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Rural Households' Forest Use in Fragmented Forest Landscapes

An Example from Tanzania's Usambara Ecosystem

H. Jo Albers, Razack Lokina, Elizabeth J.Z. Robinson and Victoria Kreinbrink

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H. Jo Albers, Razack Lokina, Elizabeth J.Z. Robinson and Victoria Kreinbrink*

Abstract

The overarching purpose of this discussion paper is to provide a starting point for consideration of the implications of changing households' access to forests and forest products and to changing management of lands outside of reserves. We study five communities located in and around the Amani Nature Reserve and the Nilo Forest Reserve, within the broader landscape of the biodiversity hot spot of Tanzania's Eastern Arc, the East and West Usambara Mountains. Based on our 2015 survey of just over 300 households, we document how villagers' own landholdings, access to forest land, and understanding of the links between forests and ecosystem services affect their willingness to cooperate with government efforts to improve forest quality. We consider the benefits that households get from nearby, albeit often degraded, forest lands, and their perceptions on whether it would be of benefit to protect a larger area of forest land to provide ecosystem services for the broader landscape. We explore villagers' attitudes to possible government efforts to reduce forest loss and fragmentation.

Keywords: forest, Tanzania, fragmentation, non-timber forest products (NTFPs), perceptions, ecosystem services, corridors, economics

JEL Codes: Q15, Q24, Q23, Q01, Q57

Rural Households' Forest Use in Fragmented Forest Landscapes: An Example from Tanzania's Usambara Ecosystem

1. Introduction

In many lower-income countries, forests in agricultural landscapes are degraded and fragmented, often due to a combination of poor enforcement of forest boundaries and increasing demand for agricultural land (Hobbs et al., 2008). The combination of deforestation and forest fragmentation often results from individual farmer choices to expand their farmland, or to migrate into an area because they can see opportunities for taking this unprotected "unclaimed" land, and so improve their livelihoods. Individual farmers may benefit in the short and even the long term from these farming opportunities. From an ecological perspective, fragmented forest landscapes are problematic for a variety of reasons including negative edge effects and an inability to support wildlife populations in small remnants. For these reasons, in our study site location, a number of efforts are being made to "de-fragment" the landscape, potentially with negative impacts on local households.

Both deforestation and fragmentation are well known to reduce the ability of the landscape to provide a broad range of critical ecosystem services, such as protection of global biodiversity (Tscharntke et al., 2005). Yet, little attention has been directed towards understanding the decisions of individuals and communities that live in these fragmented landscapes, or the impacts on households over the longer term, as they may gain farmland but lose ecosystem services such as non-timber forest products (examples related to Tanzania include Soini, 2005; Rantala et al., 2012). Individual households are likely to be negatively affected by fragmentation and deforestation if, for example, these changes make it harder and more time consuming to collect resources such as fuelwood and forest foods because forest access is now farther away, or forest resources are affected by drying and other ecological processes in high-edge forest fragments (examples include Newmark, 1991; Carlson and Hartman, 2001; Fahrig, 2003; Tabarelli et al., 2004). They may also be harmed indirectly by forest fragmentation due to the loss of ecosystem services as local public goods, such as village level provision of water resources.

Recognising the broad costs of fragmented landscapes, with particular emphasis on species conservation, NGOs, governments, and forest managers are increasingly attempting to halt and even reverse the gradual degradation and loss of forests, and part of that process is to reduce the fragmentation of forest landscapes. Yet, the reality in lower-income countries includes "matrix" areas of fragmented

forest landscapes – areas comprising multiple patches of both farm and forest land – that support rural people's livelihoods both directly and indirectly. Therefore, policies need to reflect rural people's needs, decisions, and institutions, and anticipate how these people will react to de-fragmentation policies, in order to achieve ecosystem priorities (Albers et al. 2018). To reduce forest fragmentation, agricultural land must be taken back from individual community members or otherwise modified in ways that can reduce the land user's direct benefit. These individuals will be directly harmed by such actions through the loss of harvests, even if the community as a whole over the longer term benefits from improved supporting and regulating ecosystem services.[1] Therefore, reversing fragmentation is likely to be tricky, and could cause conflict between farmers and de-fragmentation managers.

The feasibility and desirability of forest managers' actions to de-fragment the forest depend in part on whether local households living in this forest landscape support such actions, and on whether these households believe that they will be harmed or will benefit. Recognising this reaction to policy, and the importance of both people and forests, forest managers increasingly attempt to work with local communities, whether to minimize the costs imposed on them, to create incentives for involvement, to find ways to compensate these communities, or to find win-win solutions (Pagdee et al., 2006; Albers and Robinson, 2011; Robinson et al., 2013). In this paper, we provide a case study of one forest landscape in Tanzania where forest managers are considering how best to deal with forest fragmentation in the wake of the creation of the nearby Derema Corridor, which links forest fragments. Central to these choices is an improved understanding of both how villagers' livelihoods are affected by the surrounding forest-agriculture landscape and the extent to which households would support and engage with initiatives to improve forest quality.

The overarching purpose of this discussion paper is therefore to provide a starting point for consideration of the implications of changing households' access to forests and forest products and to changing management of lands outside of reserves, in the context of a fragmented agriculture-forest matrix landscape. We provide a snapshot of five communities located in and around the Amani Nature Reserve and the Nilo Forest Reserve, within the broader landscape of the biodiversity hot spot of Tanzania's Eastern Arc, the East and West Usambara Mountains. Based on our 2015 survey of just over 300 households, we document how villagers' own landholdings, access to forestland, and understanding of the links between forests and ecosystem

[1] Ecosystem services have been classified as supporting, such as soil structure and organic carbon; provisioning, such as crop yields and yields of non-timber forest products; regulating, such as crop pest control and pollination; and cultural, which can include recreation, spiritual experiences, and sense of place.

services affect their willingness to cooperate with government efforts to improve forest quality. We consider the benefits that households get from nearby, albeit often degraded, forest lands, and their perceptions on whether it would be of benefit to protect a larger area of forest land to provide ecosystem services for the broader landscape. We explore villagers' attitudes to possible government efforts to reduce forest loss and defragmentation.

The paper is structured as follows. In Section 2, we provide details of the study site and a new dataset collected in 2015. Section 3 presents the preliminary data analysis, and finally in Section 4 we discuss the implications for policy makers responsible for both livelihoods and ecosystem services.

2. Study Site and Methods

2.1 Study Site

The Eastern Arc, which stretches from southern Kenya through eastern Tanzania, is recognized for its importance for birds, primates, and flora, and the East Usambaras is one of the most important areas for biodiversity (Burgess et al., 2007). The area is also important for regional ecosystem services, particularly regulation of the flow of water to urban users in Dar es Salaam and up to 25 percent of Tanzanians (Mtalo et al., 2005; Lopa et al., 2012). The forests benefit local communities in many ways, including prevention of soil erosion and providing a source of non-timber forest products (NTFPs). In Tanzania's Eastern Arc mountains more broadly, NTFPs account for around 20 percent of household cash and non-cash income (Schaafsma et al., 2014). Local communities and NGOs have, however, noticed that forest ecosystem services appear to be declining (Pfund et al., 2011).

The households we surveyed are surrounded by a complex network of forests, each with different access rules, each containing different resources, and each providing a different mix of ecosystem services. For example, villagers as a whole have the opportunity to exert considerable control over land designated as a village forest. This land may be *de facto* open access or it may be governed under a set of village-level rules. Some village forests are covered by a formal community-based forest management arrangement. Whichever institutional arrangement is adopted, villagers typically have rights to extract non-timber forest products and may be able to get permission to cut trees for timber. Village forest reserves are actively managed by households from the relevant village and are governed by a set of formal rules. The villagers decide whether outsiders can access the forest and, if so, under what terms (Blomley and Iddi, 2009). Villagers themselves must also adhere to specific regulations governing the use of the forest, for example, whether or not extraction is

permitted and under what conditions. In contrast, a "forest nature reserve", such as Amani Nature Reserve, is a category of protected area in Tanzania that has the highest level of protection under the Tanzania Forest Act. Forest nature reserves are generally designated as such due to unique or rare contributions to biodiversity that resource extraction threatens. Thus, typically, extraction of forest resources and hunting are not allowed and the reserves are mainly used for research, education, and nature tourism. Finally, a central government forest reserve is owned and managed by the Tanzanian government. Historically there has often been little active management of forests with this classification, though increasingly these are forests where government or community forest management has been introduced. Villagers typically have few rights to extract from these forests, regardless of whether the forests are jointly managed by the village and the government. Thus, some forests can provide villagers with provisioning services, particularly non-timber forest products; whilst all will provide supporting, regulating, and cultural services to different degrees, depending on both the specific ecological aspects of the forest and the extent of degradation of the forests.

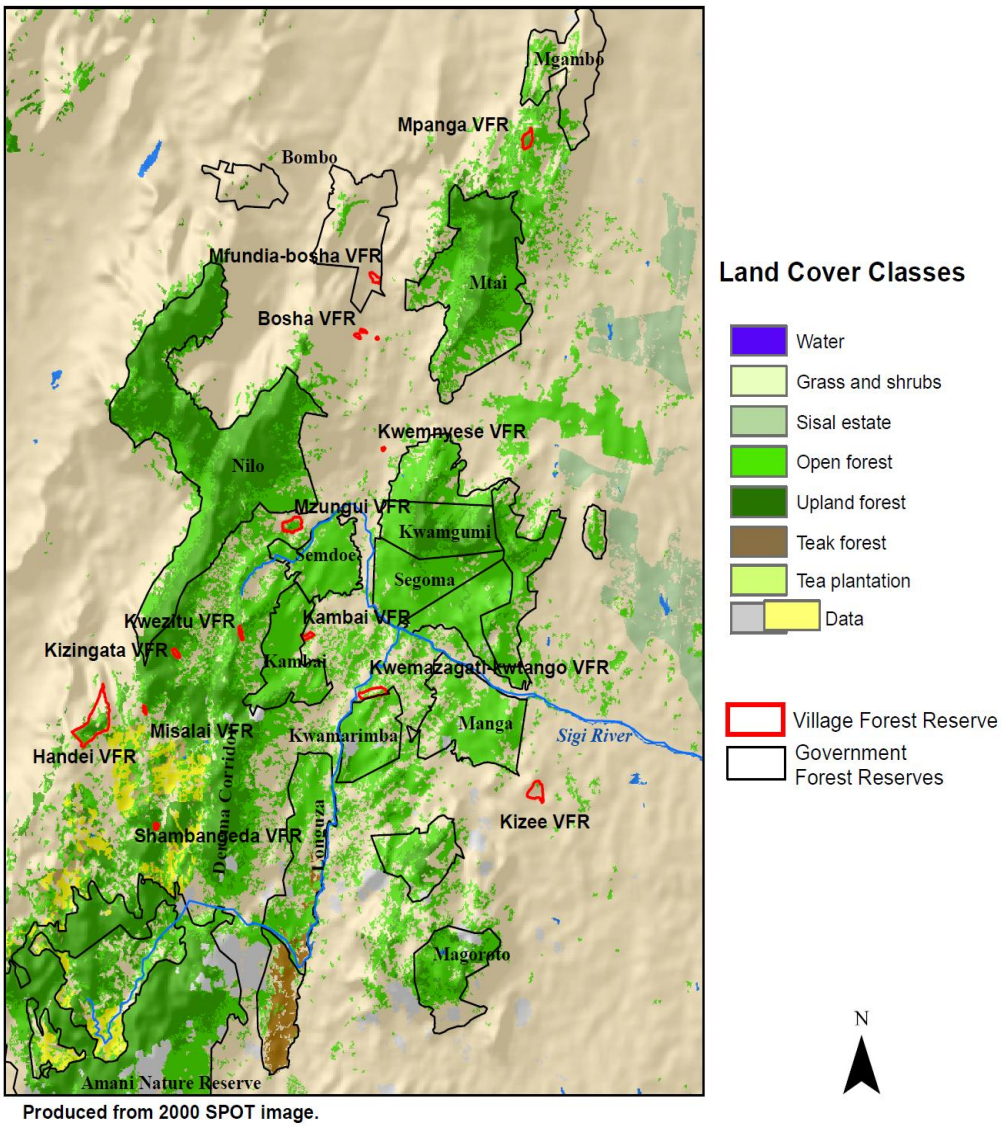
2.2 Sample and Data Collection

To develop a sense of the resource issues facing these communities and individuals, we conducted focus group discussions. These discussions generated general information on production/harvesting trends and seasonality, markets, and prices. The participants in the focus group discussion were asked to list: (i) the commonly harvested forest products (medicinal plants, grasses, reeds, palms, fuel-wood, wild animals, honey, mushrooms, wild fruits, wild vegetables); (ii) who mainly collects them (e.g. women, children); (iii) main uses; (iv) if sold: location of markets and average prices; and (v) average yield. We used this information to define the survey instrument for households.

Five villages located within Tanzania's East Usambaras (Figure 1) were selected for sampling because they have projects with the Tanzania Forest Conservation Group (TFCG). From these five villages, a total of 308 households were randomly selected and interviewed using a structured questionnaire. Two villages, Shambangeda and Mlesa, are located within Amani Nature Reserve (ANR); Kizerui village is adjacent to Nilo Forest Reserve; Misalai village is located between the two reserves; and Kambai is outside of both reserves. The survey focused on social and economic data that are particularly relevant to the communities living within the Usambara ecosystem. The first set of questions addressed socio-economic characteristics of the households, in addition to questions concerning the household's wealth, ownership of physical and financial assets, access to credit facilities and

possession of a savings account, sources of income, and the estimated income from each source. The second set of questions focused on each household's interactions with the nearby forests, such as resources extracted from forest patches, in addition to their farming activities on their own land. The questionnaire then explored conservation-related information, such as the awareness of resource values and perceptions of the general status of water flow and forest conditions. Questions on the market organization and prices of different goods within the village and outside the village were asked in order to track the value chain of products from the producer to the consumer outside the study area.

Figure 1: Government and Village Forest Reserves of the East Usambaras



We take a livelihoods-landscape perspective to frame our findings, exploring the benefits and costs that households perceive from various on-farm and off-farm

locations. We focus particularly on those ecosystem services and dis-services that households identified in focus group discussions as being important: forest products; access to water and fuelwood; and damage caused by wildlife.

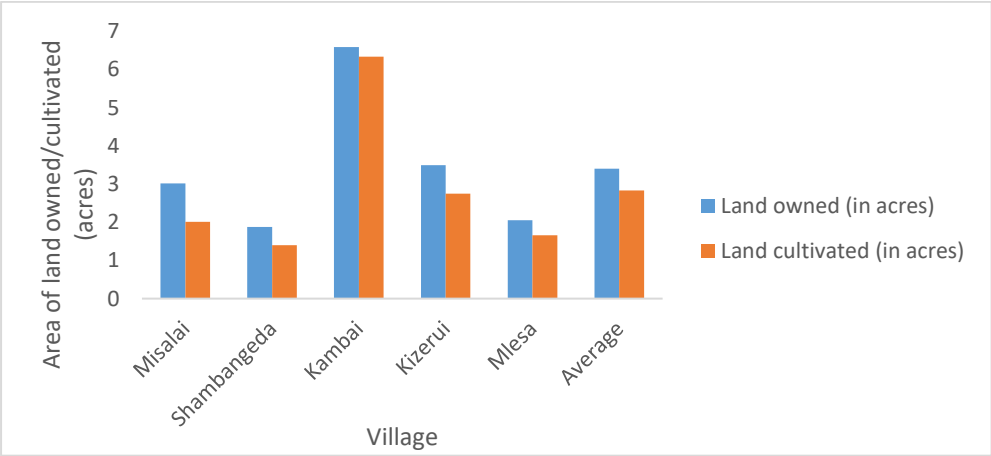
3. Findings

In this section, we present the key results from our survey to build up a picture of the livelihoods of households living within the Usambaras matrix of forest and agricultural land.

3.1 Livelihoods within the Farm-Forest Landscape

Most households (80%) in our sample have access to agricultural land, whether owning, renting, or leasing. The remaining households are classed as landless, typically owning their home and the plot of land on which it is located, but having no additional land suitable for cultivation. On average, each household cultivates around 3 acres of land, though this average varies from village to village, with those from Shambangeda cultivating just over one acre and those from Kambai just over six acres (Figure 2). Thus, most households can get direct provisioning services (primarily agricultural harvests) from their own land.

Figure 2: Average Landholdings per Household



Households also have access to a range of differently-designated forest areas at various distances from their homes. These forest institutions include individual forest land; village forest land subject to community management, including management for non-timber forest product extraction; village forest reserves that the community manages for conservation purposes, perhaps with a goal of receiving

REDD payments[2]; and federal government forest reserves to which communities may have limited legal access, with considerable illegal access. Whilst households in Shambangeda typically have their own forest land (typically owned by a particular "clan" and used for ritual purposes) and farm land close to their homesteads, other villagers, such as those living in Mlesa, are closer to government forest reserves than they are to either their individual forest land or their own farmland. This type of heterogeneity in forest access may imply that different villages face different rankings of the importance of various forest institutions based on proximity, such as government forest reserves having more importance in Mlesa than in Shambangeda (Table 1).

Table 1: Average Time-Distance from Homesteads to Farm and Forest Land

Average Walking Time (minutes)	**Own Farm Plot**	**Own Forest**	**Village forest land**	**Village Forest Reserve**	**Forest Aature Reserve**	**Gov't Forest Reserve**
Misalai	39.5	69	62	76	126	151
Shambangeda	36.6	25	33	58	106	119
Kambai	36.4	N/A	N/A	67	78	107
Kizerui	47.4	195	N/A	138	30	347
Mlesa	52.2	73	30	45	27	157
Average	42.4	91	41	77	73	176

Overall, most households stated that their livelihoods depend heavily on forest resources, although Kambai stands out as being less directly forest-dependent than the other villages (Table 2). This outcome likely links to the fact that households in Kambai have considerably more agricultural land per household than in the other sampled villages, but do not have their own forests, nor any village forest land. Perhaps due to this abundance of agricultural land and lack of dedicated forest land, people in Kambai tend to collect less from the forest on average than those in other villages (Table 3). The forests that they recognize within their broader landscape -- a village forest reserve, a forest nature reserve, and the government forest reserve -- are all categories of protected forests from which it is harder to extract resources due to enforcement activities.

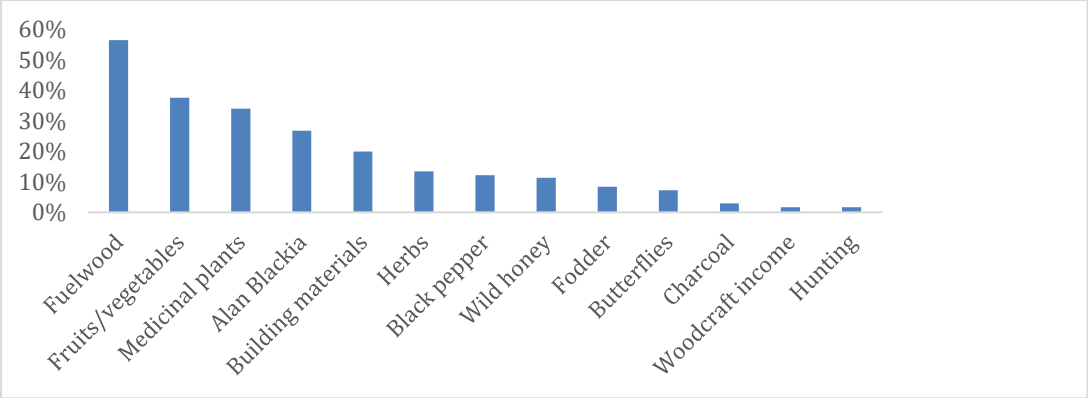
[2] REDD, reduced emissions from deforestation and forest degradation, allows for payments to lower-income countries, conditional on those countries reducing their rate of forest loss.

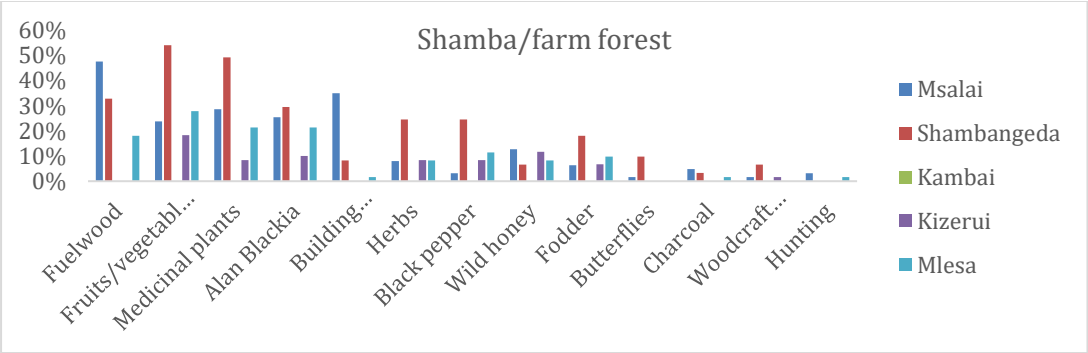
Table 2. Overall Importance of Forests for Households.

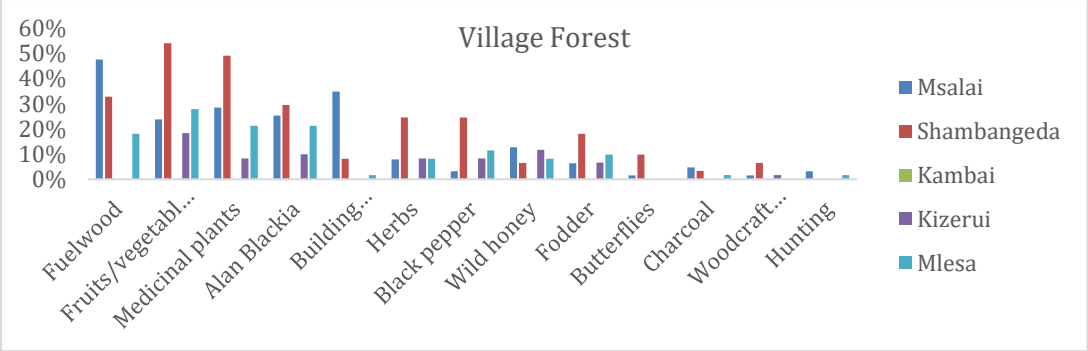
My livelihood depends strongly on the forest	Misalai	Shambangeda	Kambai	Kizerui	Mlesa
Strongly agree/agree	93.3%	85.7%	66.7%	91.6%	86.1%
Neutral	6.7%	14.3%	27.8%	0.0%	0.0%
Disagree/strongly disagree	0.0%	0.0%	5.6%	8.3%	5.0%

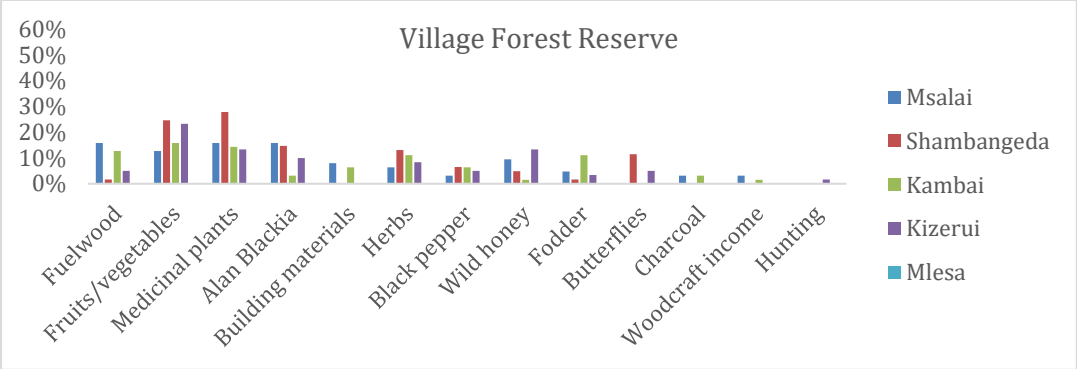
Figure 3 provides aggregated data to reveal the proportion of households in the survey that collect forest resources from any of the forested areas outside of their own homesteads. Perhaps not surprisingly, fuelwood is the resource collected by most households, with over half of households collecting fuelwood from outside of their own farms. However, wild fruits and vegetables, medicinal plants, Alan Blackia (an oil-producing tree), and building materials are important resources for many households.

Figure 3: Percentage of Households Collecting Forest Resources from any Forest Area (a), and by Forest Type and Village (b) through (d)



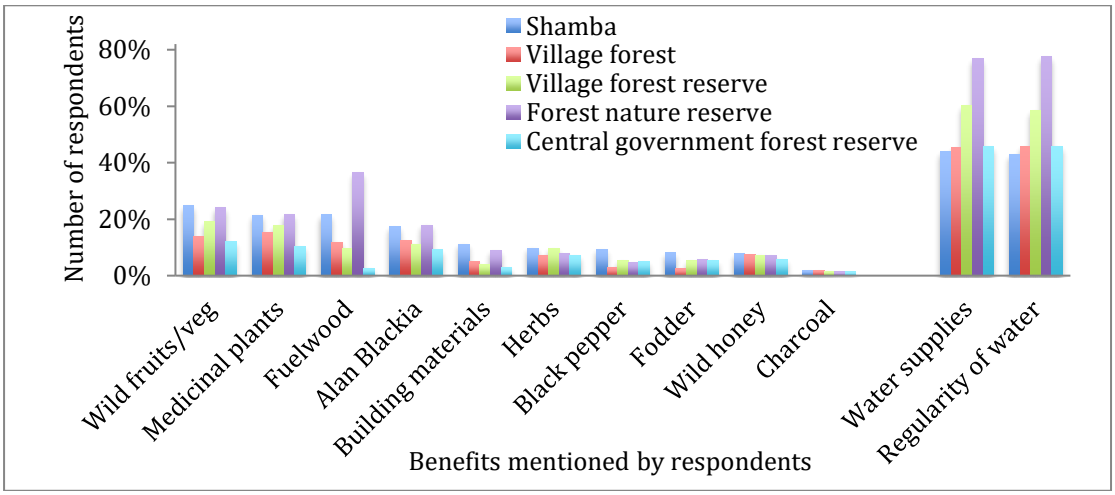






To understand the full breadth of benefits that households perceive that they derive from the forests, we asked villagers to list their perceived benefits. Villagers were asked to mention from which forested area they believed they got benefits, and what those benefits were (Figure 4).

Figure 4: Benefits Respondents Identify from Surrounding Forest Landscape



Overall, we find that 86.3% of our sample collect various products from forests (other than water) (Table 3), with most villages having more than 90% of their

dwellers undertaking extraction. The exception is Kambai, where only half of households collect forest resources. Householders in Kambai may have cash income-generating opportunities and/or a high value of labor time in agriculture as compared to extraction due to their large agricultural holdings. When forest resource collection includes water, almost all households, including those in Kambai, perceive the forests as important for forest and water resource quantity and regularity.

Table 3: Percentage of Households from each Village Gathering Forest Resources from each Forest Area

	Own Farm/ forest	Village forest land	Village forest reserve	Forest nature reserve	Gov't forest reserve	Any Forest	Any Forest (including Water as forest resource)
Misalai	68.3%	50.8%	39.7%	25.4%	19.0%	92.1%	96.8%
Shambangeda	90.2%	63.9%	45.9%	34.4%	23.0%	96.7%	100%
Kambai	0.0%	0.0%	31.7%	38.1%	31.7%	50.8%	100%
Kizerui	20.0%	0.0%	31.7%	91.7%	18.3%	95.0%	98.3%
Mlesa	42.6%	0.0%	0.0%	95.1%	18.0%	96.7%	100%
Average	44.2%	22.9%	29.8%	56.9%	22.0%	86.3%	99.0%

How households allocate their labor time provides clues as to the direct importance and contribution of forest and agricultural land for their livelihoods. In our sample, most labor time of both men (43% and 39% in the dry and rainy seasons, respectively) and women (36% and 31%) is allocated to farming, confirming the importance of agricultural land to these households. In addition, around 10% of the time of both men and women is spent collecting fuelwood and 10% collecting non-fuelwood forest products. Thus, around a fifth of households' time is spent collecting forest products, which account for around 7% of income on average.

3.2 Negative Aspects of Forest Landscape for Households

The main disadvantage of living in this forest landscape mentioned by households is the negative impact that wildlife has on their crops. Over half of our sample reported having often experienced problems with wildlife, whilst only 10% had never experienced a problem (Table 4).

Table 4. Crop Damage Due to Wildlife

	Have you experienced any problems with wildlife eating or harming your crops?			
	Often	Sometimes	Rarely	Never
Misalai	39.7%	27.0%	15.9%	17.5%
Shambangeda	55.2%	24.1%	10.3%	10.3%
Kambai	65.1%	15.9%	15.9%	3.2%
Kizerui	59.3%	15.3%	13.6%	11.9%
Mlesa	58.6%	20.7%	12.1%	8.6%
Total	55.5%	20.6%	13.6%	10.3%

Qualitative interviews revealed that wildlife damage is most likely to occur during the harvest period. Many households respond to this problem by staying at their farms overnight and either trapping or scaring away the animals. Fragmentation of forests may exacerbate this problem in the short run if more households have agricultural plots near areas of forest. However, forest fragmentation also tends to be associated with loss of wildlife, leading to less wildlife damage in the longer run.

3.3 Villager Perceptions of Forest Benefits

Given that households spend on average a fifth of their time collecting forest products, and that households in this area live in a rich forest landscape, we used a five-point Likert scale to explore household perceptions on their access to extractable forest resources, adequacy of drinking water, and attitudes towards potential forest sector interventions.

Most households that we surveyed felt that they had sufficient access to cooking fuel and almost all felt they had sufficient access to drinking water (Table 5). However, in three of the villages, between one-fifth and three-tenths of the households felt that they did not have sufficient access to fuel. In Kambai village, where only 6.4% responded that they do not have enough access to fuel, the average land holding is over twice that in the other villages, reflecting the use of own farm holdings as a source of fuelwood or reliance on markets for fuel. In Shambangeda, another village where almost all villagers felt that they have sufficient access to fuelwood, individual landholdings are on average smaller than in the other surveyed villages, but these households tend to be closer to village forest land where resource collection tends to be unrestricted. These data reflect the reality that access to fuelwood depends on own landholdings, proximity of forests, and *de facto* or *de jure* rights to collect from those forests.

Table 5. Perceptions on Access to Cooking Fuel and Water

I have enough access to cooking fuel	Misalai	Shamba-ngeda	Kambai	Kizerui	Mlesa
Strongly agree/agree	71.4%	93.4%	88.9%	68.3%	75.4%
Neutral	4.8%	3.3%	4.8%	3.3%	4.9%
Disagree/strongly disagree	23.8%	3.3%	6.4%	28.4%	19.7%

I have enough access to drinking water	Misalai	Shamba-ngeda	Kambai	Kizerui	Mlesa
Strongly agree/agree	84.1%	88.5%	90.5%	78.4%	95.1%
Neutral	4.8%	3.3%	3.2%	6.7%	1.6%
Disagree/strongly disagree	11.1%	8.2%	6.4%	15.0%	3.3%

3.4 Responses to Hypothetical Initiatives and Management

Households were, in the main, supportive of hypothetical initiatives that could improve their access to these resources, namely tree planting initiatives and forest protection initiatives (Table 6). Households were asked how strongly they agreed with the statement, "A tree planting project in our village would give me more time to do something other than collecting fuelwood." The benefits of these initiatives were presented to them as time saved in fuelwood collection, water, and other forest products, while the costs were presented as an in-kind contribution of labor time to both plant and protect the forest. Given that people responded favorably, implementing such an initiative could contribute to de-fragmenting the forest but perceptions of such a project will likely depend on what land is used.

Table 6. Support for Tree Planting Projects by Village

A tree planting project would reduce time spent collecting fuelwood and give me more time for other activities	Misalai	Shamba-ngeda	Kambai	Kizerui	Mlesa
Strongly agree/agree	77.8%	73.8%	88.9%	91.8%	82.2%
Neutral	11.1%	14.8%	3.2%	0.0%	7.8%
Disagree/strongly disagree	11.1%	11.5%	7.9%	8.2%	10.0%

In a situation in which tree planting would occur on private land, the farmers face the opportunity cost of forgone agricultural income from that land, which we do not explicitly calculate here. Only around half of respondents suggested that they

would be willing to give up some of their land for a tree planting project if other villagers also did so (Table 7). This finding, not surprisingly, reflects lower levels of support for tree planting on one's own land than on other unspecified land. What is perhaps surprising is that in Shambangeda, where villagers have relatively little farm land but also little need for more fuelwood, more than half of villagers were supportive, and less than a third disagreed with such a tree-planting scheme. For widespread defragmentation policies through tree planting to occur in this area, these results suggest that incentives beyond long-run tree plantation services may be required for much of the population.

Table 7. Willingness to Give up Land for a Tree Planting Project

I would be willing to give up some of my land for a tree planting project if others did the same	Misalai	Shamba-ngeda	Kambai	Kizerui	Mlesa
Strongly agree/agree	46.0%	54.1%	45.0%	47.4%	43.8%
Neutral	11.1%	14.8%	7.9%	6.8%	10.1%
Disagree/strongly disagree	42.9%	31.1%	45.0%	45.7%	46.1%

Finally, we consider the extent to which households are receptive to changes in forest management that may reduce their access to forest resources and how their receptiveness may be affected by their perceptions of who benefits from the different forest patches in the broader landscape. Most households reported that cash payments would not compensate them for lost access to nearby forests (Table 8). This may be because cash payments are likely to be used for short-term needs, whereas the forest provides benefits over the long term, whether fuelwood, building poles, charcoal (albeit obtained illegally), fodder, or wild fruits and vegetables.

Compared to the other study villages, Shambangeda households have the highest rate of support for forest planting on private land and the lowest support for cash payments in exchange for lost forest access (at 78.6%). This finding suggests that these villagers value forests and their products particularly highly. Indeed, on average, Shambangeda villagers use a greater variety of forest types (government, community, private) compared to other villages (2.57 forest types per person in Shambangeda versus 2.03 forest types per person for Misalai, the village with the next largest variety in forest types).

Table 8. Importance of Forest over Cash

Money cannot compensate for loss of the forest	Misalai	Shamba-ngeda	Kambai	Kizerui	Mlesa
Strongly agree/agree	86.7%	78.6%	88.9%	100%	85.5%
Neutral	6.7%	21.4%	11.1%	0.0%	15.0%
Disagree/strongly disagree	6.7%	0.0%	0.0%	0.0%	0.0%

4. Discussion

Living and farming within a fragmented agriculture-forest landscape, such as in our study area, can have advantages, such as access to ecosystem services (including extractable products and fuel) and disadvantages (such as wildlife-farming conflict and institutional constraints on forest and land access). The households in our sample describe considerable livelihood dependence on forest resources, with only the village with the largest amounts of agricultural land claiming more moderate livelihood reliance. These households report an average of 7 percent of their cash livelihood as deriving from the sale of extracted products but their report of an average of 20 percent of labor time spent in extraction and the near-complete reliance on wood for fuel reveals the high level of importance of the forests to these semi-subsistence households' production functions and "effective" income (Cavendish, 2000).

These findings appear similar to, although slightly lower than, other fragmented forest settings. For example, several studies in India and Sri Lanka find average cash contribution of NTFPs to households' livelihoods comprising approximately 20 percent of all cash sources (Malhotra et al., 1991; Gunatilake et al., 1993; Mahapatra et al., 2005). Data from African countries tend to suggest an even higher dependence on NTFPs for cash income and effective income (Cavendish, 2000; Robinson et al., 2016). Vedeld et al., (2007) undertook a meta-study across 17 countries and 51 case studies suggesting that NTFPs account for around 22% of total income (cash and in kind) for sampled households. These levels of forest dependence demonstrate the importance of addressing how rural households will meet their needs when de-fragmentation policies and forest conservation policies are implemented.

Some studies focus only on the opportunity cost of converting agricultural land to forest in calculating the costs for such de-fragmentation policies, without recognizing that rural people do not have replacement activities for agriculture, cannot readily convert a payment for their land into a long-term flow of even subsistence benefits, and rely heavily on benefits from the mosaic of forests to which

they have access (e.g. Newmark et al., 2017; Albers et al. 2017; Robinson, et al. 2016). This focus on low-value agriculture as the only opportunity cost to forest expansion and strict management leads to an underestimation of the true costs that include enforcement costs and broader livelihood burdens to rural people (Albers et al. 2018).

As is common in rural areas, most households rely on fuelwood for cooking. Indeed, when we asked villagers which fuels they used for cooking, only fuelwood was mentioned, emphasizing its importance. Where households collect their fuelwood is important, particularly when policy makers may change access rules for forests or may explore the option of tree planting to provide a source of fuelwood. Households with larger areas of land or their own forested areas might be expected to collect most of their fuelwood from these sources, whilst households with smaller landholdings might be more likely to rely on government forests and reserves. In our sample, households source fuelwood from many different forests with very different access rules. Some of this collection is sanctioned through institutions governing particular forests. In our study site, households have controlled access to collecting fuelwood in Amani and Nilo Nature Reserves. For example, in Mlesa village (located within Amani Nature Reserves), households are allowed to collect firewood twice a week (on Thursday and Saturday). To enforce this limit on extraction, patrols are arranged and performed by selected individuals from village environmental committees. If it happens that someone is caught collecting fuelwood on a day other than 'fuelwood days', they must pay a fine of 10,000 to 20,000TSh or attend a court hearing. Overall, the reaction of households to policies to de-fragment the forest in the Usambara mountains will depend on their reliance on forest resources, the set of forests and the forest management institutions to which households have access, and their agricultural holdings. Because households in our survey rely heavily on forest resources and recognize that dependence, opportunities to develop policies that de-fragment forests for wildlife habitat while increasing access to forest resources could prove beneficial and generate cooperation, but neither a simple purchasing of land nor distribution of payments is likely to be viewed favorably by these communities.

When policies are introduced that impose costs on local communities, conflict situations may arise. These conflict situations, though arguably under-researched in the environmental and resource economics literature, can be costly. These costs could be the increased need for enforcement to implement the policies or costs associated with clashes between villagers and forest managers that can result in people being physically harmed. Another cost that is tricky to quantify is the cost of lost goodwill between local communities and government agents.

Increasingly, forest managers recognize that, where communities are highly dependent on nearby forests, efforts to protect the ecosystems provided by forests through reducing forest fragmentation typically require the cooperation of these local communities. To what extent a conflict situation is likely will depend on how dependent communities are on the resource base, and the extent to which – if at all – their livelihoods will be harmed by any initiatives. For example, to reduce fragmentation, policy makers may require households to relinquish farmland where corridors are planned. Local communities may also perceive benefits from an enhanced forest system. For example, access to drinking water could be improved, or opportunities for tourism could be increased. Our survey results demonstrate that 99% of households rely on the forest in some way and that many would value tree plantation projects in the area, which would help connect forest fragments. Still, the opportunity costs of forgoing agriculture on private land in order to contribute land to such planting schemes appear to reduce household's willingness to cooperate with such plans. Our results imply that incentives beyond forest ecosystem services resulting from de-fragmentation policies must be incorporated to induce cooperation from households. In addition, our results imply that households may not react as intended to cash payments to reduce forest use.

5. Conclusion

This discussion paper provides a snapshot of how villagers depend on both their own land and a complex landscape of different forested areas for their livelihoods. The paper provides a number of insights for the next stage of research into fragmented forest landscapes and efforts to reduce that fragmentation. First, though individually villagers contribute to forest fragmentation through encroachment into the forests to expand their cropland, villagers also recognize numerous benefits from the remaining forest. Villagers highly value the nearby forests. Indeed, villagers overwhelmingly stated that they value forests and access to forests over cash payments, an important observation when considering the introduction of REDD+ into nearby areas. Second, the forests provide cash and in-kind benefits to many households; yet, in parallel, most households have suffered from crop damage due to wildlife. Thus, any efforts to reduce fragmentation will need to address this damage and consider what types of compensation for damage to crops might prove satisfactory to households. Finally, though most villagers would value a tree planting scheme to improve access to fuelwood, perhaps not surprisingly, many would not want to contribute any of their own land to a community scheme.

Reducing forest fragmentation will require some households to relinquish areas of land that they have farmed, which is particularly complicated on farms

without formal rights. Policy makers will have to make decisions about whether to replace that lost land with farmland elsewhere, compensate with cash, or not compensate at all. In addition, converting farmland to agroforestry production could enable households to maintain agricultural production while providing canopy links between forest remnants. The extent to which farmers cooperate with policy makers' efforts will be driven by broader aspects of access to both forest and farm land for cash and in-kind income.

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