these 'zero' inputs by have some stacks of observations around zero. Such large concentration of zeroes may affect the significance of the variables and hence compromise their validity. To minimize these zero observations, we lumped the rest of the input values (fertilizer, seed, livestock and other minor inputs, e.g., manure) into one variable "Other input costs". As it is observed from the last graphs of Figures A3 and A4, this reduces the number of observations with zero values.

From the bivariate plots, pair-wise relationships between output and the inputs cannot easily be picked. We therefore, use correlation coefficients in Table 2 to explore the relationships. The results show that households' total output is positively correlated with the inputs. This relationship is very strong for all the inputs in Chimaliro while in Liwonde it is only labor that is significantly correlated with the output. We then proceed to the next section where we assess if these relationships are robust when the inputs are simultaneously controlled for, and in the process estimating the shadow wages.

Table 2: Correlations of Dependent and Independent Variables

Independent variable	Correlation coefficient with output value (dependent variable)	
	Chimaliro	Liwonde
Land (log ha)	0.32***	0.12
Labor (log hours)	0.17**	0.22***
Other inputs value (log MK)	0.32***	0.06

***significant at 1%, **significant at 5%

5 Results and Discussion: Shadow Wages Estimates

The 'hybrid' output function is presented in Table 3. Equation (8) entails transforming all the variables into logarithms. However the presence of zeros in some inputs means such observations might be lost. We therefore, added one to all such variables before transforming them into logs. We present both the OLS and IV estimates. The insignificant F-statistic for the Wu-Hausman endogeneity test means the null hypothesis that the input variables are exogenous cannot be rejected. Thus, the OLS estimates could as well be used. However, theoretically it makes sense to use the IV estimates.

Concentrating on the IV model in Table 3, all the labor point estimates are significantly different from zero. In Chimaliro, the highest input elasticity is for land followed by labor: a 10% increase in land increase output by about 2% while the same 10% increase in labor increases output by 1.7%. It is not surprising that land is the most productive resource in Chimaliro given its high agricultural reliance. While land is highly significant in Chimaliro, in Liwonde land is not significant. This does not mean land is not an important resource but this result reflects the relative low reliance on agriculture in Liwonde compared with Chimaliro. In Liwonde, the most important resource according to the point estimates is labor: the labor point estimate is not only the highest but also very significant. For both sites, the constants were highly significant suggesting that output is affected by other factors. The quality of land and managerial and agronomic skills are examples of factors that have an impact on household output, but are not included in this study.

Table 3: Household Composite Output Function (log of Output Value in MK)

	Chimaliro		Liwonde	
	OLS	IV[b]	OLS	IV
Constant	8.403***	7.715***	7.483***	5.704***
	(11.90)[a]	(7.87)	(10.79)	(4.55)
Labor (log hours)	0.133*	0.174*	0.252***	0.488***
	(1.82)	(1.75)	(3.20)	(3.28)
Land (log ha)	0.228***	0.202***	0.126	0.102
	(3.93)	(3.02)	(1.20)	(1.01)
Other input costs (log MK)	0.105***	0.149**	0.016	-0.002***
	(3.59)	(2.23)	(0.83)	(-0.05)
n	203	203	163	163
F	12.25***	11.28***	4.30***	4.29***
R^2	0.18		0.06	
Wu-Hausman endogeneity F test		0.47		2.01
Over-identification test (Chi-sq)[5]		7.99		11.19

***significant at 1%, **significant at 5%, *significant at 10%

[a] t-statistics in parentheses

[b] In the IV, the labor variables and input costs are instrumented for by number of household members by category (male, female, dependents); age and education of household head; household members (except head) with: lower primary education (1 – 4 years), upper primary education (5 – 8 years) and post-primary education (over 9 years); and average village prices for inorganic fertilizer.

Table 4 provides comparisons of observed output values and those estimated from the regressions in Table 3. The OLS and IV estimates are close to each other but they both underestimate the observed outputs. The underestimation could be due to the use of household total labor endowment as opposed to actual labor usage. The former overestimates labor as an input hence underestimating productivity. Notwithstanding this challenge, the estimated output

[5] The Sargan test of over-identifying restrictions: the joint null hypothesis is that the instruments are valid, i.e. not correlated with the error term. The acceptance of the null hypothesis, i.e. the insignificant Chi-square statistic (like in this case), implies the instruments are valid (Sargan, 1958).

pattern closely follows the observed outputs for the two sites. For example, the relatively low output in Liwonde compared with Chimaliro is also reflected in the estimates.

Table 4: Estimated and Observed Output Values per Household

	Chimaliro			Liwonde		
Output (MK)	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Estimated						
OLS	42672	10270	99967	17769	2095	31401
IV	43525	6990	114607	18129	469	33258
Actual	58691	1590	444260	26826	640	135580

We now turn to the estimated shadow wages in Table 5, which are compared to household reported wages for outside employment. We complement these with the wages reported in the literature. At the time of the study (2006 – 2007), there were several public works programs being implemented in Malawi. These could roughly be categorized into two: those run by government and those run by non-governmental organizations (NGOs) (Chirwa et al., 2004). The latter were area-specific while the former covered the whole country. It is therefore the case that the government public works programs likely had the greatest influence on market wages in rural areas. The government public works program wage of MK200 per day (Beegle et al., 2012) is close to those reported by households in our sample (about MK190 per day).

Table 5: Comparison of Estimated Shadow Wages and Household Reported Wages (MK/hour)

	Chimaliro		Liwonde	
Wage	Hourly Rate (MK)	Daily Rate (MK)	Hourly Rate (MK)	Daily Rate (MK)
Shadow wage (OLS)	0.72	4.32	0.67	4.02
Shadow wage (IV)	0.95	5.70	1.09	6.54
Household reported	31.50	189.00	31.26	187.53
Public works (literature)[6]	33.33	200.00	33.66	200.33

[6] See Beegle et al. (2012) and Chirwa et al. (2004) for details on the public works' wages.

As noted in Table 5, the estimated shadow wages are much smaller than the household-reported or public works program wages. The Appendix Figure A5 shows that for both sites the shadow wages are concentrated around MK1 (about USD PPP 0.02) per hour with a few outlier households having shadow wages beyond MK2/hour. The large difference between shadow wages and market wages could be attributed to the transaction costs discussed in the theoretical framework. All things being equal, according Proposition 1, at these low shadow prices, this should trigger movement of people from own-household production to outside employment and hence reduce forest exploitation. However, in reality off-farm employment is very scarce such that demand far exceeds supply. For example, Beegle et al. (2012) report that the public works programs have always been oversubscribed to the extent that screening the beneficiaries has been one of their main challenges. Besides, the effect of implicit and explicit transaction costs as discussed in the theoretical framework means the nominally high wages are not easily obtained by all households. Therefore, despite the much higher wages associated with off-farm employment, scarcity of jobs and potential transaction costs leave most households with no option other than to fall back on their employer of last resort, natural resource endowment-based production activities.

Table 6 provides some details of outside employment. The households reported working an average of 13 days per month. However, the availability of outside employment is not evenly spread throughout the year. Most opportunities, such as those associated with public works programs, are seasonal. At both sites, provision of casual labor, locally commonly known as *ganyu*, is the most common source of outside employment as reported by over three-quarters of the households. The *ganyu* is carried out mainly on fellow smallholder farms, bigger plantations in the neighborhood, or any other available small piece works such as house construction. Public works programs are the second most common form of outside employment. Surprisingly, the reported wage rate for public works program in Chimaliro is lower than the *ganyu* rate. This could reflect the different nature of *ganyu* work. While most *ganyu* occurs on an *ad hoc* basis, public works programs have some degree of predictability and stability.[7] Therefore, expectedly, total income earned from *ganyu* is less than that from public works program.

Table 6: Outside Employment Participation, Days and Wages

	Participation (%)	Working Days per Month	Wage Rate (MK/Day)	Total Wage Income Earned (MK)[8]
Chimaliro (n = 203):				
Casual labor provision (*ganyu*)	82	9	194	1131
Public works program (household-reported)	34	18	157	2525
Others	20	22	220	4884
Total		13	189	2022
Liwonde (n = 163):				
Casual labor provision (*ganyu*)	79	9	173	1318
Public works program (household-reported)	20	14	237	3081
Others	28	23	190	4218
Total		13	187	2230

Next we turn our attention to the relationship between forest reliance and estimated shadow wages (Table 7). We find no significant relationship between shadow wages and forest income shares. There is a significant positive relationship between shadow wages and level of absolute forest for both sites implying that it is the more productive households that have more absolute forest income. However, while total income is positively correlated with shadow wages in

7 According to Beegle et al. (2012), the Government of Malawi explicitly links the public works program to the fertilizer input subsidy program (FISP) in that the timing (October to December/January) is designed to coincide with the FISP implementation period to provide households with a source of cash to purchase fertilizer and other inputs.

8 Note that this is the average of average household wage incomes and not necessarily wage rate multiply by number of days worked as shown in the table.

Chimaliro, in Liwonde the relationship is negative. This means while the high productivity is associated with more income in Chimaliro, in Liwonde the most productive households are not the richest. The possible explanation for the negative shadow wage-total income correlation could come from the fact that households in Liwonde are relatively less dependent on agriculture compared with those in Chimaliro. Among rural households, labor is a critical input, whose productivity is here being measured by the shadow wages. While labor may also be critical for other livelihood activities, such as small-scale businesses, there could be other inputs that are more critical than labor. This shadow wage-total income relationship is even clearer in Table 8.

Table 7: Correlation of Shadow wages, Forest Income and Total Income

	Correlation Coefficient of Shadow Wage With:	
	Chimaliro	Liwonde
Forest share (%)	0.05	-0.05
	(0.47)	(0.56)
Absolute forest income (MK)	0.24***	0.14*
	(0.00)	(0.07)
Total Income (MK)	0.23***	-0.22***
	(0.00)	(0.00)

Figures in parentheses are p-values ***Significant at 1% *Significant at 10%

In Table 8, we compare the shadow wages, forest reliance and income levels. For the first four quintiles, the shadow wage-income level relationship does not follow a specific pattern. Reflecting the pattern observed in Table 7, while the highest quintile has the highest shadow wage in Chimaliro; in Liwonde the highest quintile has the lowest shadow wage. Overall, results in Table 8 agree with the correlation coefficients in Table 7 that the relationship between shadow wage and income is not clear.

Table 8: Shadow Wage and Forest Reliance by Income quintile

Quintile	Chimaliro		Liwonde	
	Forest Income Share (%)	Shadow Wage (MK/hour)	Forest Income Share (%)	Shadow Wage (MK/hour)[a]
1	16.41	0.97	30.33	1.14
2	11.03	0.86	14.19	1.21
3	11.00	0.83	11.73	1.10
4	5.80	0.99	12.89	1.01
5	3.14	1.12	10.32	0.97

6 Conclusions and Implications

Although the results suggest no systematic relationship between shadow wages and forest reliance, we find some evidence that forest reliance together with natural resource-based production activities are a potential employer of last resort to rural households in absence of other viable alternatives. Despite the outside employment wages being higher than households' shadow wages, the scarcity of such employment opportunities means households continue to depend on own production activities with possible negative consequences on the natural resource endowment.

The policy implication from this finding is that the environmental conservation initiatives should go hand in hand with attempts to provide alternative livelihood activities apart from the current natural resource based production activities. An example would be the already existent public works programs. Our study however, did not go into details of these programs, and their impact on natural resource exploitation is a topic for future studies.

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APPENDICES

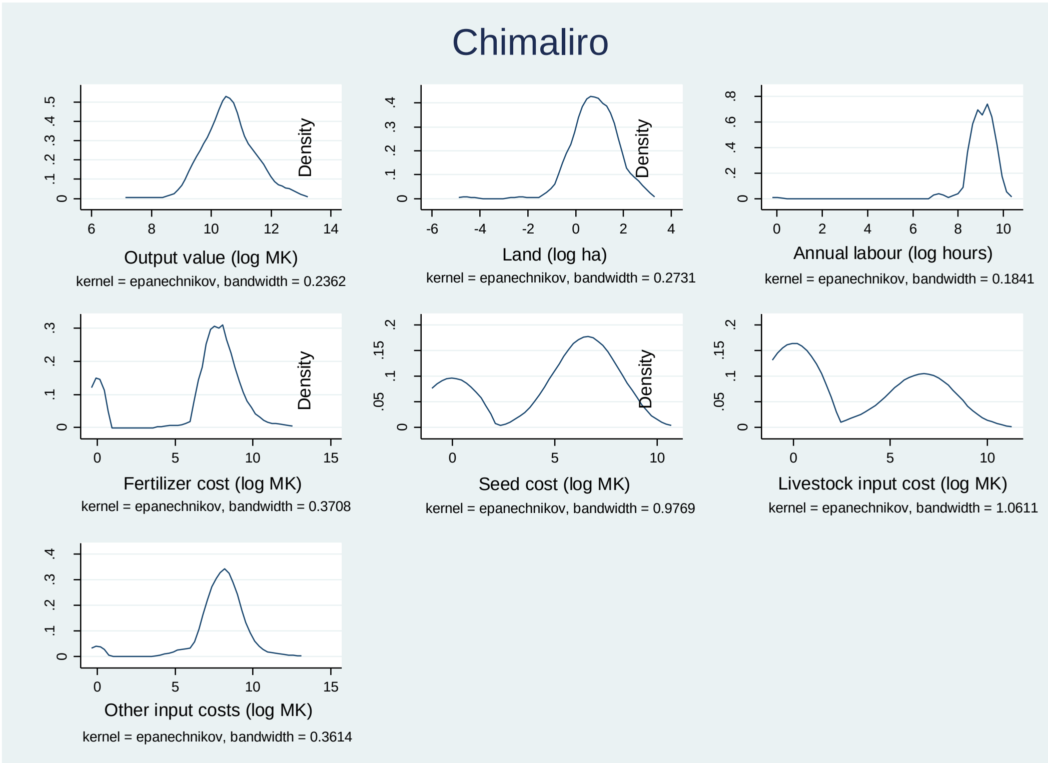

Figure A1: Kernel Densities for Independent and Dependent Variables for Chimaliro

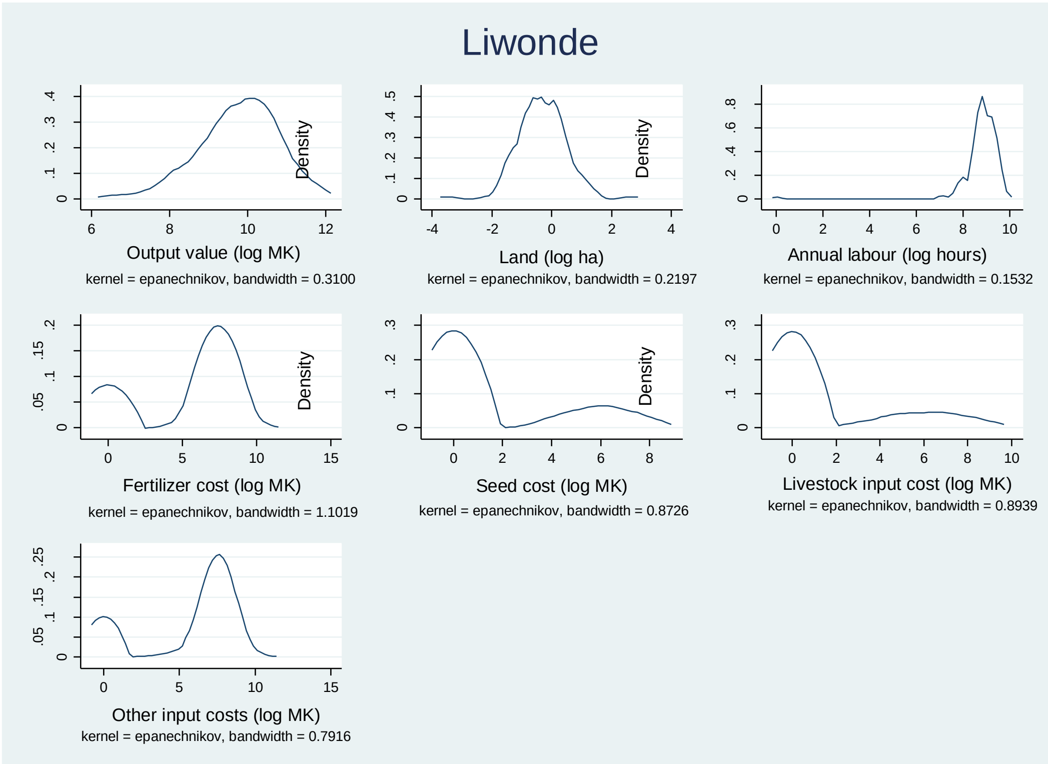

Figure A2: Kernel Densities for Independent and Dependent Variables for Liwonde

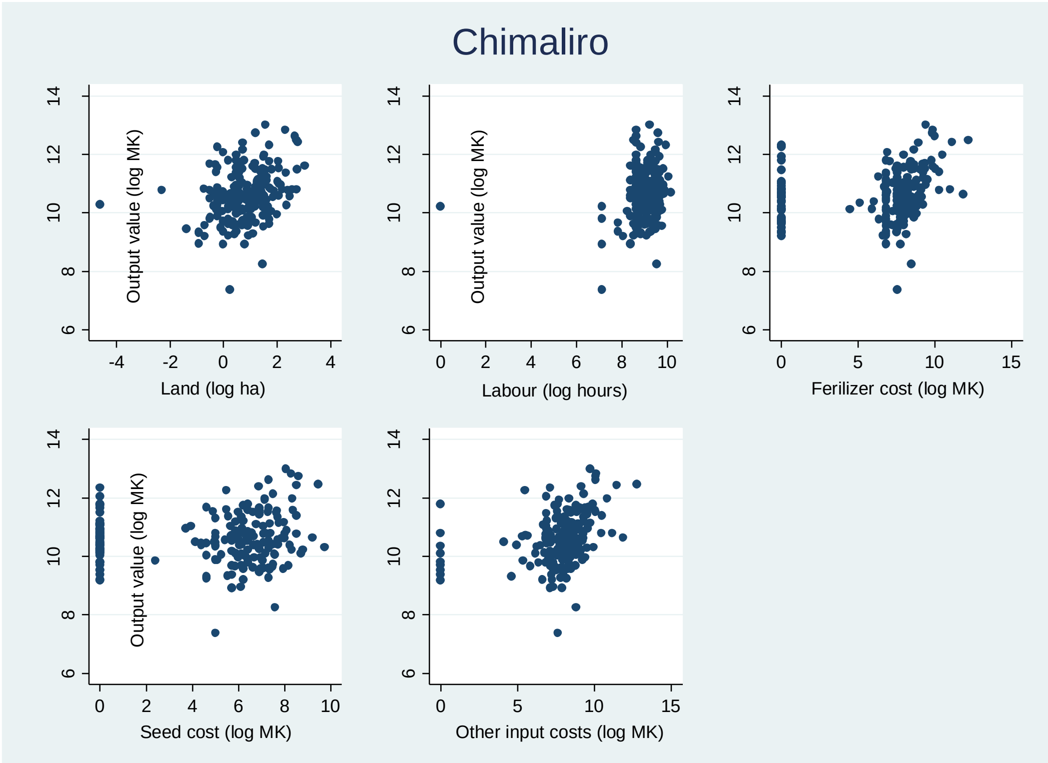

Figure A3: Bivariate Plots for Independent and Dependent variables for Chimaliro

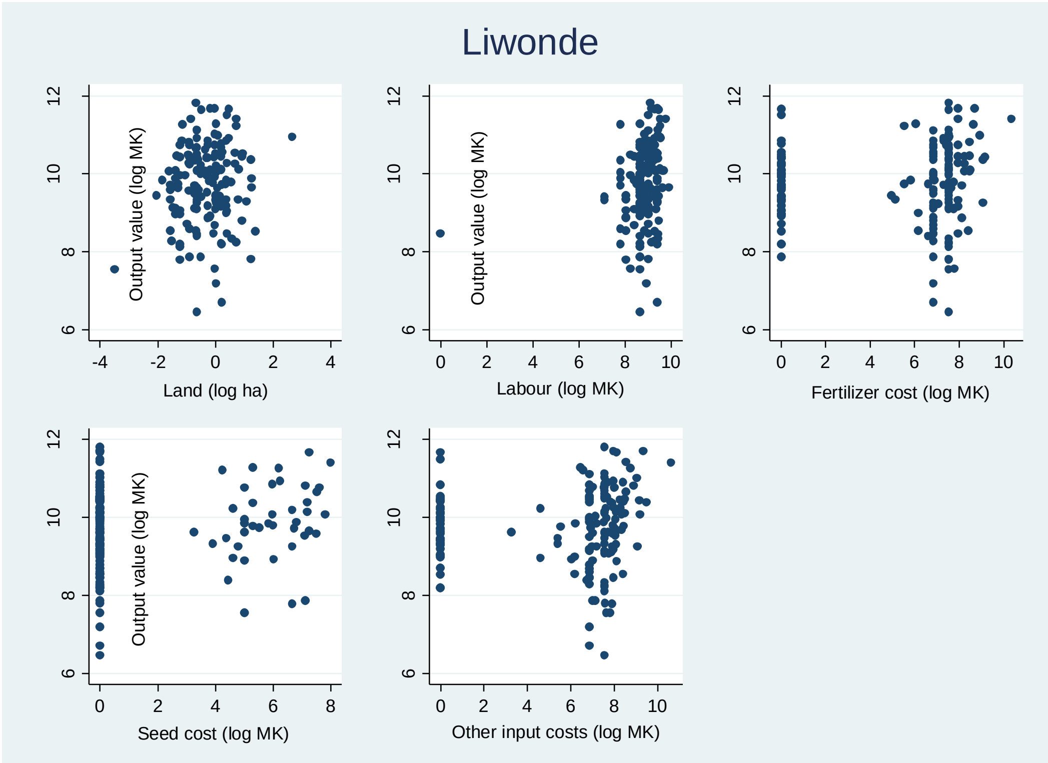

Figure A4: Bivariate Plots for Independent and Dependent variables for Liwonde

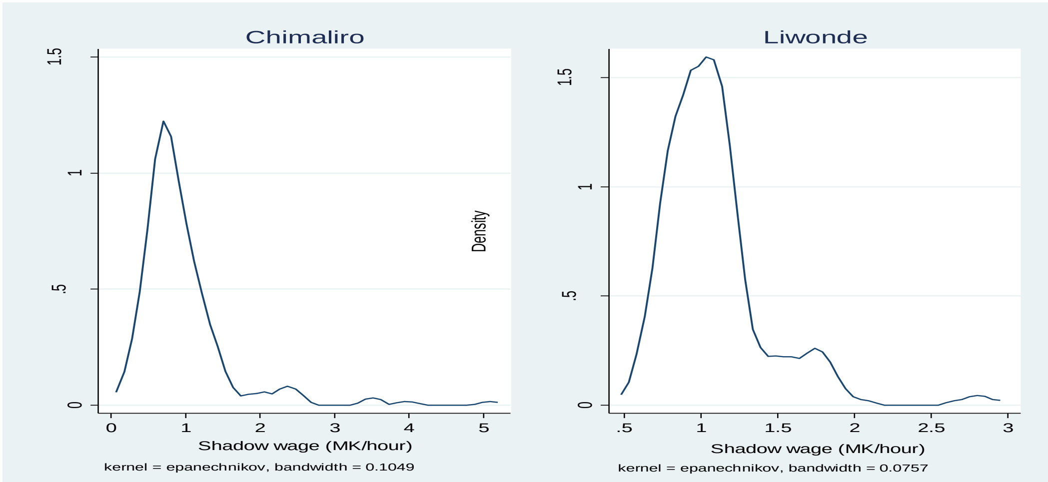

Figure A5: Kernel Density Distributions for Shadow Wages

Paper III

Forest Income and Seasonal Gap-filling in Malawi

Thabbie Chilongo* and Arild Angelsen*

Abstract

We investigate the role forest products in filling the seasonal income gaps using quarterly income survey data from households surrounding Chimaliro and Liwonde forest reserves in Malawi. We test whether forest income varies negatively with other major sources of income during the year. We introduce a modified seasonal gap-filling measure that separates seasonal and inter-household income variation. The commonly used measure of sectoral income covariance across both seasons and households can mask the role of forests or other forms of income as seasonal gap fillers, and we demonstrate how the two measures can yield different results. Forest products play a seasonal gap-filling role for the low-income households and those households where forest is one of the main livelihood activities. This gap-filling role is more pronounced in Liwonde, which has better market opportunities and higher forest reliance than the relatively remote site of Chimaliro. (JEL O13, Q23)

Key words: forest income, forest reliance, seasonality, consumption smoothing

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1 Introduction

Rural households in most developing economies rely heavily on rain-fed agriculture, with overall income and consumption strongly affected by the agricultural seasons. Periods after harvests are characterized by abundant food and relatively high incomes from agricultural produce sales. This is followed by lean periods soon after the onset of rains up to the next harvest. Under perfect market situations, credit and insurance – combined with household savings and asset sales – can smooth consumption throughout the year. However, in developing economies credit and insurance markets often do not exist and even when they do, the markets are highly imperfect (Morduch, 1995; Rose, 2001; Chaudhuri and Paxson, 2002).

Faced with strong seasonal variation in major income sources, households engage in a number of other strategies to smooth both income and consumption (Paxson, 1993; Morduch, 1995; Chaudhuri and Paxson, 2002). These strategies include diversification, off-farm employment and collection of products from the wild during off-peak and low-income periods of the year. This paper assesses the role of forest resources in filling such seasonal income gaps. We use data collected quarterly over a one-year period between August 2006 and July 2007 from households around Chimaliro and Liwonde forest reserves in central/northern and southern Malawi, respectively. Jumbe (2005) noted that despite forest reliance being seasonal, there are few studies that tackle seasonality explicitly. The few examples include Wunder et al. (Wunder et al., 2014) and Walelign and Nielsen (Walelign and Nielsen, 2013), but none specifically for Malawi. Our study is therefore adding to that small list.

We address two questions: First, does forest income play a 'seasonal gap-filling' (SGF) role in the sense that quarterly forest income varies negatively with crop and other major sources of household income? Second, (how) does the (potential) SGF role vary across groups of households? For example, is this role more important for households that are poor, pursue certain livelihood strategies or have other particular demographic characteristics?

The paper introduces a new measure to assess the SGF. Earlier works on SGF have measured simultaneously two distinct phenomena, namely seasonal and inter-households income variation. Our new SGF measure takes into account the large variation of incomes (sectoral and overall) across households by considering the household-specific seasonal income variation only, as opposed to looking at overall variation across seasons and households simultaneously. More specifically, we consider the covariance between income sources at the household level rather than at the sample level. The empirical results show that using the 'overall income variation' approach indeed masks the role of forest as a SGF.

The rest of the paper is organized as follows. Section 2 reviews earlier studies and builds a conceptual framework from which we draw the study hypotheses. Section presents the data and methods used. The results are presented and discussed in Section 4. Section 5 concludes and provides some policy and research implications of the findings.

2 Frameworks and Hypotheses

This study falls within the broader literature on income and consumption smoothing. Smoothing of income and of consumption are often discussed jointly, but are different albeit related phenomena. Ultimately, a household is concerned with an even level of consumption over a year, in particular for food. The consumption pattern over a year can be separated from the income pattern though loans and savings. Given limited possibilities to engage in formal or informal credit markets and low opportunities for saving due to incomes close to subsistence levels and high discount rates, consumption smoothing for many households *in practice* means income smoothing. Combined with the lack of consumption data, this study therefore focuses on income smoothing.

Given the poor functioning or absence of markets, especially the financial (insurance and credit) and labour markets, income smoothing becomes a major element of the livelihoods strategy of rural households in developing economies (Morduch, 1995). Average incomes are not only low but also volatile emanating from seasonality fluctuations due to high dependence on agriculture (Paxson, 1993; Morduch, 1995; Kochar, 1999; Rose, 1999; Rose, 2001; Chaudhuri and Paxson, 2002). For poor households, this seasonality of income and consumption means that there are potential "hunger months" within the year.

When markets are well-functioning (specifically financial and labour markets), households turn to credit, savings, insurance or hire-out their labour to smooth income and eventually consumption (Morduch, 1995; Byron and Arnold, 1999; Rose, 2001; Chaudhuri and Paxson, 2002). The general consensus is, however, that financial and labour markets in developing countries are either missing or function imperfectly (Morduch, 1995; Rose, 2001).

Studies observe behavioural and institutional responses to fill gaps left by market failure. Such responses include depleting assets, relocating labour to off-farm income-generating activities and diversifying economic activities (Chaudhuri and Paxson, 2002). Forest resource extraction forms both part of an off-farm income activity and as a diversification strategy. Forest foods are widely used to fill dietary shortfalls during lean seasons of the year or serve as substitutes during emergencies (Byron and Arnold, 1999; Angelsen and Wunder, 2003). Byron and Arnold (1999: 792) noted that "the importance of forest income is usually more in the way it fills gaps and compliments other income, than in its absolute magnitude and share of overall household income." Forest therefore contribute to rural households well-being by providing a form of natural insurance against annual income volatility (Pattanayak and Sills, 2001).

The literature provides mixed evidence on the role of forest products to mitigate effects of other external shocks. Several studies found a positive correlation between forest product use and negative shocks (e.g. Pattanayak and Sills, 2001; Fisher, 2004; Cavendish and Campbell, 2008; Khundi et al., 2010; Völker and Waibel, 2010; Debela et al., 2012). However, others found no convincing evidence that forest products are used to mitigate against or to cope with shocks (e.g., Wunder et al., 2014). Overall, however, there appear to be more studies reporting high forest use when faced with shocks, especially for the poorest households (Pattanayak and Sills, 2001).

The role of forest as a coping mechanism depends on the type of shock. (Wunder et al., 2014) postulate that all things being equal, higher forest use should be associated with covariate rather than idiosyncratic shocks. Covariate shocks may render some safety-net mechanisms that depend on communities (e.g., selling labour, borrowing money) less viable as a large share or the whole community is affected by the same shock. Because forest extraction is labour intensive, idiosyncratic shocks that reduce adult labour availability should reduce the probability of higher forest use as a coping mechanism (Völker and Waibel, 2010; Wunder et al., 2014). The response to covariate shocks also depends on whether such shocks have also affected the availability forest products or not, e.g., drought or forest fire. Thus the type of covariate or idiosyncratic shock will also matter for the degree to which forest use can act as a safety net/coping mechanism.

The use of forest as a gap filler (or in general as a safety net/coping mechanisms) also depends on demographic characteristics. There is some consensus that poor households receive a bigger share of their income from forests compared with the better-off households (see for example, Byron and Arnold, 1999; Pattanayak and Sills, 2001; Angelsen and Wunder, 2003; Cavendish and Campbell, 2008; Babulo et al., 2009; Tesfaye et al., 2011; Debela et al., 2012). Several characteristics of the forest products, such as low capital and skill requirements and open or semi-open access, make many forest products attractive to the poor (Angelsen and Wunder, 2003). The relatively high forest reliance by the poor people could be a symptom of their limited livelihood options and hence turn on forest resources as an 'employer of last resort' (Byron and Arnold, 1999; Coxhead et al., 2002; Angelsen and Wunder, 2003). Chilongo (2014) found that forest income form a major part of some livelihood strategies for poor households in Malawi. Other characteristics that increase the likelihood of high forest reliance include young male household heads (McSweeney, 2004; Fisher and Shively, 2005), as they are yet to accumulate sufficient assets to serve as a buffer (Perz, 2001); small landholdings; large household sizes, which provides the necessary labour requirements (McSweeney, 2004; Takasaki et al., 2004); low educational levels as this leads to lack of access to more remunerative employment opportunities (Fisher et al., 2010; Völker and Waibel, 2010); and closeness to forests as it facilitates easy access to forest resources (Pattanayak and Sills, 2001; Vedeld, 2004; Fisher and Shively, 2005; Fisher et al., 2010).

Based on the above review and previous studies, we put forward the following hypotheses:

1. Forest income acts as a seasonal gap filler (SGF): quarterly forest income increases when income from other major income sources decline over the seasons, i.e., there is a negative correlation between forest income and (other) major income sources.

2. The likelihood of forest being used as a seasonal gap filler (SGF) increases when the household has low total income, has forests as a major source of livelihood, and is asset-poor (e.g., low educational, land and physical assets).
3. Labour-related idiosyncratic shocks (such as illness and death of productive family member) are associated with less forest use and income and therefore reduces forest's seasonal gap-filling (SGF) role.
4. Income-related idiosyncratic shocks (such as crop failure, loss of productive assets and costly social ceremonies) are associated with more forest use and income and therefore increases forest's seasonal gap-filling (SGF) role.

3 Data and Methods

3.1 Study Area

The sample of households in this study is drawn from the villages surrounding the Chimaliro and Liwonde forest reserves in the central/northern and southern regions of Malawi, respectively. Both forests were pilot sites for a forest co-management (FCM) programme. Unlike the previous policy regime on total government forest control, under FCM the communities surrounding the forests co-manage the forests jointly with the government.

The sites are over 400 km apart and have distinct geographical, social and agro-ecological differences. Chimaliro lies in one of the most productive agricultural zones of Malawi. Tobacco, which is Malawi's major export earner, is the main cash crop of the area. Liwonde has lower agricultural potential. Like most of southern Malawi, Liwonde is characterised by high population densities resulting in small landholding sizes, averaging less than one hectare per household (Quinion, 2008; Chilongo, 2014).

Chimaliro forms part of the Kasungu-Lilongwe Plains and is relatively flat, compared with Liwonde. Chimaliro's altitude varies from 1000 to 1600 metres above sea level (masl) (Quinion, 2008) with temperatures ranging from 12 to 24 degrees Celsius (Jumbe, 2005). Like the rest of Malawi, there is only one rainfall season between November and March (Quinion, 2008). Chimaliro is relatively wet (annual rainfall between 800 to 1600 mm, (Jumbe, 2005)) compared with the rest of the Kasungu district (700 to 1000 mm, (Quinion, 2008)). Liwonde's altitude ranges from 800 to 2080 masl and is on average warmer than Chimaliro with temperatures ranging from 20 to 25 degrees Celsius (Jumbe, 2005). Liwonde is drier than Chimaliro and receives annual rainfall of 500 to 800 mm from October/November to April.

Farming is the main livelihood activity of both sites, and is almost exclusively rain-fed. The rainy season is the lean period, up until harvesting of crops begins (around May in Chimaliro and March/April in Liwonde). The rainy season is also the time when mushrooms, one of the most marketable forest products, are abundant (see Table 1). The lean period therefore presents an opportunity of forest products to fill seasonal income gaps. For both sites, firewood, mushrooms and thatching grass are the three most commonly collected forest products (Chilongo, 2014).

3.2 Data

Data for this study come from household surveys conducted under the Poverty and Environment Network (PEN) program of the Centre for International Forestry Research (CIFOR) (www.cifor.org/pen). For this paper, we use data from 283 households (163 in Chimaliro and 121 in Liwonde). Four quarterly surveys were conducted between August 2006 and July 2007, generating a four-period balanced panel data set. These surveys collected data on all sources of household income, including forest income. The quarterly income surveys were complemented by two annual household and two annual village surveys. The household surveys collected basic information on, *inter alia,* household composition and assets, while the village surveys collected data on, *inter alia*, institutions and infrastructure.

Table 1 gives the months covered by the quarterly surveys and key seasonal features of each survey period. While each survey was supposed to cover a three-month recall period, due to logistical problems there was an overlap of some months (but in different years) between first and fourth quarters.

Table 1: Quarterly Survey Distribution and Key Seasonal Features

	Quarterly Survey 1	Quarterly Survey 2	Quarterly Survey 3	Quarterly Survey 4
Year	2006		2007	
Months covered	Jun. to Aug.	Sept. to Dec.	Jan. to April	May. to Jul.
Key features	-Post-harvest period -Abundant period especially for Chimaliro. -Onset of lean period in Liwonde (around August)	-Onset of rains/planting season -Lean period for both sites -Mushroom season from forests	-End of rains -Lean season for both sites but ending in Liwonde with early harvests from March. -Mushroom season from forests	-Harvesting period (more for Chimaliro and some late harvests in Liwonde). -Relatively abundant season for both sites

Valuing subsistence income, such as firewood, is a major issue in rural household surveys (Wunder et al., 2011). Although primarily used for subsistence, most forest products were also traded within the villages and local market prices were used. In other cases, subsistence products were exchanged between households in barter trade, and households did not face major problems in putting the equivalent cash price on them. For the remaining and small minority of products, we used prices reported by the household based on self-valuation of the product.

For more details on the study sites and data, we refer to Chilongo and Angelsen (2014) and Chilongo (2014).

3.3 Measuring Seasonal Gap-filling (SGF)

A key new element of this paper is the measure of income seasonality and the (potential) seasonal gap-filling (SGF) role of a particular income source. Most studies analysing SGF treat the sampled households as one group, i.e., they correlate forest income with other major income sources (in particular crops) across seasons and households (e.g., Walelign and Nielsen, 2013; Wunder et al., 2014). A negative correlation between forest and other income sources indicates that forest income acts as a gap filler: forest income is relatively high in periods when other income sources are relatively low, and vice versa. We label this covariance the *Overall Correlation*, given by:

$$Corr_{ov}^{fs} = \frac{\frac{1}{Q(N-1)}\left(\sum_{i=1}^{N}(Y_{iq}^{f}-\overline{Y}^{f})(Y_{iq}^{s}-\overline{Y}^{s})\right)}{S^{f}S^{s}} \qquad (1)$$

$Corr_{ov}^{fs}$ is the covariance between forest (*f*) and any another income source (*s*); Y_{iq}^{f} and Y_{iq}^{s} are sector (forest and other) incomes for household *i* in quarter *q*; $\overline{Y}^{f}$ and $\overline{Y}^{s}$ are the overall means for sector incomes across quarters and households; S^{f} and S^{s} are overall standard deviations for sector income; *N* is the total number of households, and *Q* the total number of quarters (4 in our case).

We argue that the *Overall Correlation* may lead to a mix up of two phenomena: a seasonality pattern and inter-household pattern. High-income households tend to also have high absolute forest income (Angelsen et al. 2014), and this correlation can mask a negative seasonal correlation at the household level. This pattern is also found in our data (Appendix Table A1): total income is strongly and positively correlated with absolute forest income and all other major income sources, meaning the absolute incomes from forest and other major sources increase with increase in total household income. Obviously, large income sources such as crop are, by construction, closely correlated with total income.

As an alternative to the *Overall Correlation* measure we introduce the *Within-Household Correlation*, where for a given income source we replace the overall mean ($\overline{Y}$) with the household-level mean ($\overline{Y}_i$).

$$Corr_{hh}^{fs} = \frac{\frac{1}{Q(N-1)}\left(\sum_{i=1}^{N}\sum_{q=1}^{4}(Y_{iq}^{f} - \overline{Y}_i^{f})(Y_{iq}^{s} - \overline{Y}_i^{s})\right)}{S_i^f S_i^s} \qquad (2)$$

The two critical changes compared with Equation (1) are that we use household-specific means ($\overline{Y}_i$) and standard deviations (S_i). The intuition behind the modified measure is straightforward: first, we calculate the seasonal covariance between forest income and other income at the household level; second, we take the sample average of these household-specific covariances. In other words, while *Overall Correlation* interacts the products of income deviations from the overall means, *Within-Household Correlation* uses deviations from the household means. While we find the *Within-Household Correlation* measure to be the more appealing on theoretical grounds, we use both measures in the results section to explore the implications of using different measures.[1]

The covariance between sector incomes across quarters is a useful indicator of potential seasonal gap-filling, but there is also an important asymmetry. From a gap-filling perspective, we are interested in whether a particular income source (in our case: forest) is high in lean periods (when other and dominating income sources are low) and not concerned about the particular income being low in peak periods.[2] We therefore construct a forest *gap-filling indicator (G)* at the household level. Conditional on forest income in a given quarter being above the annual mean ($Y_{iq}^{f} > \overline{Y}_{i}^{f}$), the indicator variable *G = 1* if the interaction between forest and another income source is negative, $(Y_{iq}^{f} - \overline{Y}_{i}^{f})(Y_{iq}^{s} - \overline{Y}_{i}^{s}) < 0$.[3] Otherwise *G = 0*.

We then use a random effects panel probit model to assess factors that increase or decrease the probability of forest income being a gap filler specified as follows:[4]

$$G_{iq}^{*} = X_{iq}'\beta + \varepsilon_{iq} \tag{3}$$

with

$$G_{iq} = 1 \; if \; G_{iq}^{*} > 0$$

---

[1] One possible weakness of the "within household correlation" measure is that we have to calculate covariance for each household based on just four observations (quarters). We are, however, not using these individual household covariances, but the average for larger groups of households. This should even out possible erratic estimates at the household level which are due to a low number of observations for each household.
[2] As an income source cannot be above average in all quarters, there is a link between the two. Consider a case of just two periods. Relatively high forest income when crop income is relatively low would also imply the reverse. With four periods as here, this correlation is not perfect and this motivates our gap-filling indicator.
[3] The condition that forest income is above its mean is important because we are interested in situations when households increase their forest use 'above normal' when income from other sources drop. Otherwise, the interaction can also be negative when forest is below its mean but the other source income is above its mean.
[4] The random effect model is chosen because household and village characteristics were time-invariant.

$$G_{iq} = 0 \; if \; G_{iq}^{*} \leq 0$$

where G_{iq}^{*} and G_{iq} are latent and observed gap-filling indicators for household i in quarter q, X_{iq}' is a vector of household and village characteristics, and ε_{iq} is an error term.

4 Results and Discussion

4.1 Seasonal Income Patterns

The income shares vary considerably throughout the year, as shown in Figure 1. Forest was among the top two income sources in all quarters, except in the third quarter in Chimaliro. The figure also depicts a seasonal pattern, particularly in Chimaliro, where forest reliance is higher when the main income source (crop) is lower. Although quarters 2 and 3 (roughly September to April) are generally considered lean periods in Malawi, some site variations are observed. In the southern region of Malawi, maize harvesting starts as early as March while in the central/northern regions harvesting starts around May. This explains why crop income increases sharply in the third quarter in Liwonde but not Chimaliro. The end of quarter one (around August) is therefore the onset of the lean season in the southern region, while in the central region produce is still relatively abundant by that time. Quarters 2 and 3 therefore represent the lean season in Chimaliro while quarters 1 and 2 fall within the lean season in Liwonde.

For both sites, the results suggest that forest reliance was relatively high in the lean quarters, with quarter 2 in Chimaliro and quarter 1 in Liwonde having the highest shares. Apart from forest income, other income sources that increased when the main income source (crop income) decreased were wages and the 'other' sources (mainly remittances).

Arguably, the pattern revealed in Figure 1 that forest share increases when that of the main income source decreases, could be by construction: the income shares add up to 100% and hence a decrease in one would, *ceteris paribus*, automatically lead to an increase in the other. It is therefore also relevant to look at *absolute* income, and unless otherwise specified, for the remaining part of the paper we focus on absolute income rather than income shares.[5] From a gap-filling and safety net perspective one can also argue that the absolute levels are more important. Figure 1 is still important to understand the overall forest reliance patterns, and – as will be seen – helps to explain some observed patterns in absolute incomes.

[5] For detailed papers on forest share as a measure of forest reliance, we refer the reader to two other papers using the same data (Chilongo, 2014; Chilongo and Angelsen, 2014).

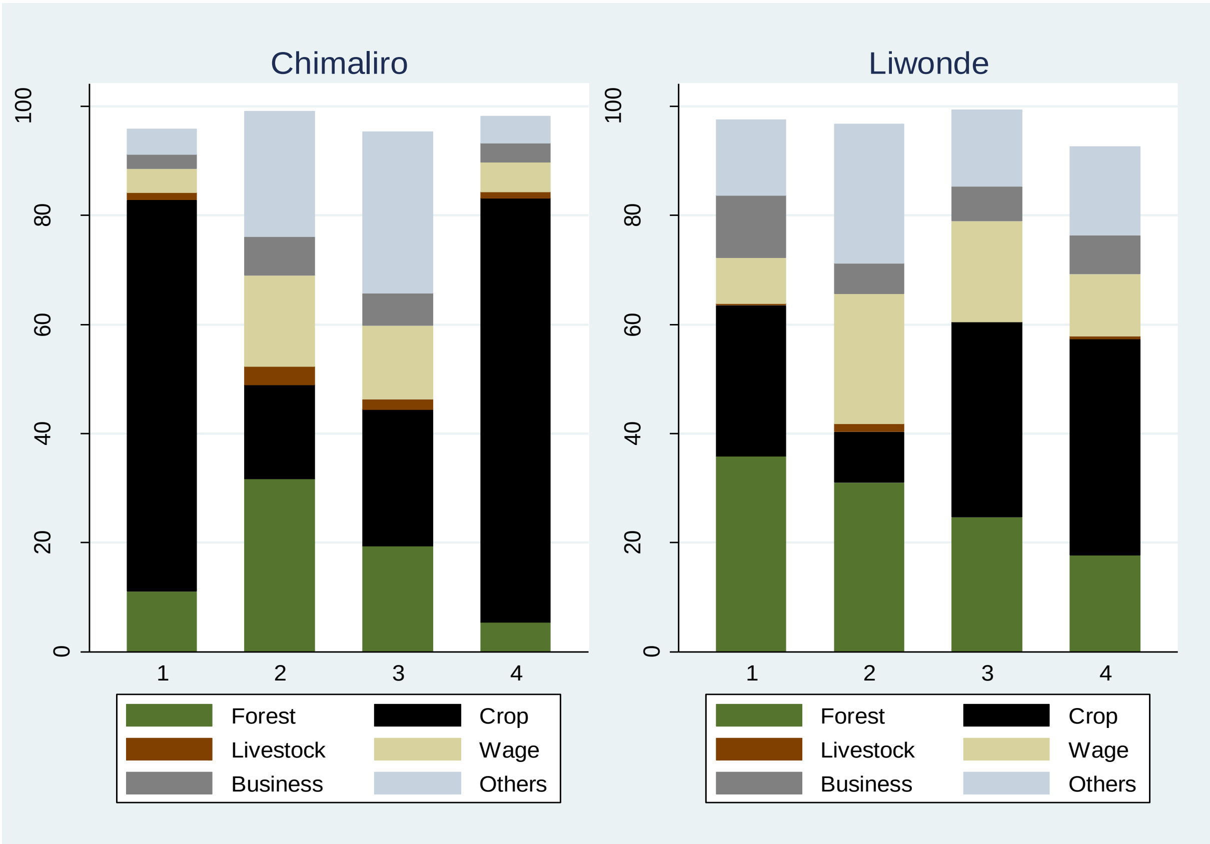

Figure 1: Seasonal income shares

Table 2 confirms that the lean periods (low total income) in Chimaliro are quarters 2 and 3 while in Liwonde they are quarters 1 and 2. Note that the quarterly pattern of absolute incomes cannot be compared directly with the pattern of income shares in Figure 1. For example, while forest income share was consistently in top two for all but one quarter that is always the case with the absolute incomes in Table 2. This is due to the way income shares are calculated: they are averages of household income shares as opposed to first summarizing absolute incomes across households and then calculate income shares. The "average of averages" method is recommended when the studies have a livelihoods and household focus (e.g., Davis et al., 2010; Angelsen et al., 2014). The measure is sensitive to the distribution of forest income across households. The fact that forest reliance tend to be higher among low-income households means that the forest contribution appears higher when looking at income shares (Figure 1) rather than absolute income (Table 2).

Table 2: Seasonal income distribution by site

Quarter	Income sources: Absolute (MK/aae)							
	Forest	Crop	Live-stock	Wage	Business	Others	Total	Diversity index
Chimaliro								
1	385	4777	736	225	88	776	6987	0.29
2	342	879	690	300	185	659	3056	0.44
3	148	1375	123	170	61	758	2635	0.39
4	106	5233	349	171	110	377	6348	0.23
CV (%)	151	258	675	253	416	280	205	
Liwonde								
1	156	827	6	85	335	309	1717	0.19
2	373	178	46	390	146	270	1403	0.44
3	237	2243	0	230	114	343	3168	0.29
4	517	1858	24	303	224	373	3299	0.30
CV (%)	430	261	905	247	383	260	173	

Table 2 also includes the Simpson Diversity Index (Simpson, 1949), which captures the diversity of income sources in the quarters.[6] The diversity index ranges from 0 to 1, with 0 indicating no diversification (all income from one source) while it approaches 1 when the number of sources becomes large with even shares. For both sites, the second quarter, which is one of the leanest periods, is the most diversified suggesting that income diversification is a coping mechanism.[7]

[6] The formula for Simpson Diversity Index is $1-\sum_{i=1}^{n}(S_i)^2$, where S_i is the share of income source *i* relative to total household income, and *n* is the number of households.

[7] But, also in this case a drop in the dominant (crop) income will, *cet. par.*, automatically increase the diversity index.

Morduch (1995) observes that faced with non-functioning or absent credit and insurance mechanisms, households in low-income countries use diversification as a consumption and income smoothing measure. The findings also agree and complement Chilongo (2014), who found that the livelihoods strategies of low income households were more diverse compared with those of high income households.

Incomes from both sites portray a high degree of seasonal variation as captured by the coefficient of variation (CV).[8] For all income sources and both sites, the CVs range from 151% to 905%. This income volatility is typical of rural households in most developing economies. Kochar (1999) reports crop income volatility of between 59% and 212% and suggests that households therefore opt for diversification as a means of smoothing consumption and income.

Narrowing down to forest income, Figure 2 gives an idea of the forest income that is potentially available for SGF. We categorise forest income into "food subsistence" (e.g., mushrooms, wild fruits and honey); "non-food subsistence" for all other non-edible forest products (e.g., firewood); and "cash". The potential of SGF is the sum of forest cash and food subsistence incomes, labelled in Figure 2 as "Potential SGF". In Chimaliro, the Potential SGF closely matches that of Non-food subsistence income, and even exceeds the latter in the first quarter. In Liwonde, we note how the Potential SGF is more than the non-food subsistence income in all the quarters. Forest cash income in Liwonde is far higher than the one in Chimaliro. The high cash income in Liwonde is not surprising given its proximity to major trading centres. More generally, Figure 2 shows that among the forest products, there is a high potential for them to play a seasonal gap-filling role.

[8] The CV is a scale neutral measure of variation, calculated as the ratio between standard deviation and mean, and here multiplied by 100 (percentage).

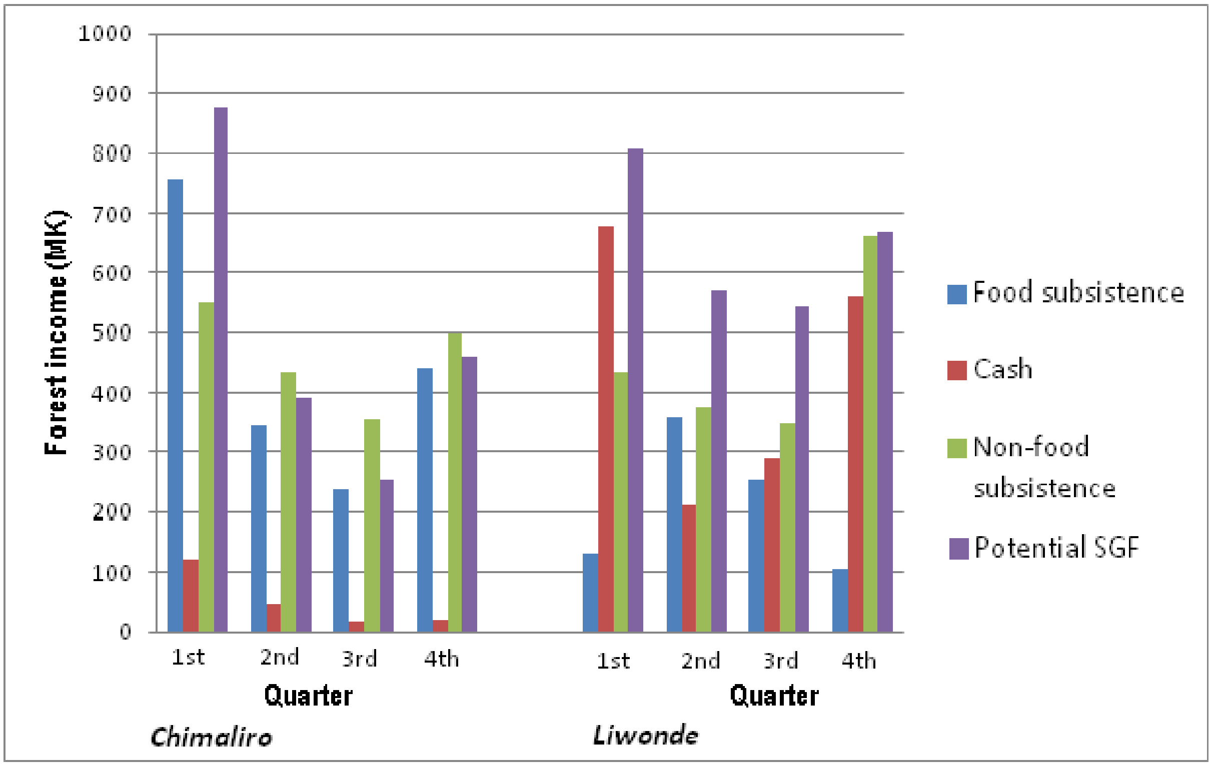

Figure 2: Quarterly forest cash and subsistence income distribution

4.2 Forest Seasonal Gap-Filling Role at Aggregate Household Level

Table 3 presents correlation results of forest income with both non-forest income and crop income only, as crop income is generally the major income source and also display large seasonal variation.[9] We report both overall and within-household covariance. Two conclusions emerge from the table. First, for both sites and both measures, in all but one correlation, forest income co-varies positively with both non-forest and crop incomes. This casts doubts on the SGF role of forest income, at least when households are pooled together. However, our subsequent analyses when households are categorized into livelihood strategies or quintiles modify this

[9] As is noted in Table 3, because most of non-forest income is crop, their (crop and non-forest) correlations with total income are very close. In the next tables therefore, we drop non-forest and remain with crop income only.

picture. Second, the *Within-Household Correlation* are generally lower that the *Overall Correlation*, confirming our hypothesis that the overall measure captures some positive correlation between high forest and non-forest incomes across households. In one case, crop income in Liwonde, the correlation turns from positive to negative (albeit not significant), demonstrating how the *Overall Correlation* could be masking a possible SGF role.

Table 3: Correlation of seasonality of forest income with non-forest and crop incomes

Correlation	Chimaliro		Liwonde	
	Correlation of forest income with:		Correlation of forest income with:	
	Non-forest income	Crop income	Non-forest income	Crop income
Overall	0.13***	0.11***	0.15***	0.14***
Within households	0.11**	0.08*	0.01	-0.07

*Significant at 10% **Significant at 5% ***Significant at 1%

If the main incomes do not negatively vary with forest income, what other income sources could be possible gap fillers? In Table 4, we report the correlation between crop income and wage, livestock and other income sources.[10] We include livestock income because of its potential to act as a gap-filler. Stories of stress livestock selling during crises are common in Malawi. In Chimaliro, crop income correlates negatively with wage income for both covariance measures. In Liwonde, there is no evidence to suggest any gap-filling by wage and other incomes. Again we note the lower values (including higher negative values) of the *Within-Household Correlation* compared to the *Overall Correlation*.

[10] Other minor income sources including remittances, Government/NGO support and gifts from friends and relatives

Table 4: Correlation of crop income with other income sources

Correlation	Chimaliro			Liwonde		
	Correlation of crop income with:			Correlation of crop income with:		
	Wage income	Livestock income	Other sources	Wage income	Livestock income	Other sources
Overall	-0.03	0.09*	0.16***	0.09*	0.04	0.11**
Within households	-0.06**	0.01	-0.12***	0.01	0.01	-0.01

*Significant at 10% **Significant at 5% ***Significant at 1%

The analysis so far does not provide sufficient evidence in support of forest extraction being used as seasonal income gap filler, with a possible exception for Liwonde. In Chimaliro, this role is played by wages and ‘other income sources’ (remittances). The inability to use forest products as gap-fillers in Chimaliro could reflect a constraint on behaviour rather than choice. Among other things, the relative remoteness of Chimaliro may constrain the marketing of forest products hence affecting their usefulness as income gap-fillers. Next, we investigate how these results hold up when looking at specific groups of households.

4.3 Forest Seasonal Gap-Filling Role by Livelihood Strategies

In this section, we classify households based on livelihood strategies identified through principal component and cluster analyses in (Chilongo, 2014). A livelihood strategy is a combination of several livelihood activities, but we conveniently named the strategies according to the main income source(s). Table 5 presents correlations of forest and crop incomes across these livelihood strategies.

Table 5: Correlation of forest income with crop income by livelihood strategy

Livelihood strategy	Overall correlation	Within-household correlation	Households (%) that increase forest income when crop income declines
Chimaliro:			
Food crop	0.08	0.09	22.84
Tobacco-food crop	0.19	0.05	31.25
Food crop-livestock	0.17**	0.19**	26.09
Food crop-forest	0.09	-0.22**	30.00
Liwonde:			
Food crop-nonfarm	0.52***	-0.04	21.43
Wage-livestock-forest	-0.08	-0.07	23.53
Forest-business	-0.14	-0.02	11.11
Food crop	-0.01	-0.11	27.36

**Significant at 5% ***Significant at 1%

Disaggregating the results by livelihood strategies provides some evidence of counter-cyclic forest income and hence a potential role of forests as SGF. In Chimaliro, households in the *Food crop-forest* livelihood strategy that showed some potential of forest income acting as a gap filler (Table 5). Again this was only captured by the *Within-Household Correlation* and not the *Overall Correlation*. It should not be surprising that this role of forests is limited to the strategy that makes most use of the forest. For other livelihood strategies, Appendix Table A2 suggests that wages (for *Food Crop* and *Food Crop-Livestock Mix* strategies) and livestock (for *Food Crop-Forest Mix* strategy) also could fill income gaps when crop income is low. In Liwonde, the *Within-Household Correlation* shows that for all livelihood strategies forest income vary negatively with crop income over the quarters although it is only the Food Crop strategy that is marginally significant (p = 0.14). Appendix Table A3 shows that the *Overall Correlation*, except for the *Forest-Business Mix* strategy, generally masks the forest gap-filling potential.

In summary, there is some evidence to suggest forest income being a potential seasonal income gap filler in Liwonde than in Chimaliro when households are grouped by their livelihood strategies and more so when we consider the *Within-Household Correlation*. This finding makes good sense given the relatively high forest reliance in Liwonde compared to Chimaliro. We also observe in Table 5 that, compared with the *Overall Correlation,* the *Within-Household Correlation* is generally lower (and even switch from positive to negative values). A notable exception is for households in the forest-business strategy in Liwonde.

As discussed in the methods section, there are some problematic aspects of using of correlations as indicators of SGF. The last column of Table 5 provides information on the share of households that experience an increase in forest income when crop income is below average. Despite the correlations giving mixed results on forest as a SGF, it can be noted that in every livelihood cluster and both sites, there are at least some households that receive higher forest income when their crop income declines. A clear pattern is not easy to discern, except that the *Forest-Business* strategy has the lowest share of households (11%) that report higher forest income when crop income declines. Crops provide, however, only 6% of the income to households in this strategy, compared with business (47%), forest (32%) and wages (25%) (Chilongo, 2014). This pattern is even clearer in Appendix Table A3 where business income vary positively with total income but negatively with all the other main income sources.

4.4 Forest Seasonal Gap-Filling Role by Household Income Levels

Low income households generally rely more on forest income, and we might thus expect that these low income households are also more likely to use forests as SGF. Table 6 reports the correlations between forest income and non-forest income and crop income by income quintiles.

Table 6: Correlation of forest income with crop income by income quintiles

Quintile	Overall	Within households	Households (%) that increase forest income when crop income declines
Chimaliro:			
Lowest	-0.10	0.20***	28.46
2nd	-0.29***	0.00	40.77
3rd	-0.28***	-0.02	27.13
4th	-0.31***	0.09*	18.46
Highest	-0.00	0.08	8.53
Liwonde			
Lowest	0.23**	0.06	14.43
2nd	-0.24**	-0.11**	31.96
3rd	-0.24**	-0.12**	38.14
4th	-0.32***	-0.12**	21.65
Highest	-0.03	-0.08	11.46

**Significant at 5%   ***Significant at 1%

The households within a quintile have – by construction – smaller income variation compared to the pooled households. We therefore expect smaller differences between the two correlation measures. The *Overall Correlation* suggests forest and crop incomes have pro-cyclic patterns for all quintiles in Chimaliro though not significantly different from zero for the highest quintile (Table 6). The Appendix Table A4 shows that the highest quintile uses wage income as a gap filler. Wage income varies negatively with all income sources for that quintile. Looking at the *Within-Household Correlation*, in Chimaliro only in the third quintile does forest income vary negatively (but not significant) with crop income. For Liwonde, both the *Overall Correlation* and *Within-Household Correlation* yielded negative and significant covariances between forest and crop incomes for the middle three quintiles. This generally agrees with the Appendix Table A5 where forest varies negatively with most income sources across the quintiles. Similar to the analysis by livelihood strategies, the analysis by quintiles also suggests a higher potential for forest income to be a SGF in Liwonde than in Chimaliro.

Table 6 also reports the share of households for which quarterly forest income increases when crop income decreases. For both sites, less than 12% of households in the uppermost quintile demonstrated the forest gap-filling characteristic compared to at least 14% for the four lower quintiles. This confirms the earlier findings that it is mostly the low-income households that use forest income as a safety net.

Table 7: Correlation of crop income with other income sources by income quintiles

Quintile	Crop income correlation with:					
	Wage income		Livestock income		Other income sources	
	Overall	Within households	Overall	Within households	Overall	Within households
Chimaliro:						
Lowest	-0.10	-0.02	-0.04	0.04**	-0.08	-0.03
2nd	-0.37***	-0.12***	-0.08	0.00	-0.42***	-0.20***
3rd	-0.40***	-0.15***	-0.20**	-0.03*	-0.56***	-0.16***
4th	-0.43***	-0.04	-0.15*	-0.01	-0.59***	-0.14***
Highest	-0.16*	0.01	-0.00	0.03	0.07	-0.09**
Liwonde:						
Lowest	0.05	0.00	-0.02	0.01	-0.06	-0.03
2nd	-0.28***	-0.04	0.00	0.03*	-0.16	0.02
3rd	-0.31***	0.05	0.00	0.00	-0.26***	0.03
4th	-0.42***	-0.02	-0.13	-0.00	-0.40***	-0.10**
Highest	-0.11	0.05	-0.07	0.03*	-0.11	0.06

*Significant at 10% **Significant at 5% ***Significant at 1%

We next investigate whether there are other potential income gap-fillers, apart from forest income, when the main income (crop) source decreases. The results of Table 7 show that wage, livestock and other income sources (including remittances and support from friends or relatives) could act as SGFs. The *Overall Correlation* shows that wages vary negatively with crop income for all the quintiles and at both sites. The *Within-Household Correlation* however, reveals that this pattern is not robust for the top quintile, and is only significant for the second and third quintiles in Chimaliro, while in Liwonde it is the third and fourth quintiles where the correlations are robustly negative. The results suggest that the livestock has more potential as a SGF in

Chimaliro than in Liwonde. This is intuitive given that Chimaliro has more livestock than Liwonde (Chilongo, 2014).

4.5 Shocks, Coping Mechanisms and Forest Use

To triangulate the income data analyzed above, in one of the surveys, the farmers were asked to indicate the shocks they faced within the 12 months preceding the survey, i.e., August 2006 to July 2007 (Figure 3). In addition, they were also to indicate coping mechanisms they used to manage the shocks (Figure 4). The main aim was to find out whether farmers perceive forest income as a coping mechanism or not. We assess below if there is any link between the shocks and forest use.

For both sites, crop failure, illness and livestock loss came out as the top three shocks experienced with at least a quarter of the households mentioning them (Figure 3). The pervasiveness of the crop failure, reported by 60% of the households in Chimaliro, suggests it was more of a covariate than an idiosyncratic shock, although we did not collect detailed information on the nature of the shock. The agricultural seasons during the survey were normal in terms of rainfall. Nevertheless, other covariate factors that could lead to crop failure such as pests or inadequate input supplies cannot be ruled out. Death of an active household member was another significant shock reported by at least 10% of the households.

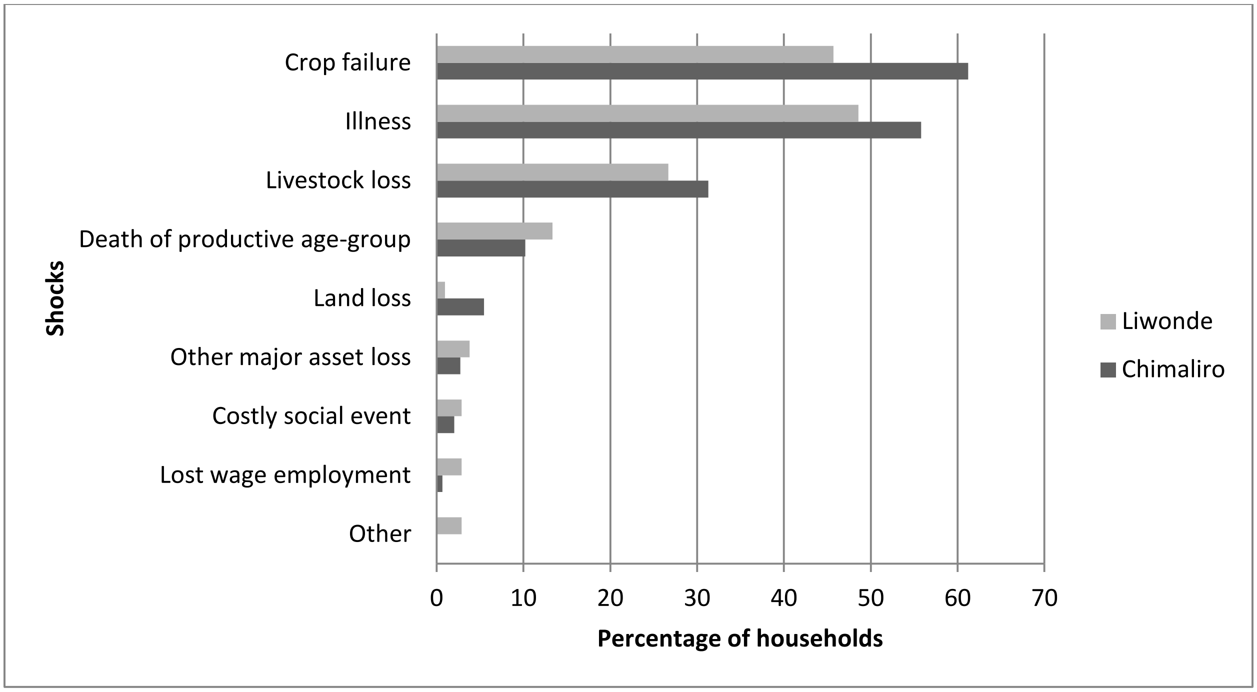

Figure 3: Household shocks for the preceding 12 months (2006/2007)

Figure 4 presents what farmers reported as first-ranked coping mechanisms. Use of forests as a coping mechanism ranks last at both sites. Only one household in Chimaliro and six households in Liwonde explicitly stated that they used ‘harvesting more forest products’ as a main coping mechanism. The other related coping mechanism of ‘harvest more wild products’ (non-forest sources) was only mentioned by two households in Liwonde. As a second option (not presented in Figure 4), forest as a coping mechanism was mentioned by only one household in Liwonde. In general, households do not perceive forest income as a coping mechanism.

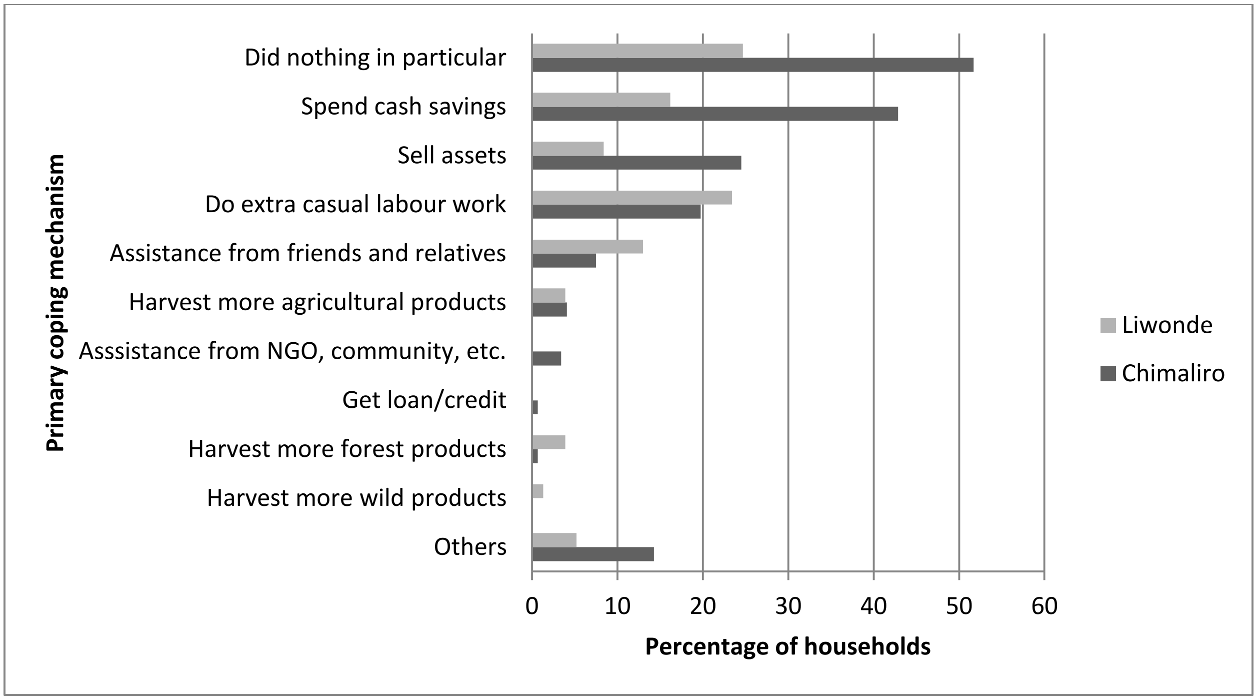

Figure 4: Primary coping mechanisms to shocks as reported by households

The finding that households do not perceive forest income as a coping mechanism was also reported by (Debela et al., 2012) in a study from Western Uganda. The authors do, however, cautioned that self-reporting can be misleading. Although their households reported not using forest income as a coping mechanism, their analysis of actual behaviour showed otherwise. As noted by Chilongo and Angelsen (2014), the subsistence nature of forest products makes them less likely to be mentioned as a coping mechanism. This takes us to Table 8 where we report the correlation between forest income and shocks.

Table 8: Correlation between forest income seasonality and shocks

Forest income correlation with:	Chimaliro		Liwonde	
	Overall	Within households	Overall	Within households
Income shock index	-0.11***	-0.12***	0.17***	0.16***
Labor shock index	-0.11***	-0.14***	-0.01	0.01
Asset shock index	-0.09**	-0.11***	-0.02	0.00

**Significant at 5%   ***Significant at 1%

If forest income is to be a potential shock coping mechanism, the general expectation is that forest income will increase when a household faces shock. However, this may not always be the case. The type of shock should be taken into context. A labor shock may, for example, lead to a decrease in forest use due to the fact that most forest collection activities are labor intensive. Following Chilongo and Angelsen (2014), the various types of shocks were aggregated into three types: income (crop failure, costly social event, loss of wage employment); labor (sickness or death of a productive household member); and asset shocks (livestock, land aand other major asset losses).[11] In addition, for each shock the households were asked to indicate its severity (0 = no shock, 1 = moderate shock, 2 = severe shock). We added the severity under the shock categories to generate an aggregate shock index.[12]

[11] We acknowledge that there could an overlap in this categorization, e.g., illness could lead to both labor and income losses. Our assumption here is that the shock affects labor supply first with income loss as a second level effect.

[12] For example, if a household reported 'moderate' crop failure (1), 'severe' loss of wage employment (2) and 'moderate' income loss due a costly social event (1), then the income shock index for such a household is aggregated to 4.

From Table 8, the negative forest-income shock correlation in Chimaliro casts doubts on the use of forest resources as a coping mechanism. In Liwonde however, the results suggest that forest use increases when faced with income shocks. As expected, labor shock is associated with a decrease in forest income in Chimaliro. To sum it up, Table 8 shows that it is only during income shocks in Liwonde that forest income could have been used to fill the income gap.

4.6 Regression analysis of gap-filling quarters

So far we have studied correlations between forest income and other income sources (crop income in particular) and shocks. A necessary condition for forest income to be a gap-filler is for the correlation to be negative. This could happen when forest income is above its mean and the other incomes are below their means, or when the other incomes are above their mean and forest income is below its mean. Although these are related, by construction, our main interest is the former, i.e., the potential of forest to fill gaps when major incomes fall short. Table 9 presents the *Gap-filling Indicator (G)*, cf. Equation 4. In Chimaliro, for example, about 25% of the households experienced an increase in forest income when crop income decreased. In general about a quarter of the observations for both sites and incomes showed evidence of forest gap-filling.

Table 9: Forest and Other Income Sources Seasonality Dynamics

		Chimaliro		Liwonde	
		Forest Income		Forest Income	
		Above mean (% hh)	Below mean (% hh)	Above mean (% hh)	Below mean (% hh)
Crop Income	Above mean (% hh)	18.5	21.3	15.9	27.3
	Below mean (% hh)	24.7	35.5	23.6	33.3

We assess the determinants of forest income as a gap-filler, using a random effects panel regression analysis (Table 10). The dependent variable is the Gap-filling Indicator dummy. We hypothesized that more educated household heads to rely less on forests as a safety net, based on the assumption that they have other more remunerative sources of income and coping strategies (Wunder et al., 2014). The sign and significance of the coefficients for the educational variables varies, and does not support our hypothesis. A possible explanation might be that the education levels (averaging about 7 years) were still not sufficient to secure these households high-paying off-farm jobs during slack seasons.

Table 10: Random Effect Probit Model Result of Determinants of Forest as an Crop Income Gap-Filler

Variable	Chimaliro		Liwonde	
	Coefficient	t-statistic	Coefficient	t-statistic
Constant	-0.860	(-1.12)	-1.806***	(-3.48)
Household Characteristics				
Age of household head (years)	0.006	(1.10)	-0.000	(-0.01)
Female household head (1/0)	0.137	(0.57)	0.366*	(1.71)
Education of household head (years)	0.039*	(1.76)	0.003	(0.12)
No. of hh[b] members with primary education (excl. hh head)	-0.067	(-0.88)	-0.056	(-0.64)
No. of hh members with post-primary education (excl. hh head)	-0.184*	(-1.64)	-0.075	(-0.60)
Household size (aae)[c]	0.112	(0.95)	0.085	(0.63)
Community forestry membership (1/0)	-0.090	(-0.67)	-0.088	(-0.53)
Belonging to main ethnic group (1/0)	0.273	(1.37)	-0.110	(-0.73)
Distance to forest (km)	0.010	(0.23)	0.036	(0.38)
Assets				
Implements value (log MK/aae)	0.006	(0.70)	0.016	(1.32)
Land size (ha)	0.014	(0.73)	-0.011	(-0.20)
Cattle ownership (1/0)	-0.114	(-0.69)		
Poultry ownership (1/0)	-0.305	(-0.89)	0.217	(0.98)
Goat/sheep/pig ownership (1/0)	0.229	(0.64)	0.012	(0.04)
Village characteristics				
Distance to district center (km)	-0.019**	(-2.08)	0.029	(1.30)
Formal credit access (% of households)	0.007	(1.04)	-0.037*	(-1.79)
Shocks				
Income shock index	0.522	(1.53)	-0.306	(-1.18
Labor shock index	-0.667*	(-1.66)	-0.045	(-0.23)
Asset shock index	-0.398	(-1.14)	-0.134	(-0.46)
Quarterly dummies				
2nd Quarter (1/0)	1.362***	(8.35)	1.517***	(7.36)
3rd Quarter (1/0)	0.436***	(2.59)	0.612***	(2.87)
4th Quarter (1/0)	-0.561*	(-1.74)	0.425	(1.58)
Number of observations	648		484	
Log Likelihood	-278		-217.24	
Wald Chi-Square	120.68***		81.59***	

*significant at 10% **significant at 5% ***significant at 1%

[b] hh = household

[c] aae = adjusted adult equivalent

Female-headed households are more likely to use forest as seasonal gap fillers than male-headed ones in Liwonde. This is in line with the relatively easy access to forest resources and that female-headed households tend to be more resource constrained.

The further a village is located from a district center the lower the likelihood of forest being a gap filler in Chimaliro. A possible explanation is that proximity to a district centre provides better market opportunities for forest products.

Access to formal credit means access to alternative safety nets in case of lean periods (Fisher et al., 2010; Völker and Waibel, 2010). Access to credit can therefore be expected to reduce the reliance of forest as a safety net. The regression analysis finds this to be the case for Liwonde (coefficient significant at 10% level) but not in Chimaliro (coefficient close to zero). One reason for the rather weak results may be the low availability of credit: only about 2% in of the sampled households in Liwonde and 5% in Chimaliro had access to formal credit.

None of the shock variables were significant for Liwonde while the results for Chimaliro generally agree with the forest-shock correlations in Table 8. Households that experience a labor shock rely less forest as a seasonal gap-filler; the reduced availability of labor makes labor-intensive forest product collection less attractive.

We also included quarterly dummies as controls, and they agree with the seasonal pattern of forest resource availability (Figure 1). In Chimaliro, forests are used more frequently as gap fillers in the lean quarters two and three (roughly September to April) than in the abundant season of first quarter (June to July). In Liwonde, the likelihood of forest being as a gap filler is higher in the second and third quarters than in the first quarter. However, going by the magnitude of the coefficients, it was the in the leanest second quarter (September to December) at both sites that showed the highest probability of forest income being used as a safety net against drops in main income sources.

5 Conclusions

The paper has introduced new measures to assess whether forest or other income sources are pro-cyclical or counter-cyclical, i.e., whether they serve as seasonal gap fillers (SGF) (in our case: compensate for low crop incomes outside the harvesting season). While many studies look at overall covariance between income sources across seasons and households simultaneously, we argue that the covariance should be estimated by seasons only, i.e., estimated for each household and then averaged across households. Looking at overall covariance can mask the role of forest or other income sources as SGF, due to the often strong correlations across households between absolute incomes from all sources. In addition, a simple negative covariance between, for example, forest and crop income threats seasons of "high forest-low crop" incomes and "low forest-high crop" incomes symmetrically, although it is the former that is of interest from a gap-filling viewpoint. We therefore introduced a simple "gap-filling indicator" to capture only the former.

The findings on the role of forest in seasonal gap-filling are nuanced. When looking at the sampled households as a group, there is limited evidence of forest income *on average* acting as a SGF. Other income sources such as wages and remittances showed higher potential of being a SGF. This picture changes when households are divided into in categories by livelihood strategies and total income. The results confirm the relatively higher importance of forests to the low-income households compared to the better-off ones. However, when looking at the gap-filling role, it is not the very poorest but those in the second (and also third for Liwonde) poorest quintile with the highest use of forests as gap fillers. When categorizing households according to livelihoods strategies, we find a negative covariance (an indicator of SGF) in all three livelihood strategies that have forests as a major income component. In general, Liwonde portrays more potential to use forest income for seasonal income gap-filling than Chimaliro, which may reflect the better market access in that site.

Overall, the analysis does not provide a simple “yes” or “no” answer to the question whether forests act as a SGF. It does for some (categories of) households. Yet, this aspect of forest reliance should become an integral part of the forest-livelihoods analysis when seasonal data are available. If forests or other income sources have a gap-filling role, their contribution to the households’ livelihood goes beyond what aggregate income shares suggest.

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Appendices

Table A1: Correlation Matrix for Main Income Sources

Chimaliro					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.16*	1.00			
Crop	0.94*	0.11*	1.00		
Livestock	0.38*	0.05	0.09*	1.00	
Wage	0.05	0.07*	-0.03	0.02	1.00
Liwonde					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.47*	1.00			
Crop	0.88*	0.14*	1.00		
Livestock	0.14*	0.16*	0.04	1.00	
Wage	0.24*	0.05	0.09*	0.02	1.00

*Significant (p<0.1)

Table A2: Correlation Matrix for Main Income Sources by Livelihood Strategy for Chimaliro

Food Crop					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.16*	1.00			
Crop	0.98*	0.08	1.00		
Livestock	0.08	0.06	0.05	1.00	
Wage	0.11*	0.00	-0.02	0.04	1.00
Tobacco-Food Crop Mix					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.21	1.00			
Crop	1.00*	0.19	1.00		
Livestock	0.00	0.00	0.00	1.00	
Wage	0.16	0.25	0.14	0.00	1.00
Food Crop-Livestock Mix					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.23*	1.00			
Crop	0.86*	0.17*	1.00		
Livestock	0.62*	0.14*	0.21*	1.00	
Wage	0.05	0.04	-0.06	0.05	1.00
Food Crop-Forest Mix					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.13	1.00			
Crop	0.93*	0.09	1.00		
Livestock	0.22*	-0.04	-0.02	1.00	
Wage	0.15	0.42*	0.05	0.19*	1.00

*Significant ($p<0.1$)

Table A3: Correlation Matrix for Main Income Sources by Livelihood Strategy for Liwonde

	Total	Forest	Crop	Livestock	Wage	Business
Food Crop-Nonfarm Mix						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.81*	1.00				
Crop	0.81*	0.52*	1.00			
Livestock	0.61*	0.69*	0.44*	1.00		
Wage	0.31*	0.06	0.14*	0.12	1.00	
Business	0.27*	0.24*	0.04	-0.03	0.03	1.00
Wage-Livestock-Forest Mix						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.25*	1.00				
Crop	0.77*	-0.08	1.00			
Livestock	0.00	0.00	0.00	1.00		
Wage	0.79*	0.11	0.36*	0.00	1.00	
Business	0.16	0.16	-0.11	0.00	0.01	1.00
Forest-Business Mix						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.40*	1.00				
Crop	-0.06	-0.14	1.00			
Livestock	0.12	0.13	-0.07	1.00		
Wage	-0.14	-0.12	-0.10	-0.08	1.00	
Business	0.81*	-0.18	-0.07	-0.03	-0.09	1.00
Food Crop						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.11	1.00				
Crop	0.98*	-0.00	1.00			
Livestock	0.05	0.00	-0.01	1.00		
Wage	0.23*	0.08	0.10	0.03	1.00	
Business	0.13*	0.01	0.02	0.05	-0.10	1.00

*Significant (p<0.1)

Table A4: Correlation Matrix for Main Income Sources by Income Quintiles for Chimaliro

Lowest Quintile					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	-0.09	1.00			
Crop	0.51*	-0.10	1.00		
Livestock	-0.12	-0.00	-0.04	1.00	
Wage	0.00	0.80*	-0.10	-0.02	1.00
Second Quintile					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.06	1.00			
Crop	0.36*	-0.29*	1.00		
Livestock	0.06	0.10	-0.08	1.00	
Wage	0.04	-0.06	-0.37*	-0.06	1.00
Third Quintile					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.08	1.00			
Crop	0.40*	-0.28*	1.00		
Livestock	0.12	-0.03	-0.21*	1.00	
Wage	0.01	-0.07	-0.40*	-0.03	1.00
Fourth Quintile					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	-0.05	1.00			
Crop	0.45*	-0.31*	1.00		
Livestock	0.17*	-0.03	-0.15*	1.00	
Wage	-0.01	0.07	-0.43*	-0.06	1.00
Highest Quintile					
	Total	Forest	Crop	Livestock	Wage
Total	1.00				
Forest	0.04	1.00			
Crop	0.91*	-0.00	1.00		
Livestock	0.38*	0.02	0.00	1.00	
Wage	-0.10	-0.09	-0.16*	-0.01	1.00

*Significant (p<0.1)

Table A5: Correlation Matrix for Main Income Sources by Income Quintiles for Liwonde

Lowest Quintile						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.40*	1.00				
Crop	-0.03	0.23*	1.00			
Livestock	0.05	0.02	-0.02	1.00		
Wage	0.32*	-0.07	0.05	-0.03	1.00	
Business	0.23*	-0.15	-0.02	-0.02	-0.05	1.00
Second Quintile						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.22*	1.00				
Crop	0.22*	-0.24*	1.00			
Livestock	0.00	0.00	0.00	1.00		
Wage	0.31*	-0.19	-0.28*	0.00	1.00	
Business	0.15	0.16	-0.14	0.00	-0.22*	1.00
Third Quintile						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.14	1.00				
Crop	0.34*	-0.24*	1.00			
Livestock	0.00	0.00	0.00	1.00		
Wage	-0.11*	-0.17	-0.31*	0.00	1.00	
Business	-0.22	-0.17	-0.21*	0.00	-0.21	1.00
Fourth Quintile						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.20*	1.00				
Crop	0.30*	-0.32*	1.00			
Livestock	-0.04	-0.03	-0.13*	1.00		
Wage	0.09	-0.03	-0.41*	-0.10	1.00	
Business	0.16	-0.03	-0.33*	0.11	-0.14	1.00
Highest Quintile						
	Total	Forest	Crop	Livestock	Wage	Business
Total	1.00					
Forest	0.48*	1.00				
Crop	0.83*	0.03	1.00			
Livestock	0.04	0.15*	-0.07	1.00		
Wage	0.01	-0.02	-0.11	-0.02	1.00	
Business	-0.02	-0.00	-0.22*	-0.03	-0.20*	1.00

*Significant (p<0.1)

Paper IV

Trapped in Forests or Saved by Forests? Forest Reliance and Poverty Transitions in Malawi

Thabbie Chilongo* and Arild Angelsen*

Abstract

What role does forest income play in movements in and out of poverty? Using a two-period, balanced panel data set of 248 households in Chimaliro and Liwonde forests in Malawi, we test whether households with high forest reliance are likely to remain poor or fall into poverty and whether forest use is a safety net when households fall into poverty or face shocks. Overall, our results suggest that forests were not poverty traps but rather fulfilled important safety net functions for the chronically poor and households that fell into poverty. (JEL O13, Q23)

Key words: forest income, forest reserves, poverty dynamics, safety net

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1 Introduction

There is a broad consensus among researchers that forest and other forms of environmental income play an important role in rural livelihoods, particularly for the poorest segments of the population (Cavendish, 2000; Angelsen and Wunder, 2003; Sunderlin et al., 2005; Babulo et al., 2009; Angelsen et al., 2014). Most studies are, however, based on one period, cross-sectional data only, and therefore cannot address critical questions concerning fluctuations in income over time and poverty dynamics.

This study uses a balanced panel from Chimaliro and Liwonde forest reserves in Malawi, with data collected in 2002 and 2006/7. These two sites pioneered co-management of forest reserves in the country. They also represent an instructive contrast in terms of ecological, demographic and market characteristics. In 2002, the average income was similar in the two sites, but while Liwonde has experienced a sharp decline, the average household in Chimaliro has enjoyed a measurable income growth.

This paper seeks to assess if high forest reliance – defined as forest income divided by total household income – is likely to perpetuate poverty, or if forest income acts as a safety net for those that experience income shortfall or face other shocks. To address the "trapped in the forest" part of the question asked in the title, we test the hypothesis that households with initial high forest reliance experienced a lower income growth between the two periods. We also explore if and how forest reliance affects movements in and out of poverty. To address this "saved by forest" part of the question, we test the hypothesis that forest use and reliance increase when households fall into poverty and/or face shocks.

The paper makes two contributions to the current literature on forests and poverty. First, the use of panel data opens up for analyzing the link between forest reliance and poverty dynamics, a topic which has not been explored much so far mostly due to unavailability of panel data on forest use. Second, with data coming from two distinctly different areas, the study also provides an opportunity to investigate how the poverty dynamics differ between the two sites, including how the contrasting state of the forest ecosystem and the market access in the two sites shapes the forest-poverty dynamics.

The rest of the paper is organized as follows. Section II gives a theoretical framework of poverty dynamics in general and forest-poverty link in particular, leading to a formulation of the specific hypotheses to be tested. Section III describes the study areas, data collection and the estimation methods employed. This is followed by the results and discussion in Section IV. Finally, Section V sums up the major conclusions.

2 Frameworks and Hypotheses

2.1 Poverty Definitions and Concepts

Three key elements in defining poverty are the *indicator*, *identification* and *aggregation* (Sen, 1976; Fields, 2001; Calvo and Dercon, 2009). The indicator refers to how poverty is measured. Identification determines who is poor or not, and is mostly done by a poverty line (Foster, 2009). Aggregation is the summing up of individuals who are defined as poor to get a single, aggregate measure.

Poverty and poverty lines can be defined and measured either by income, consumption expenditure (Fields, 2001), assets (Carter and Barret, 2006), or a combination of indicators (Alkire and Santos, 2010). Fields (2001) regards consumption to be a better indicator of living standard than income but cautions that the former requires comprehensive data collection. Cavendish (2000) observes that in most developing countries there is little distinction between the two. The reason is limited savings and high consumption of own-produced and own-collected goods, which represent both income and consumption. In our sample, an average of 55 % of the household income is consumed directly. Further, income data are more suitable for causal analysis of poverty, e.g., how income composition changes with changes in income. This paper therefore uses income as a measure of poverty.

Deaton (1997) and Fields (2001) recommend adjusting household income to per adult equivalent (*ae*) to accommodate differences across age and sex in basic needs. Deaton further advises adjustments by economies of scale to take care of public goods within the household. We therefore use income per adult equivalent adjusted for economies of scale (adjusted adult equivalents – *aae*) (Deaton, 1997). (See Appendix for details on how *aae* is calculated.)

The National Economic Council has estimated two poverty lines for Malawi to distinguish the poor from the moderately poor (National Economic Council (NEC), 2000). These were based on the nation-wide Integrated Household Survey 1, undertaken in 1997-98 (see also Mukherjee & Benson (2003), who use the same data). We chose the lower poverty line, as the upper one implies that approximately 80% of the households in the sample were below the poverty line.[1] Further, we adjusted the national poverty lines from per capita to per aae[2], and for inflation using the Consumer Price Index (CPI). With these corrections, the 2002 adapted regional poverty lines used in this study were MK 7 757 (USD PPP 528) and MK 6 566 (USD PPP 447)[3] per adult equivalent per annum for Chimaliro and Liwonde, respectively.

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[1] Similarly, using the poverty line from IHS2 (2004/2005) produced a skewed distribution with roughly 90% of households below the poverty line.

[2] This was done by multiplying the per capita poverty line with the ratio of household size to *aae* for the two sites.

[3] MK = Malawi Kwacha, the currency of Malawi; PPP = Purchasing Power Parity; PPP Exchange Rate: USD1 = MK14.70 in 2002 (Heston et al., 2006).

The final issue is the aggregation into a poverty measure. The Foster, Greer and Thorbecke (FGT) class of measures (Foster et al., 1984) gives a range of different poverty measures, commonly referred to as the P_α class. For the purposes of this paper, and in line with the poverty dynamics literature, we adopt the very simplest measure, the poverty headcount (P_0), which defines a household as poor if its income per *aae* is below the poverty line.

2.2 Poverty Dynamics

Poverty dynamics refers to the time dimension of poverty. The time dimension is relatively new in poverty analysis (Addison et al., 2009) and has opened up a new array of questions to be addressed such as: Why do people fall into or get out of poverty? How are chronic poor different from transient poor (Jalan and Ravallion, 1998; Carter and Barret, 2006)? These questions are critical in understanding poverty, yet they are addressed scarcely, mostly due to lack of relevant panel datasets.

Calvo and Dercon (2009) provide basic terms that are important to understand the dynamics of poverty. The analysis of poverty dynamics is concerned with the assessment of poverty over a lengthy *period* of time, which can be decomposed into *spells*. In our case, the period is 4 years with two spells, i.e. 2002 and 2006/07. In each spell, we observe a level of standard of living and in the process define poverty transitions. The poverty transitions can be categorized into three groups: the chronically poor, the transitory poor, and the never poor. There is some arbitrariness in how the poverty transitions are applied in different studies. This mostly depends on the period and spells of a study. For example, in their 10-year period and yearly spells study, Hulme and Shepherd (2003) define chronic poverty as being poor for at least five years. In our case, being only a two-spell study, we identify the *chronically poor* as those who were poor in both spells. The *transitory poor* are sub-divided into two: households falling into poverty (non-poor in 2002 but poor in 2006/07), and households escaping poverty (poor in 2002 but non-poor in 2006/06). *Never poor* households were above the poverty line in both spells.

In contrast to the income/expenditure approach discussed so far, Carter & Barrett (2006) use an asset approach to study poverty dynamics in general and poverty traps in particular. Households are said to be trapped in poverty when the income from the low return activity is not sufficient to accumulate the necessary assets to switch to the high-return production system. While the present study bears some resemblance to the poverty trap logic, we do not undertake the full analysis to identify, for example, the critical asset threshold. The reasons are lack of data and only two spells, and that we focus on other variables than assets (forest reliance in particular) in poverty transitions.

2.3 Forest Reliance, Poverty and Shocks

For a general discussion of the link between rural livelihoods/poverty and forest income, we refer to Angelsen *et al.* (2014). Several studies, from Africa and other developing countries, have shown that the poor rely more on forest as measured by share of forest income in total income, while the non-poor have higher absolute forest income (Cavendish, 2000; Jumbe and Angelsen, 2007; Babulo et al., 2009). This high forest reliance by the poor begs the question whether forest reliance should be regarded as a safety net or as a poverty trap? In other words: are some households forest-reliant because they are poor, or are they poor because they are forest-reliant?

This safety net-poverty trap duality has been expressed in different forms in the literature. Fisher (2004) notes that forests can both prevent/reduce poverty or perpetuate poverty. Narain *et al.* (2008) observes a significant reliance on common pool resources (including forests) among the rural poor. The policy implications of this finding are, however, not straightforward: is the positive correlation indicating that these are low return activities with limited potential, or that they are vital sectors to the poor that deserve government support? A critical insight is that many of the characteristics that make products from uncultivated environments attractive to the poorest households *also* limit their potential to be "stepping stones" out of poverty (Belcher and Schreckenberg, 2007).

Angelsen and Wunder (2003) outline different scenarios under which forest reliance can be considered a safety net or a poverty trap. The safety net explanation assumes poverty is *exogenous* and our interest becomes to understand why poor people rely more on forests. The poor have few alternative income opportunities, e.g., little agricultural land or low skills that exclude them from well-paid off-farm jobs. Further, many forest-based activities have characteristics that make them attractive to the poor relative to their better-off neighbors: low returns to labor, low capital requirements, and open or semi-open access. Thus, the poverty of forest-reliant households reflects their lack of opportunities, and forest-based activities become an "employment of last resort".[4]

Forest reliance as a poverty trap suggests that poverty is *endogenous*. The relevant question then becomes: why are forest-reliant people poor? This is mainly attributed to low returns from most forest products. If forests form a major component of a household's livelihood, it is likely to remain poor. Angelsen & Wunder (2003) argue, however, that labeling this as a trap would only be justified to the extent better opportunities exist, and there are mechanisms that prevent poor and forest reliant households to take advantage of these, cf. Carter & Barrett (2006).

[4] Note that the term "safety net" is in the forest-livelihoods literature is used in different meanings. While some refer to it as a form of insurance, i.e. a source of quick cash when immediate needs arise due to, for example, illness, this paper takes a longer term perspective and use it to what extent it helps households with few assets and alternative income sources to meet their basic needs.

Forest use is also affected by shocks (Godoy et al., 1998; Pattanayak and Sills, 2001; McSweeney, 2004; Takasaki et al., 2004; Fisher and Shively, 2005; Khundi et al., 2010; Völker and Waibel, 2010; Debela et al., 2012). Households devise *ex ante* risk management and/or *ex post* risk coping strategies to deal with shocks. Debela *et al.* (2012) provide examples of risk management strategies in the form of asset accumulation and agricultural diversification, while risk coping strategies include selling assets, consumption smoothing and seeking (more) off-farm employment. Higher forest use can be both a management and coping strategy, with the latter most commonly discussed in the literature.

Several factors influence the use of forests as a safety net against shocks. First, some find that forests are more frequently used after only idiosyncratic (household specific) shocks (Debela et al., 2012), while others find forest use to respond to both idiosyncratic and covariate (common) shocks (Völker and Waibel, 2010). Second, the shock itself should not reduce the availability of forest products, e.g., a forest fire (McSweeney, 2004; Völker and Waibel, 2010). Third, the actual role of forest depends on availability of other coping mechanisms. The absence of off-farm employment, formal credit, insurance and agricultural diversification are positively related to use of forest reliance as a safety net (Völker and Waibel, 2010). Finally, and partly linked to the above factors, evidence suggests a positive correlation between use of forests as a safety net and remoteness to markets (Godoy et al., 1998), closeness to forests (Pattanayak and Sills, 2001; Vedeld, 2004), asset/income poverty (Takasaki et al., 2004; Fisher and Shively, 2005; Völker and Waibel, 2010) and young households (McSweeney, 2004).

Based on the above discussion, this paper tests the following hypotheses:

Hypothesis 1 (forests as poverty traps):

(a) Households with high initial forest reliance (share of forest income in total income) are more likely to be chronically poor or fall into poverty.

(b) Income growth for households with initially high forest reliance is lower than income growth for households with low forest reliance.

Hypothesis 2 (forests as safety nets):

Households increase their forest use (absolute forest income) and reliance (forest income share) when they move into poverty and/or face shocks.

3 Data and Estimation Methods

3.1 Study Area

Data were collected from two sites in Malawi, the Chimaliro and Liwonde forest reserves. The reserves cover 160 000 ha (Chimaliro) and 274 000 ha (Liwonde), and both are categorized as semi-deciduous and evergreen natural *miombo* woodlands. The sites were selected in 1996 as pilots for the forest co-management (FCM) program in Malawi, and thus share a history of donor and government sponsored interventions aimed to promote local participation and sustainable forest management through forest user groups (Jumbe and Angelsen, 2006).

There are distinct differences between the two sites (Jumbe and Angelsen, 2007). The sites are separated by over 400 km, with Chimaliro in the Central/Northern region and Liwonde in the Southern region (Figure 1). Chimaliro is relatively flat compared to the hilly Liwonde site. People in Chimaliro are culturally homogenous, dominated by the *Tumbuka* tribe, with *Ngoni* and *Chewa* representing the minority tribes. Inheritance is patrilineal through (the oldest) male children, wives normally move to the husband's village, and husbands dominate in making key household decisions. The population of Liwonde is ethnically more heterogeneous, with *Yao* being the dominant tribe. Inheritance is matrilineal through (the oldest) female children, and husbands normally reside in their wives' village. Although the husband is traditionally considered the household head, consent from the wife is important in undertaking household investment decisions (Botha, 2003; Jumbe and Angelsen, 2007). Place et al. (2001) hypothesize and find some evidence of husbands in matrilineal societies being less interested in long term investments in agriculture and forestry, as they have less control over decisions and feel less ownership to these resources.

Both sites lie along Malawi's main highway, which connects the country from south to north (Figure 1). Chimaliro is relatively remote compared to Liwonde, which is located at the crossroads of major cities and towns. The reserve is only 3 km from Liwonde Town, and approximately 30 km from Balaka Town and Zomba City, the former capital of Malawi. The closest major towns to Chimaliro are Kasungu (about 70 km south) and Mzuzu City (about 180 km north).

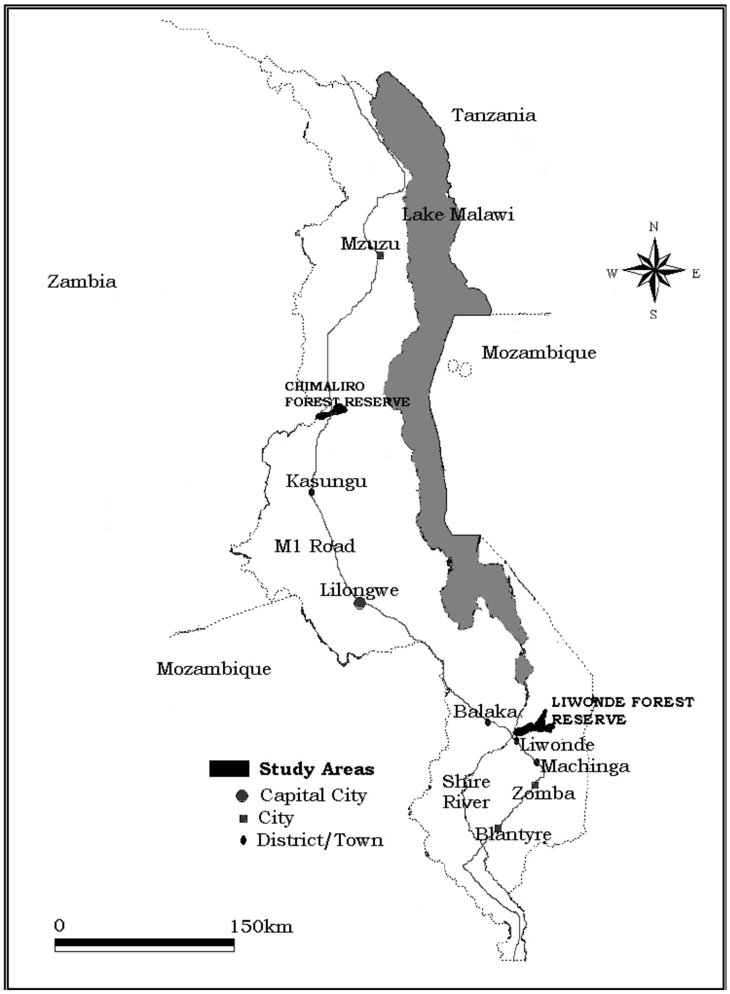

FIGURE 1

Map of Malawi Showing the Study Areas

The more central location of Liwonde helps to explain why the quality of the forest stock is much lower than in Chimaliro. Makungwa and Kayambazinthu (1999) reported a stocking density for Chimaliro between 372 and 932 stems per ha compared to only about 50 stems per ha for Liwonde. Jumbe and Angelsen (2006) also reports on more degradation and unsustainable use in Liwonde than in Chimaliro.

Crops account for about half of household income: 56 % in Chimaliro and 43 % in Liwonde among the sampled households in the 2006/7 survey. Maize is the main crop in both sites.

Tobacco and groundnuts are major cash crops in Chimaliro, while Liwonde also relies on cassava and rice, the latter mainly grown as a cash crop. The proximity to towns provides more opportunities for off-farm work in Liwonde, and wage and business income contributed to about 20 % of total income, compared with 8 % in Chimaliro (Figure 2).

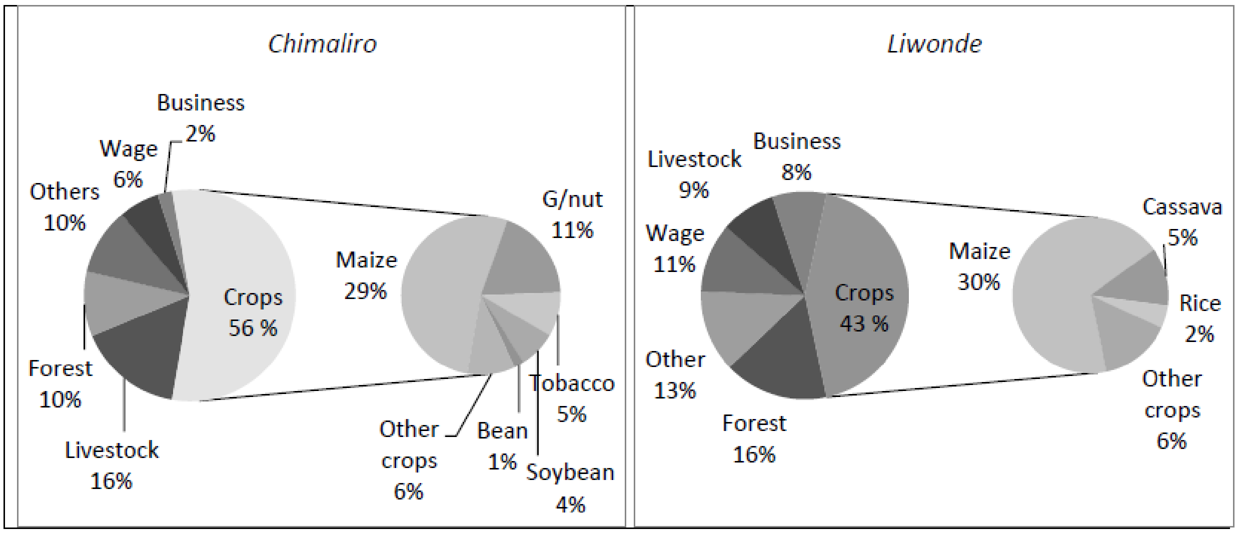

FIGURE 2
Income Sources for Chimaliro and Liwonde for 2006/07

Households use a variety of forest products. For both sites, firewood, mushroom and thatching grass are the three most commonly collected products. These tree products, together with poles in Liwonde, are also among the most valuable forest products (Table 1). With the exception of wooden utensils in Liwonde, the subsistence share is above 80% for all forest products in both sites. As will be discussed later, this partly explains the limitations of forest income as a stepping stone out of poverty. Due to its proximity to major trading centers, the forest cash share in Liwonde (13 %) is more than twice the share in Chimaliro (6 %).

TABLE 1

Main Forest Products

Products	Observations (collectors)	Avg. income for collectors (MK/aae)	Avg. income for all households (MK/aae)	Subsistence share (%) (Collectors)	Cash share (%) (Collectors)
Chimaliro	***145***	***1039***	***685***	***93.7***	***6.3***
Firewood	143	261	257	97.6	2.4
Mushroom	132	134	122	94.2	5.8
Thatching grass	85	171	100	96.1	3.9
Wild fruits	71	117	57	90.7	9.3
Wooden utensils/tools	56	47	18	93.3	6.7
Poles	51	132	46	97.4	2.6
Others	68	177	83	86.9	13.1
Liwonde	***103***	***1476***	***672***	***87.3***	***12.7***
Firewood	101	310	304	92.2	7.8
Mushroom	76	122	90	82.1	17.9
Thatching grass	30	206	60	89.2	10.8
Poles	30	434	126	84.0	16.0
Wooden utensils/tools	26	274	69	79.4	20.6
Wild fruits	14	46	6	90.5	9.5
Others	20	84	16	93.7	6.3

Charcoal production from the two forests reserves is not permitted, and anybody involved in charcoal making is unlikely to come forward with that information. While we cannot rule out under-reporting of (illegal) extraction from the forest reserve, we do not expect this to be very significant. One of the aims of the forestry co-management program was to reduce illegal uses and serious measures are introduced, including fines for trespassers. Proceeds from the fines are shared between the community co-management committee and the forestry department, thus there are local incentives to enforce the regulations. Combined with other information collected, we conjecture that most of the charcoal sold along the road is done by outsiders or temporary migrants not included in the survey.

3.2 Data Sources

Our data come from a two-round panel data set, collected in 2002 and 2006/2007. The initial sample included 205 randomly selected households from complete lists of the population in 28 villages in Chimaliro, and 199 households from 11 villages in Liwonde[5]. Identifying households that participated in earlier surveys is a challenge in repeated surveys. In cases where the household head had changed (due to death, divorce, migration or simply misspelling of the name in the first survey), the names of other household members helped us to locate the households. Out of the initial sample of 404 households, 267 could be matched in 2006 with certainty, giving an attrition rate of 34 %. In addition, 19 households missed two or more quarters in the 2006/07 survey, and were dropped. Thus the study is based on a matched sample size of 248 households.[6]

Although attrition rates often are high in panel surveys, an attrition rate of 34 % could raise systematic biases in the sample. Survey attrition does not necessarily imply that a household has permanently left the village; the reasons could be temporary absence, divorce or misspelling of the name in either of the surveys. Given the relatively high attrition, using the 2006/07 data, we undertook bias checks on the matched households versus those households that were missing in the 2002 survey but available in 2006/07. We came up with descriptive statistics and a probit model of the two samples[7]. The results show that generally the two samples were not statistically different, and the matched sample is therefore taken to be representative of the initial sample.

The 2002 survey used a one-round survey with 12 months recall, while the 2006/07 income data were collected in four quarterly surveys with one or three months recall periods, in the standard

[5] Villages in Chimaliro are smaller (both in area and population) than in Liwonde, hence more villages were sampled from the former site than from the latter.

[6] The 2006/07 survey had other objectives apart from creating a panel data set, hence the households not found were replaced such that the total sample size became 404 households also for the second round.

[7] Not included due to space limitations but available on request.

PEN format (see Angelsen et al., 2014). Differences in frequency and recall periods can lead to systematic biases, e.g., long recall periods leading to underreporting of incomes that are generated frequently but in small amounts such as minor forest products. We cannot rule out this bias, although the average sample income in the two periods are quite close and suggest limited or no systematic bias at the aggregate level. Also, the fact that (forest) income is increasing in one site and decreasing in the other raises our confidence in the comparability of the two datasets.

To make incomes in the two periods comparable, incomes in the 2006/07 round were adjusted using the consumer price index (CPI) of the Malawi National Statistical Office (NSO). Throughout this paper, all incomes are therefore presented in constant 2002 Malawi Kwacha (MK).

Valuing subsistence income is a major issue in rural household surveys (Wunder et al., 2011). Most forest products, although being mainly used for subsistence, are also traded within the villages, and local market prices were then used. In other cases, subsistence products were exchanged between households in a barter trade, and households did not have major problems in putting the equivalent monetary value on them. For the remaining and small minority of products, we used prices reported by the household based on its own valuation of the product.

3.3 Empirical Analyses

Impact of Forest Reliance on Poverty Transitions and Income Growth

In testing hypotheses 1a and 1b, we ask the question whether forest reliance is one of the determinants of poverty and income growth. We closely follow the methods of Lawson *et al.* (2006) and Jalan & Ravallion (1998) who carried out similar studies on poverty transitions in Uganda and China.

A multinomial logit (MNL) model is used to test whether households with high initial forest reliance are more likely to be poor or not (Hypothesis 1a). The dependent variables are the four categorical poverty transitions: chronic poor, falling into poverty, escaping poverty, and never poor. Our regressors are 2002 assets, household characteristics and human capital (age, household size, dependency ratio, sex of household head, education) and two change variables that could reasonably be treated as exogenous for our purposes: change in household size and in sex of household head.[8]

Next we test the effect of forest reliance on income growth (Hypothesis 1b). Differences in logarithms of income in the two periods represent income growth. The specification of the model is as follows:

$$(\ln Y_{i2} - \ln Y_{i1}) = \beta_0 + \beta_1 X_{i1} + \varepsilon_i \qquad (1)$$

Subscript *i* represents individual households, while *1* and *2* refer to 2002 and 2006/07. The same X variables are used here as in the estimation of poverty transition above, in addition to initial forest income and initial total income. We estimated the model by Ordinary Least Squares (OLS), using robust standard errors to control for potential heteroskedasticity (Verbeek, 2008; Wooldridge, 2009).

Our choice of regressors is guided by the livelihood framework (Carney, 1998; Ellis, 2000) and previous studies (Mukherjee and Benson, 2003; Lawson et al., 2006). A household's livelihood outcome (in this case: poverty transition or income growth) is a function of assets (natural, physical, human, social and financial), which are themselves shaped by, *inter alia*, policies and institutions (not included due to limited variation in our data set). Studies have shown that

[8] We are interested in male to female (and not female to male) because of the expectation that female-headed household are more vulnerable than their counterparts. We therefore expect female-headed households to be poor and relying more on forests, *ceteris paribus*.

whether a household is poor or not in the next period is strongly influenced by its initial conditions, i.e., a set of household and village characteristics (Jalan and Ravallion, 1998; McCulloch and Baulch, 1999; Krishna et al., 2006; Lawson et al., 2006).

Using both MNL and OLS models exploit their different strength and weaknesses. In the MNL model there is a loss of information due to the categorization of the dependent variable (Ravallion, 1996; Cameron and Trivedi, 2005; Lawson et al., 2006). The OLS model avoids this by using income (change) as a continuous variable. The strength of the MNL model is that it permits asymmetric impacts, e.g., the impact of an increase in one variable on the likelihood of moving into poverty is not necessarily the exact opposite of the impact on moving out of poverty.

Higher Forest Use and Reliance as Safety Net

The second hypothesis concerns the role of forests as a safety net against poverty and/or shocks. We take advantage of panel data to assess how shocks and poverty affect *change* in forest reliance. The dependent variable is *change* in absolute forest income or share represented by Equations (3) and (4) respectively:

$$(\ln F_{i2} - \ln F_{i1}) = \beta_0 + \beta_1 X_{i1} + \beta_2 P_i + \beta_3 S_i + \varepsilon_i \qquad (2)$$

$$(f_{i2} - f_{i1}) = \beta_0 + \beta_1 X_{i1} + \beta_2 P_i + \beta_3 S_i + \varepsilon_i \qquad (3)$$

P_i is a vector of poverty transition dummies, S_i is a shock index; and the rest are as defined in Equation (1).

In the 2006/07 survey, households reported on shocks they experienced in the 12 preceding months. The most common shocks were crop failure, illness and livestock loss (Table 2). The various types of shocks were aggregated into three types: income, labor and asset shocks[9]. In addition, for each shock the households were asked to indicate its severity (0 = no shock, 1 = moderate shock, 2 = severe shock). We added the severity under the shock categories to generate an aggregate shock index.[10]

We analyze changes in both absolute forest income and share. Changes in absolute income are closely linked to changes in quantities of forest products and therefore what households actually use (some variation may also be due to price changes). Forest income share, on the other hand, takes into account the income distribution, and does better represent the importance of forest income in the livelihood of a particular household. A decline (increase) is, however, not necessarily be due to a decline (increase) in forest income but may come from increases (decline) in other income sources.

For both absolute and share of forest income, two variants of the model are run, i.e., with and without poverty transition dummies. We estimated these models by using Ordinary Least Squares (OLS) with robust standard errors to control for potential heteroskedasticity.

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[9] We acknowledge that there could an overlap in this categorization, e.g., illness could lead to both labor and income losses. We assume that the shock affects labor supply first with income loss as a secondary effect, and illness is therefore classified as a labor shock.

[10] For example, if a household reported 'moderate' crop failure (1), 'severe' loss of wage employment (2) and 'moderate' income loss due a costly social event (1), then the income shock index for such a household is aggregated to 4.

TABLE 2

Frequency of Shocks Reported by Households

Shock	Chimaliro		Liwonde	
	Frequency	Percentage	Frequency	Percentage
Income shocks				
Serious crop failure	69	47.6%	28	27.2%
Wedding or other costly social event	3	2.1%	3	2.9%
Loss of wage employment	1	0.7%	3	2.9%
Labor shocks				
Serious illness in the family	65	44.8%	31	30.1%
Death of productive adult	10	6.9%	11	10.7%
Asset shocks				
Major livestock loss	36	24.8%	15	14.6%
Land loss	4	2.8%	-	-
Other major asset loss	3	2.1%	3	2.9%

For all the models, the regressors were subjected to diagnostic tests. We used Variance Inflation Factor (VIF) test to check potential collinearity of the explanatory variables. Of particular concern was the potential collinearity between shocks and the poverty transitions in Equations (2) (3). All tests showed no collinearity (mean VIF values were below the collinearity threshold of 10). In addition, we conducted a Ramsey Reset Test (Barrett et al., 2001) to check for omitted variables, hence indirectly checking for endogeneity.[11] In Equation (1), the Ramsey test failed to reject the null hypothesis of no missing variables while, as expected, the opposite was true for Equations 2 and 3. Therefore, we cannot rule out potential endogeneity, and the regression results for Equations (2) and (3) should be treated more as "robust (partial) correlations" than cause-effect relationship.

[11] Ramsey test checks for omitted-variable-induced endogeneity. The null hypothesis is that there are no omitted variables.

4 Results and Discussion

4.1 Descriptive Analysis

Table 3 presents key statistics by poverty status for the two sites. For both 2002 and 2006/07, asset values in Chimaliro were significantly higher than in Liwonde. This difference mainly comes from livestock, and largely reflects cultural differences: in Chimaliro, livestock - especially cattle - is used to pay bride price. In 2006/07, livestock contributed 16 % (Chimaliro) and 9 % (Liwonde) to household income (Figure 2). Not surprisingly, the poor households had lower asset value and less agricultural land than the non-poor. For Chimaliro, households that fell into poverty experienced almost 50 % decline in their assets while those that escaped poverty more than doubled their assets.[12] The never poor households not only had far more initial assets than the other groups, but also experienced the highest asset increase (almost five times the 2002 value). For Liwonde, asset value generally declined during the period, except for the never poor. Overall, Table 3 suggests a close positive correlation between changes in assets and income, and between initial assets and *changes* in assets and the poverty status.

[12] The assets included livestock and household implements. Farm land was treated separately.

TABLE 3

Summary Statistics by Poverty Status and Site

		Chimaliro					Liwonde				
		Chron. poor	Into poverty	Out of poverty	Never poor	**Site average**	Chron. poor	Into poverty	Out of poverty	Never poor	**Site average**
Household characteristics:											
Age of hh head	2002	45.4	43.8	50.0	45.0	**46.4**	43.0	41.6	45.4	40.9	**42.7**
	2006/07	50.1	49.0	51.6	49.1	**50.2**	46.8	44.4	46.8	49.5	**46.7**
Hh size (head count)	2002	6.4	5.3	5.2	4.9	**5.7**	5.5	5.1	5.6	4.6	**5.2**
	2006/07	7.0	6.3	5.1	4.5	**6.0**	5.3	5.3	5.2	4.5	**5.2**
Hh size (aae)	2002	4.2	3.7	3.7	3.6	**3.9**	3.9	3.6	4.0	3.1	**3.7**
	2006/07	4.6	4.2	3.4	3.2	**4.0**	3.6	3.7	3.6	3.2	**3.5**
Female-headed hh (%)	2002	1.7	4.2	16.7	9.5	**7.6**	19.1	19.2	0.0	11.1	**14.7**
	2006/07	12.1	20.8	14.3	14.3	**14.5**	21.4	34.6	11.8	11.1	**21.4**
FCM membership (%)	2002	43	33	43	29	**39.3**	55	46	47	50	**50.5**
	2006/07	43	38	50	43	**44.1**	19	23	53	28	**27.2**
Assets:											
Agric. land size (ha)	2002	1.9	2.7	2.0	2.6	**2.2**	1.0	0.9	1.0	1.3	**1.0**
	2006/07	1.7	2.0	2.0	3.1	**2.0**	0.9	0.6	0.7	1.1	**0.8**
Asset value (MK/aae)[13]	2002	10576	18751	13130	24613	**14702**	4431	5774	5116	5757	**5115**
	2006/07	10483	9547	28519	111260	**30148**	2535	2793	3736	7786	**3716**
Income:											
Total (MK/aae)	2002	3374	14814	4179	15780	**7297**	4473	12409	3600	14105	**8015**
	2006/07	4006	4616	16146	27660	**11049**	3218	2823	10365	11044	**5666**
Forest (MK/aae)	2002	157	135	128	1148	**289**	1062	3443	1290	3094	**2056**
	2006/07	436	484	819	1176	**662**	539	380	821	1097	**643**

Note: hh = household; aae = adjusted adult equivalent; FCM = forest co-management group; asset value excludes land.

[13] Total value of household implements, tools and equipment.

While the mean household income was about the same in the two sites in 2002, it increased by approximately 50 % in Chimaliro and declined by 30 % in Liwonde, making the average household in Chimaliro having almost twice the income of Liwonde in 2006/7. This pattern corresponds with district level income data collected in a national survey around the same period (2004/05): Kasungu district, where Chimaliro is located, had average household income 2.6 times that of Machinga district, where Liwonde is located (National Statistical Office (NSO), 2005). Malawi is an agro-based economy, with tobacco as the main cash crop. Kasungu is one of the major tobacco-producing districts, and during the 2006/07 season the commonly grown burley tobacco was sold at relatively high prices compared with other seasons.[14]

An even more dramatic change is observed in forest income, as discussed further below. Table 4 singles out the relationship between forest reliance and poverty transitions. As there is a quite different trend in total and forest income between the sites, we introduce a measure of *Relative Forest Reliance* (RFR) to find out how the forest reliance changed relative to the average reliance for the two sites between the two years. RFR for an individual household *i* is calculated by dividing the individual forest reliance (FR_i) by the mean forest reliance among all *n* households in the site:

$$RFR_i = \frac{FR_i}{\frac{1}{n}\sum_{i=1}^{n} FR_i} \qquad (4)$$

RFR > 1 (<1) indicates above (below) average forest reliance. Table 4 reports the average RFR for the four groups, and the changes in RFR between the two surveys.

[14] According to the Tobacco Control Commission (of Malawi), burley tobacco fetched an average of USD1.73/kg in 2007. This was an increase from an average of USD1.25/kg in the previous decade (1995 – 2005).

TABLE 4

Forest Reliance by Poverty Transition

	Forest Income Share (Forest Reliance)		Relative Forest Reliance (RFR)		
	2002	2006/07	2002	2006/07	Change
Chimaliro					
Chronically poor	6.9	12.2	1.4	1.2	-0.2
Into poverty	0.9	12.9	0.2	1.3	1.1
Out of poverty	4.1	6.4	0.8	0.6	-0.2
Never poor	6.1	7.4	1.2	0.7	-0.5
Total	**5.0**	**9.9**	**1.0**	**1.0**	**0.0**
Liwonde					
Chronically poor	26.1	20.5	0.9	1.3	0.4
Into poverty	27.8	20.0	1.0	1.2	0.2
Out of poverty	36.8	8.5	1.3	0.5	-0.8
Never poor	22.7	9.1	0.8	0.6	-0.2
Total	**27.7**	**16.4**	**1.0**	**1.0**	**0.0**

Three interesting and related findings emerge from Tables 3 and 4.[15] First, there are contrasting stories to be told from the two sites. In Liwonde, absolute forest income declined by almost 70 % (Table 3), while share of forest income (forest reliance) was halved from 28 % to 16 % (Table 4). In Chimaliro, both absolute forest income and forest income share approximately doubled. Several studies have observed that Chimaliro Forest is better managed than Liwonde Forest (Makungwa and Kayambazinthu, 1999; Jumbe and Angelsen, 2007). This could be due to higher group homogeneity in Chimaliro, which is an enabling factor for sustainable management of common-pool resources (Baland and Platteau, 1996; Agrawal, 2001). An interesting observation – consistent with this claim – is that membership in forest co-management (FCM) groups has

[15] Note that the average forest reliance is calculated as the mean of the households' forest reliance. Because forest reliance tends to be higher among poorer households, the figures of Table 4 and Figure 2 would not be the same if we calculated the average forest reliance by dividing *average* forest income by *average* total income for the four different groups in Table 3.

increased in Chimaliro to 44 %, while it is almost halved to only 27 % in Liwonde (Table 3). Further exploring the role in institutions in forest use is beyond the scope of this paper.

Second, the relationship between poverty and forest income (absolute and share) for both sites agrees with what most studies have found (Cavendish, 2000; Babulo et al., 2008; Babulo et al., 2009). The non-poor have higher absolute forest income than the poor, but the poor have higher forest reliance than households that either moved out of poverty or were never poor.

Third, and related to the second hypothesis, the chronically poor and those that fell into poverty increased their forest reliance more than those that escaped poverty or were never poor (Table 4). In Chimaliro, this group increased their forest reliance from 6.9 to 12.2%. Those that fell into poverty increased their reliance dramatically, from a tiny 0.9 to 12.9%. Also when looking at the relative forest reliance (RFR), this group moved from having well below average (0.2) to having well above average (1.3) reliance on forest products.

Several factors might explain the drastic increase of forest reliance for those falling into poverty in Chimaliro. Total income contracted by 68%, automatically increasing forest reliance by a factor of three, assuming no change in absolute forest income. This group also had notable changes in household characteristics (Table 3). In particular, the share of female-headed households increased from 4.2 to 20.8%. This and other factors rendered this group more vulnerable to falling into poverty.

Households in Liwonde experienced a general decrease in forest incomes, but the decline was much lower for the poor than the non-poor households. While the non-poor decreased their forest reliance from 22.7 to 9.1%, the corresponding decrease for the chronically poor was from 26.1 to 20.5%. Those that fell into poverty also had a modest decline from 27.8 to 20.0 %.

4.2 Is Forest Reliance Responsible for Being Poor?

The poverty transitions illustrated in Tables 3 and 4 are analyzed further through a multinominal logit (MNL) model. The marginal effects coefficients presented in Table 5 are to be interpreted as marginal probabilities of being in a given poverty transition status for a one-unit increase in the independent variable.

TABLE 5

Multinomial Logit Model Marginal Effects

	Chimaliro				Liwonde			
Variable	Chronic. Poor	Into Poverty	Out of Poverty	Never Poor	Chronic. Poor	Into Poverty	Out of Poverty	Never Poor
Initial forest income								
Initial forest reliance (share, %)	0.09***	-0.17***	0.05***	0.03***	-0.00	-0.00	0.00	-0.00
	(6.08)	(-6.68)	(3.78)	(3.39)	(-0.48)	(-0.08)	(1.18)	(-0.30)
Initial assets								
Land size (ha)	-0.05	0.02	-0.00	0.03	-0.07	-0.02	-0.06	0.15***
	(-1.59)	(1.29)	(-0.02)	(1.31)	(-0.70)	(-0.28)	(-0.83)	(2.66)
Asset value (excl. land) (MK, log)	-0.03	-0.01	0.02	0.02	-0.00	-0.00	0.01	-0.00
	(-0.86)	(-0.75)	(0.54)	(0.85)	(-0.01)	(-0.31)	(0.62)	(-0.33)
Initial household characteristics								
Age (years)	-0.00	-0.00	0.00	-0.00	0.00	-0.00	0.00	-0.00
	(-0.41)	(-0.16)	(1.38)	(-1.10)	(0.07)	(-0.74)	(0.79)	(-0.03)
Household size (aae)	0.14***	0.00	-0.08***	-0.06**	0.09*	0.02	0.02	-0.13***
	(5.07)	(0.15)	(-2.74)	(-2.56)	(1.84)	(0.40)	(0.51)	(-3.17)
Dependency ratio[16]	0.04	-0.02	0.02	-0.05	0.04	0.00	-0.02	-0.03
	(0.73)	(-0.44)	(0.34)	(-0.97)	(0.60)	(0.07)	(-0.43)	(-0.41)
Education (1=no educ., 2=primary educ., 3=secondary educ., 4=tertiary educ.)	-0.10	-0.08**	0.01	0.17***	-0.19**	-0.04	0.11	0.13*
	(-1.32)	(-1.96)	(0.16)	(3.24)	(-2.10)	(--0.52)	(1.47)	(1.95)
Household head (0=male, 1=female)	-0.20	0.02	0.16	0.02	0.94	0.68	-1.89	0.28
	(-1.15)	(0.27)	(1.24)	(0.17)	(0.01)	(0.01)	(-0.01)	(0.01)
Distance to forest (km)	0.04	0.01	-0.03	-0.01	0.10	-0.11	-0.07	0.07
	(1.14)	(0.31)	(-0.89)	(-0.58)	(1.40)	(-1.38)	(-0.91)	(1.51)
Change variables								
Household size change (aae)	0.10***	0.04**	-0.07**	-0.07***	0.02	0.04	-0.02	-0.04
	(3.47)	(2.15)	(-2.40)	(-3.15)	(0.43)	(0.89)	(-0.58)	(-1.08)
Head change (male->female)	1.40	0.31	-2.35	0.64	0.72	0.67	0.34	-1.73
	(0.02)	(0.02)	(-0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(-0.01)
Number of observations	145				103			
Log-likelihood	-120.69				-113.60			
LR Chi-square	136.48***				43.78 ***			

Note: t-statistics in parentheses

*** significant at 1 % level, ** significant at 5 % level, * significant at 10 % level.

16 Ratio of dependents (=<14 years and >=65 years) to active household members (15 to 64 years)

The “poverty trap” hypothesis suggests high initial forest income to be positively associated with being chronically poor or falling into poverty. In Chimaliro, the results are dominated by the large and significant *negative* “initial forest reliance” coefficient for those that fell into poverty (cf. also Table 4). While high forest reliance reduced the likelihood of falling into poverty, it increased the likelihood of being in any of the other transition categories. In Liwonde, high initial forest reliance was not significant for any of the poverty transitions. The MNL results therefore do not support the hypothesis.

For the other variables, their impacts on poverty transitions do not differ much between the two sites. Being chronically poor was positively associated with large initial and increase in household size. The results are consistent with finding from similar studies (Krishna et al., 2006; Lawson et al., 2006). This intuitively makes sense, given that income is measured per adjusted adult equivalents: more household members imply more members to share the household income. Although the labor endowment also increases, there are fixed resources like land which help to explain the result. The dependency ratio, however, had no significant impact on poverty transitions.

The other significant variables have mainly the expected signs. An increase in land size increases the likelihood of being never poor in Liwonde (significant at 1 % level). High education was associated with the never poor in both sites, while the opposite was true for those falling into poverty in Chimaliro and the chronically poor in Liwonde.

4.3 Does Forest Reliance Inhibit Income Growth?

Turning to the second part of the first hypotheses, which seeks to assess whether households with high initial forest income experienced lower income growth, Table 6 presents results from the income change regression model. The main result is that "initial forest reliance" was *not* significant in influencing income growth. The coefficients and t-statistics are close to zero for both sites.

TABLE 6

Income Change Models

Variable	Chimaliro Change in income (log) Coefficient	t-statistic	Liwonde Change in income (log) Coefficient	t-statistic
Constant	5.76***	5.81	8.87***	6.22
Initial income				
Initial forest reliance (share, %)	0.00	0.13	-0.00	-0.08
Initial income (MK, log)	-0.85***	-10.39	-1.04***	-7.47
Initial assets				
Land size (ha)	0.01	0.21	0.31*	1.90
Asset value (excl. land) (log)	0.25***	3.06	0.02	0.77
Initial demographic characteristics				
Age (years)	0.00	0.25	-0.00	-0.53
Household size (aae)	-0.23***	-4.13	-0.16	-1.56
Dependency ratio[17]	-0.08	-0.72	-0.08	-0.55
Education (1=no educ., 2=primary educ., 3=secondary educ., 4=tertiary educ.)	0.31***	2.82	0.16	0.77
Household head (0=male, 1=female)	0.06	0.30	-0.41	-1.44
Distance to forest (km)	-0.10**	-2.14	0.02	-0.13
Change variables				
Household size change (aae)	-0.29***	-5.34	-0.13	-1.24
Head change (male->female)	-0.56*	-1.97	-0.55	-1.53
Number of observations	*145*		*103*	
F-test	*21.14****		*8.26****	
R^2	*0.60*		*0.43*	

*** significant at 1 % , ** significant at 5 %, * significant at 10 %

The model gives a strong and significant negative relationship between initial income and income growth. This is in line with what most panel studies of rural incomes in poor countries find, e.g., Lawson *et al.* (2006). A common explanation is income fluctuations; households can have good luck some years (a bumper harvest, a lucrative off-farm job, etc.), while they have bad luck other years (drought, illness of major breadwinner, etc.). Good and bad fortunes vary over

[17] See footnote to Table 5.

time, hence high or low incomes tend to return to a more normal level (Carter and Barret, 2006). The fluctuations can also occur due to measurement errors: income for some households were overestimated (underestimated) in the first round, but is unlikely to be so for the same households in the second period.

The regression models are consistent with the descriptive figures of Table 3. In Chimaliro, households that moved out of poverty experienced the highest rate of income growth (286 %). In comparison, the never-poor households had a 75 % income growth. The same was true for Liwonde: households that moved above the poverty line were the only ones that experienced income growth.

The magnitude of the initial income coefficient is also relevant. Recall the formulation of our model as given in Equation (1). We estimated: $(\ln Y_2 - \ln Y_1) = \beta_0 + \beta_1 \ln Y_1$, which is equivalent to: $\ln Y_2 = \beta_0 + (\beta_1 + 1) \ln Y_1$. Hence, $\beta_1 = -1$ means that income in spell 1 (2002) has no impact on income in spell 2 (2006/07). This seems to be the case for Liwonde, with a coefficient around unity. It is indicative of a situation with high volatility, a picture also painted by Table 2 with dramatic reductions in total income and forest income. This income volatility is a weaknesses of income (or expenditure) as a measure of chronic poverty as opposed to assets (Carter and Barret, 2006).

The other results are generally in line with the poverty transition model above. The coefficient for household size is negative and significant for Chimaliro. Expectedly, more education of household heads was associated with more income growth (not significant in Liwonde). In Chimaliro, households that changed headship from male to female experienced lower income growth (a typical case would be the death of the husband). The other variables – dependency ratio and asset value – had the expected signs but were not significant. The significant variables are in line with our expectation and are consistent with similar studies carried out in Malawi (Mukherjee and Benson, 2003) and elsewhere (Krishna et al., 2006; Lawson et al., 2006).

4.4 Do Households Use Forests as Safety Nets?

The second hypothesis concerns how forest use and reliance change when households fall into poverty and/or face shocks. We study changes in both absolute forest income (Models I and II) and forest income share (Models III and IV). Two variants – with the poverty transitions (Models I and III) and without (Models II and IV) – are presented in Tables 7 (Chimaliro) and 8 (Liwonde). For the poverty transition models, the "never poor" is the default category.

TABLE 7

Absolute Forest Income and Forest Income Share Change Regressions for Chimaliro

	Change in absolute forest income				Change in forest income share			
	Model I		Model II		Model III		Model IV	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
Constant	6.11***	6.12	6.24***	5.83	25.64*	1.83	25.12	1.41
Initial income								
Total income (MK, log)	-0.01	-0.13	-0.04	-0.47	0.37	0.32	-0.10	-0.06
Forest income (MK, log)	-0.83***	-7.73	-0.82***	-7.72				
Forest income share (%)					-0.88***	-5.15	-0.86***	-4.58***
Initial assets								
Asset value (exc. land) (MK, log)	-0.02	-0.30	-0.03	-0.45	-2.65***	-2.73	-2.46***	-3.07
Land size (ha)	-0.05	-0.89	-0.06	-1.12	-0.59	-0.97	-0.60	-1.02
Initial household characteristics								
Age (years)	-0.01	-1.19	-0.01	-1.41	-0.01	-0.15	-0.00	-0.03
Household size (aae)	-0.18***	-3.91	-0.13***	-2.70	-0.06	-0.10	-1.19*	-1.87
Dependency ratio[18]	0.09	0.84	0.09	0.89	1.71	1.23	1.52	1.16
Education (1=no educ., 2=primary educ., 3=secondary educ., 4=tertiary educ.)	0.22	1.46	0.23	1.60	1.98	0.77	3.43	1.45
Household head (0=male, 1=female)	-0.23	-0.8	-0.33	-1.17	-4.90*	-2.18	-3.20	-1.44
Distance to forest (km)	-0.05	-0.87	-0.04	-0.69	0.45	0.80	0.21	0.41
Change variables								
Household size change (aae)	-0.18***	-3.91	-0.28***	-4.26	-1.30	-1.00	-2.49**	-2.00
Head change (male->female)	0.07	0.30	0.17	0.73	1.73	0.76	-1.16	-0.61
Shocks								
Income shock index	-0.05	-0.60	-0.03	-0.33	1.73	0.76	0.22	0.18
Asset shock index	0.04	0.42	0.02	0.23	-1.92	-1.30	-1.60	-1.15
Labour shock index	0.02	0.33	0.01	0.19	-0.33	-0.38	0.28	0.35
Poverty transitions								
Chronically poor (dummy)			-0.19	-0.69			6.21	1.39
Into poverty (dummy)			0.06	0.27			9.95***	3.63
Out of poverty (dummy)			0.22	0.90			0.10	0.02
Number of observations	*145*		*145*		*145*		*145*	
R^2	*0.54*		*0.57*		*0.42*		*0.49*	
F-statistic	*7.34****		*6.73****		*6.24****		*8.12****	

*** significant at 1 % , ** significant at 5 %, * significant at 10 %

[18] See footnote to Table 5.

We find a strong negative relationship between change in absolute (log) forest income and the initial forest incomes. The explanations are similar as for total income: fluctuations in (forest) income and possibly also measurement errors. The coefficients (for initial income and other variables) are quite unaffected by the inclusion/exclusion of the poverty transition variables.

The "safety net" hypothesis relates to two sets of variables. First, we expected households that moved into poverty or were chronically poor to increase their forest use and reliance, cf. Tables 3 and 4. The regression results (Tables 7 and 8) give little conclusive evidence of households using forest as a safety net when they move into poverty, after controlling for other factors. The poverty transition coefficients in the absolute forest income (Model II) are not significant. For forest income share (Model IV), the coefficients for "into poverty" are positive – as hypothesized - and significant for both sites, with a stronger effect for Liwonde. Similarly, the "chronic poor" variable is positive in both sites, but only significant in Liwonde.

Second, we tested the impact of different forms of shocks on the change in forest reliance. We find no significant coefficients for Chimaliro (Table 7). A surprising result is the negative and significant asset shock variable for Liwonde (Table 8). An asset shock does not result in an immediate income loss and therefore less of a short term need for income compensation by, for example, increasing forest income. Yet the result remains puzzling.

TABLE 8

Absolute Forest Income and Forest Income Share Change Regressions for Liwonde

	Change in absolute forest income				Change in forest income share			
	Model I		Model II		Model III		Model IV	
	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics	Coefficient	t-statistics
Constant	4.58**	2.11	-1.24	-0.25	20.96	0.55	-19.98	-0.47
Initial income								
Total income (MK, log)	-0.19	-0.86	0.39	0.95	-1.29	-0.41	2.03	0.48
Forest income (MK, log)	-0.98***	-6.44	-0.99***	-6.13				
Forest income share (%)					-0.97***	-12.79	-0.96***	-13.01
Initial assets								
Asset value (exc. land) (MK, log)	0.18	1.12	0.18	1.16	0.18	0.54	0.26	0.82
Land size (ha)	0.40*	1.82	0.62*	1.74	-0.05	-0.02	1.72	0.49
Initial household characteristics								
Age (years)	0.01	0.85	0.01	0.81	-0.01	-0.04	0.01	0.04
Household size (aae)	-0.23*	-1.76	-0.28	-1.55	-1.74	-0.95	-3.05*	-1.67
Dependency ratio[19]	0.16	0.61	0.07	0.31	-0.59	-0.16	-1.53	-0.42
Education (1=no educ., 2=primary educ., 3=secondary educ., 4=tertiary educ.)	0.52**	2.06	0.53*	1.77	6.48	1.41	9.43**	2.04
Household head (0=male, 1=female)	0.16	0.42	0.15	0.42	5.64	0.65	2.92	0.35
Distance to forest (km)	-0.04	-0.24	-0.03	-0.15	-2.30	-0.62	-3.00	-0.83
Change variables								
Household size change (aae)	-0.10	-0.67	-0.12	-0.75	2.28	1.23	1.20	0.69
Head change (male->female)	0.05	0.17	0.04	0.13	12.33	1.39	11.91	1.46
Shocks								
Income shock index	0.26	1.49	0.17	0.97	3.97	1.42	3.04	1.05
Asset shock index	-0.35*	-1.89	-0.38**	-1.98	-5.84**	-2.58	-6.95***	-3.04
Labour shock index	-0.03	-0.21	-0.10	-0.73	-0.12	-0.05	-1.01	-0.50
Poverty transitions								
Chronically poor (dummy)			1.45	1.22			19.09***	2.87
Into poverty (dummy)			0.93	0.91			11.91***	2.69
Out of poverty (dummy)			1.78	1.39			3.23	0.41
Number of observations	*103*		*103*		*103*		*103*	
R^2	*0.43*		*0.46*		*0.68*		*0.72*	
F-statistic	*7.19****		*5.72****		*22.42****		*26.35****	

*** significant at 1 % , ** significant at 5 %, * significant at 10 %

[19] See footnote to Table 5.

Another seemingly surprising result is the positive and significant coefficient for the *Education* variable for Model IV in Liwonde. Another paper using the same dataset (Chilongo, 2014) finds that households with the highest forest reliance (those pursuing the *Forest-Business* livelihood strategy) also had the highest level of education (7.4 years). Thus, a (small) group of relatively well-educated households in Liwonde has used commercial forest products (mainly fuelwood) as a major income generating activity.

In summary, the results are not conclusive, but there is some evidence to support the hypothesis that forest are used as safety nets in the way that forest reliance increases when households fall into poverty or are chronically poor.

4.5 Discussion of Hypotheses

An important feature of the local economy is the strong subsistence orientation. More than half (55%) of the income is direct consumption of products collected or cultivated by the household. Forest income is even more subsistence-oriented (90 %). This has several implications relevant to our hypotheses. First, forest income is relatively sheltered from price fluctuations in the market. Combined with the fact that forest production, compared to agriculture, is less sensitive to annual variations in rainfall, we can also expect relatively lower variation in forest income from year to year. Second, the fact that forest income is dominated by subsistence uses also puts a limit on the current potential of forest income to serve as a pathway out of poverty. Put simple: it is hard to move out of poverty by using more firewood for domestic cooking.

Hypotheses 1a & 1b (forests as poverty traps)

Hypothesis 1a predicted high initial forest reliance to be one of the determinants of poverty transition (chronic or into). The MNL results for Chimaliro showed that households with high initial forest reliance were more likely to be chronically poor, and this was the case for the categories “out of poverty” and “never poor”. The model even predicted that households with low initial forest reliance were more likely to fall into poverty. In Liwonde, coefficients of initial forest reliance were all close to zero and mostly not significant. Overall, these results were not consistent with the prediction that only those that remained chronically poor and fell into poverty would have higher initial forest reliance than the other two transitions.

Similarly, hypothesis 1b predicts that income growth is lower for households with high initial forest reliance than those with lower initial forest reliance. Table 4 gave no clear pattern for initial forest shares across the poverty transitions. Although the chronically poor had the highest forest income share in Chimaliro, they were followed by the never poor and not those that fell into poverty. The group that escaped poverty in Liwonde had the highest initial forest share. The income change model in Table 6 showed that the effect of initial forest on change in total household income was not different from zero in both sites. In short, the study has *not* provided any evidence to conclude that forest reliance was a hindrance for moving out of poverty.

Several preconditions must be in place if forest extraction is to be a poverty trap: (i) it should constitute a large share of household income, (ii) should be a low-return activity, and (iii) high-return alternatives should be readily available. These are only partly met in our study area. Forest income makes up 10% (Chimaliro) and 16% (Liwonde) of household income, as compared to crops constituting about half of the income portfolio. While forest extraction may be characterized as a low return activity (cf. the high overall subsistence share), this is not the case for all households. In Liwonde, we find a sub-group of households that pursue a livelihoods strategy of forest and business activities, and that have high income compared to those pursuing other livelihoods strategies (Chilongo, 2014). Forest income makes up 39% of the total income for this group, and these households are able to take advantage of their favorable location close to markets.

Hypothesis 2 (forests as safety nets)

The second hypothesis predicted that households moving into poverty increase their absolute forest income and forest income share (reliance). The figures of Table 3 do not lend support to this hypothesis. In Chimaliro, those escaping poverty had the highest increase in absolute forest income. In Liwonde, where household income declined, those getting out of poverty had the smallest decline in absolute forest income. In the regression model, change in absolute forest income was not affected significantly by "falling into poverty" or most of the shock variables. These results are not surprising as studies have shown that the richest households have higher absolute forest income than the poorest (Cavendish, 2000; Jumbe and Angelsen, 2007; Babulo et al., 2009; Debela et al., 2012).

More support for the safety net role of forest is revealed when *forest income share* is considered. In both sites, households that fell into poverty increased their forest reliance substantially while those that moved out of poverty reduced their reliance (Table 4). This pattern became even clearer by examining what we have termed the 'relative forest reliance' (RFR), which takes site level trends in forest and overall income into account. Households that fell into poverty generally experienced the highest RFR change while those that escaped poverty had the least change in their relative forest reliance (Table 4). These results were to some extent confirmed by regression model (Table 7 and 8), where falling into poverty was associated with higher forest reliance.

When analyzing the links between shocks and forest income, the results provide little evidence to support the hypothesis that households use forests as a safety net against shocks. This was contrary to our expectations and some previous studies (Fisher, 2004; Debela et al., 2012). The reasons for our results could be several. On the methodological side, our shock variables only covered a 12-month period. Studies with longer shock period, such as Debela *et al.* (2012), found a very significant positive relationship between shocks and forest reliance. Another possible weakness could be the way we measured the shock variable since we did not attempt to measure the magnitude of the shock (e.g., amount of income lost). But, the results also suggest that in the Malawian context forests do not easily fulfill safety net functions, as they are primarily for subsistence of specific products, and these do not easily substitute cash income shortfalls. Our result also fits with the broader findings of the PEN project which this study was part of: intensified forest use may not be as common as a coping strategy as sometimes assumed in the literature (Wunder et al., 2014)

There is some evidence to suggest that households in Liwonde rely more on forests as a safety net more than in Chimaliro (i.e. forest income being more important when falling into or staying in poverty, cf. Table 49). This finding seems counterintuitive from the postulations that access to off-farm employment and a central location are negatively related with using forest as safety nets (Godoy et al., 1998; Völker and Waibel, 2010). Liwonde has also more degraded forests than Chimaliro. The probable explanation for the difference between the sites is the better market access of Liwonde for forest products, and as illustrated by cash share of forest income being twice that of Chimaliro. In our study, market access seems to trump forest access when it comes to forests playing a safety net role.

Overall, our results gave mixed evidence in regards to the safety net hypothesis, and the answer depends on what measures one consider (shock vs. income decline) and forest income share vs. absolute forest income. This should also serve as a warning to researchers not to only consider one single measure of forest use.

5 Conclusions

This paper has presented one of the very few studies that use panel data to investigate the role of forest income in poverty dynamics and transitions. Following the same households over time permits researchers to answer the kind of questions asked in the title, i.e., whether rural households with significant forests reliance are trapped in the forest or saved by the forest.

We find strong evidence of higher forest reliance among the poor compared to the non-poor. However, *absolute* forest income is higher among households above the poverty line. These results are consistent with the majority of findings in the literature.

We find some evidence in support of the hypothesis that forests function as a safety net when households fall into poverty, particularly in the descriptive analyses. We introduce a new indicator to measure this, the relative forest reliance (RFR), which is a household's forest reliance divided by the average forest reliance in the site. This indicator increased from 0.2 to 1.3 in Chimaliro, and from 1.0 to 1.2 in Liwonde for households falling into poverty. The opposite is, however, not the case: those that got out of poverty did not reduce the relative forest reliance as much as those that fell into poverty.

Are the forest-reliant people trapped in the forests? We find no support of this hypothesis, if anything those with high forest reliance in 2002 appear to have done slightly better than their neighbors. But we also found little evidence that forests helped people move out of poverty, and in that sense the forest-reliant people are not saved by forests. The study has, however, both shown that the poor people depend more on forests, and that those that fall into poverty increase their forest reliance. In that sense poor people in the two study sites in Malawi are saved by forests.

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APPENDIX:

Calculation of Adjusted Adult Equivalent (aae)

Each individual is given an adult equivalent weight based on age and sex, which reflects their consumption needs, cf. Table A1. The sum of these gives the household's total adult equivalent (*ae*), which in turn is multiplied by their corresponding economies of scale factors to generate an adjusted adult equivalent (*aae*).

TABLE A1

Adult Equivalent and Economies of Scale Calculation Coefficients

Age (years)	Adult Equivalent Scale		Economies of scale	
	Male	Female	Household size (ae)*	Economies of scale factor
0-2	0.40		0-2	1.000
3-4	0.48		2-3	0.946
5-6	0.56		3-4	0.892
7-8	0.64		4-5	0.851
9-10	0.76		5-6	0.807
11-12	0.80	0.88	6-7	0.778
13-14	1.00	1.00	7-8	0.757
15-18	1.20	1.00	8-9	0.741
19-59	1.00	0.88	9-10	0.729
60+	0.88	0.72	10-11	0.719

*Adult equivalent unit (unadjusted to economies of scale)

Source: *Deaton (1997)*

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Thabbie Maxwell Saukira Chilongo was born in Blantyre, Malawi. He holds a BSc. in Agriculture (Agricultural Economics) and an MSc. in Agricultural Economics, both obtained from University of Malawi in 2001 and 2005 respectively.

This thesis assesses the role and determinants of forest products on livelihoods of rural households surrounding Chimaliro and Liwonde forest reserves in Malawi. The task is achieved in four independent but thematically-related papers. The thesis consists of an introductory chapter, which summarizes and synthesizes the papers. Full paper insertions follow the introductory chapter.

Paper I investigates rural livelihood strategies in Malawi. Specifically, the study addresses three questions. First, what are the main livelihood strategies? Second, what shapes these strategies? Third, how do the outcomes of these livelihood strategies compare with the degree of household forest reliance? Principal component and cluster analyses identify four livelihood strategies at each site. The findings suggest that some households turn to forest and other non-agricultural activities to compliment inadequate agricultural income.

Paper II assesses the relationship between labor productivity and forest reliance by testing the hypothesis that the forest is an employer of last resort. The paper employs a 2SLS method to estimate shadow wages in a composite agriculture-forest output as a proxy for household labor productivity. Despite that the market wage rate exceeds the average household shadow wage, the low-incidence of off-farm employment in the sample suggests strong rationing in the labor market. This means households continue to depend on self-provisioning activities, implying eventual negative consequences for the local agricultural and forest resource base. The policy implication from this finding is that environmental conservation goals will be advanced by investing in agriculture and expanding employment opportunities in rural areas.

Paper III investigates the role of forest products in filling the seasonal income gaps in a rural developing country context. The study uses quarterly survey data collected over a period of one year. Apart from the commonly used correlation measure, the paper introduces a new seasonal gap filling measure that separates seasonal and inter-household income variation. The results demonstrate that forest products play a seasonal gap filling role for the low-income households and those households where forest is one of the main livelihood activities.

Paper IV investigates the role forest income plays in movements in and out of poverty. Using a two-period, balanced panel data set of 248 households, the paper tests whether households with high forest reliance are likely to remain poor or fall into poverty and whether forest use is a safety net when households fall into poverty or face shocks. The results suggest that forests were not poverty traps but rather fulfilled important safety net functions for the chronically poor and households that fell into poverty.

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