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ORIGINAL PAPER

How does rural in-migration affect forest clearing and smallholder land use in tropical forest frontiers? Evidence from the Zambian Miombo woodlands

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Abstract

One of the main sources of increasing population pressure in forested landscapes of Zambia is in-migration from other rural areas. This in-migration is driven by environmental degradation and limited employment options in the villages of origin, and, to a limited extent, in-migration from urban areas due to widespread unemployment and increased cost of living in cities**.** The current study examines the relationship between in-migration, forest clearing, and land use change in forested landscapes in Zambia. This question is especially relevant considering that in 2020, 85% of total carbon dioxide emissions in the country were attributed to Land Use, Land-Use Change, and Forestry (LULUCF). Based on a dataset of 1123 households living in or near the Miombo woodlands in Zambia, we estimate a multivariate tobit model to explain forest clearing and the area under annual crops at the household level. Households reported the availability of agricultural land, natural resources, or fertile soils as their main reason for migration. Regression results showed that being an in-migrant household was associated with 28% more forest area cleared for crop production during the 5 years prior to data collection and with an 8% increase in area cultivated with annual crops. Our results add to limited available quantitative evidence on the impacts of in-migration on forest clearing and land use in tropical forest frontiers at the micro-scale. With rising in-migration in the future that leads to further forest clearing in migrant-receiving areas, the cycle can repeat itself, where increasing population pressure and deforestation can lead to environmental degradation and migration to other forested landscapes. To address this chain, future policy should aim to deal with the root causes of internal migration, including by investing in landscape restoration and sustainable agricultural intensification in origin areas.

Keywords In-migration · Miombo woodlands · Smallholder land use · Forest clearing · Zambia · Rural livelihoods

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Introduction

Migration of people, as an important factor affecting population distribution, can occur in many forms and is driven by various socioeconomic, political, and environmental factors (Hecht et al., 2015). While population pressure is one of the key drivers of deforestation, in-migration is a major cause of population growth in tropical forest frontiers (Carr, 2004). In addition, migration in response to climate change is considered a form of adaptation to environmental degradation and change (Nicoletti et al., 2022; Vinke et al., 2022) and the number of migrants is projected to increase under continued climate change (Adger et al., 2015; Serdeczny et al., 2017). Furthermore, migration linked to climate change-related drivers, including sea-level rises and extreme shifts in weather conditions, is expected to be especially prominent in Sub-Saharan Africa (SSA) (Gemenne, 2011). Previous research links various environmental problems to the migration decisions of households in different parts of SSA. For instance, many such problems—soil degradation, severe droughts, increasing pressure on natural resources due to rapid population growth, shrinking of Lake Chad and problems in Niger River, such as water pollution and siltation—were reported by internal migrants in Niger as the main reasons for their decisions to move (Afifi, 2011) and irregular rainfall patterns were listed as the major driver of seasonal migration in a case study in Burkina Faso (Vinke et al., 2022).

In Zambia, internal migration—migration of people within the country borders—is a primary form of mobility that affects mainly the poor (Black et al., 2006). In particular, rural-rural and urban–rural migration flows have been reported in recent literature (Chamberlin et al., 2020; Handavu et al., 2019). Rural-rural migration in Zambia is often driven by the rural dwellers' search for new agricultural land and by environmental degradation and limited employment options in the villages of origin, while urban–rural migration is a result of widespread unemployment and poor living conditions in cities (Handavu et al., 2019; Kalaba, 2013; Kalaba et al., 2013). Despite the fact that some households in rural Zambia have family members working in urban areas, the rural–urban links are considered weak, with no regular flow of remittances to support families in the rural areas since many poor urban dwellers struggle with access to resources (Black et al., 2006). Some internal migration flows are also linked to the developments in the mining industry. For instance, the opening of new mines in the North-Western Province (NWP) led to the movement of skilled labour from the Copperbelt Province to NWP, while unskilled rural labour was pulled to the newly emerging mining cities (Üllenberg et al., 2017). However, the Zambian economy remains highly dependent on copper exports, resulting in unstable urban employment, and with agriculture's role as a safety net, migration in Zambia can be viewed as a "multi-local rural–urban livelihood system" as people move between rural and urban areas depending on economic opportunities (Üllenberg et al., 2017).

Internal migration has already contributed to deforestation in some parts of Zambia. For example, migration from the Southern Province into Lusaka and

Copperbelt Provinces has led to areas such as Chongwe and Masaiti Districts being opened up for new settlements and forests being cleared for crop production (Vinya et al., 2011). Migration of people from the southern part of Zambia into other rural areas has been linked in part to droughts and land degradation and to a limited extent to floods; and these factors are exacerbated by political instability, lack of governance, and inadequate disaster management (Makondo & Thomas, 2019). Another form of rural in-migration in Zambia was linked to a large increase in "emergent" farms (with the size of 5–20 ha), as some wealthier individuals based in urban areas have increasingly invested in agricultural land since the Land Reform Act of 1995 (Sitko & Jayne, 2014).

Although the links between migration and the degradation of natural resources have been recognized for some time, there has been growing interest in the role of migration in driving large-scale environmental change over the past couple of decades (Unruh et al., 2005). Moreover, research on population dynamics and forest cover change at micro-scales remains limited even though associations between population growth and deforestation have been reported to be significant at the global and regional scales (Carr, 2004). Furthermore, while the effects of out-migration have been discussed widely in the literature, the role of rural in-migration, especially as a cause of rural transformations, has received little attention until now (Chamberlin et al., 2020; Hecht et al., 2015). Land use and land cover change (LUCC) outcomes of rural-rural migration have been largely overlooked in both migration and LUCC research (Carr, 2009), while reliable quantitative evidence that links migration to land use change remains very limited (Thung & Juniwaty, 2018). The data on internal migration remain poor in many countries and need to be better integrated when collecting economic and population data by government institutions (Hecht et al., 2015).

The goal of this paper is to examine the relationship between rural in-migration, which in this study comprises both rural-rural and urban–rural migration, and land use change in forested Zambian landscapes. We use a comprehensive cross-sectional dataset of 1123 households living in or near the Miombo woodlands in the Copperbelt, Eastern, and North-Western Provinces to analyse the influence of different factors on forest clearing by farm households, with the focus on the impact of in-migration.

There are several gaps in the previous literature that this study aims to address. First, our study explores the impact of in-migration on frontier areas in the Miombo woodlands and sheds light on potential drivers of this in-migration, explores regional differences, and provides quantitative evidence of in-migration's effect on forest clearing and smallholder land use. Furthermore, previous studies on migration mostly focus on out-migration from rural areas, while in-migration to rural areas can be substantial and have serious implications for environmental degradation (Bilsborrow, 2002). Finally, a lot of attention has been given to determinants of migration, yet theories on the outcomes of migration remain limited (Bilsborrow, 2002). This is particularly the case for the environmental consequences of migration. The evidence provided in this study can offer a useful basis for developing a comprehensive framework to explain and predict outcomes of migration to forest frontiers on deforestation and forest degradation.

Past evidence on in-migration to forest frontiers and its environmental outcomes

Before analysing the relationship between migration and environmental change, it is important to understand the factors that influence migration to rural areas in the first place. Different theories exist in the literature that seek to explain the drivers behind migration of people. One of the prominent ones refers to the "push–pull" framework outlined by Lee in 1966. According to Lee, migration depends on factors that "push" the migrants to leave their places of origin and factors that "pull" or attract migrants to their places of destination (Lee, 1966). Environmental push factors can include degradation of land and natural resources or an increase in the occurrence of natural disasters such as floods and earthquakes; and environmental pull factors refer to the availability of fertile land and natural resources or favourable climatic conditions (Bilsborrow, 2002).

The relationship between in-migration and land use change is a complex one. In general, the extent to which in-migrants clear the forest and the length of the fallows that affect forest regrowth are often influenced by the broader socio-economic situation in the country, including developments in agricultural markets, social conflicts, and economic crises (Mertens et al., 2000). Migration has been hypothesized to affect households' land use decisions in many micro-level studies (Hettig et al., 2016). Some researchers suggested that due to shorter planning horizons, in-migrants are likely to pursue unsustainable agricultural practices through the encroachment of the forest frontier compared to host populations (Sunderlin & Pokam, 2002). In the case of rural Burkina Faso, migrants' rights to land were perceived as insecure compared to the indigenous population because migrants were excluded from a permanent claim to land unless they lived in the area for a generation (Etongo et al., 2015). As a consequence of tenure insecurity, migrants were more likely to contribute to deforestation than the indigenous population (Etongo et al., 2015). In a field report from Zambia, it was observed that migrant households tend to clear forest areas much larger than subsequently cultivated to demonstrate their claim to that land (Unruh et al., 2005). In a case study from Ghana, migrant households were found to undertake more land-intensive agricultural practices, which contribute to land degradation over time compared to the host population (Codjoe & Bilsborrow, 2012). Migrant households followed shorter fallow periods and reported greater fertilizer use compared to the host population (Codjoe & Bilsborrow, 2012).

Some argue that migration of people from different cultural and institutional backgrounds can lead to weakened traditional institutions as differences in cultural beliefs and perception of customary rights as inferior to statutory ones can reduce adherence to traditional rules and taboos with regards to forest use (Kalaba, 2013). Kalinda (2014) reports on concerns of locals in Magobbo, Zambia, over the conversion of use and access rights to land from customary tenure to titled land by in-migrants and other financially better-off households who acquired land titles in order to participate in sugarcane out-grower schemes.

Research that links migrant remittances to deforestation also remains limited (Afawubo & Noglo, 2019). Remittances have been linked to a shift from traditional fuels such as firewood or charcoal to more modern fuels in rural Zambia (Wu et al., 2021). A cross-country study focusing on 106 developing countries found that remittances were associated with reduced deforestation in low- and middle-income countries, potentially by increasing agricultural productivity (Afawubo & Noglo, 2019). In the case of Zambia, the overall impact of remittances on forest use may not be substantial due to irregular remittance flows from poor urban dwellers (Black et al., 2006). However, empirical evidence on the impact of remittances on forest clearing in Zambia has not been reported in the previous research.

Previous evidence on the impact of in-migration on land use at the global level remains mixed (Thung & Juniwaty, 2018). Evidence from SSA on the implications of in-migration for forests and land use is mostly qualitative, whereby quantitative empirical evidence that in-migrants and non-migrants have different land use patterns is not available to the best of our knowledge.

Based on previous studies and an initial analysis of our data, we hypothesize that (1) in-migration is likely to affect forest clearing and land use among smallholder households in the Miombo woodlands and (2) differences between migrants and local smallholders to clear land might be related to land tenure insecurity.

Materials and methods

Study sites and data

The Miombo woodlands are the most extensive dryland forest ecosystem in SSA, covering an area of around 2.4 million km^2 and stretching across parts of Angola, Botswana, Burundi, Democratic Republic of Congo, Malawi, Mozambique, Namibia, Tanzania, Zambia, and Zimbabwe (Gumbo et al., 2018). It is one of the five global biodiversity hotspots, harbouring about 8500 higher plant species (Frost, 1996). Moreover, the Miombo woodlands are a crucial source of livelihood for the local communities that live within or around the forests (Gumbo et al., 2018; Kalaba et al., 2013; Kazungu et al., 2020). More than 100 million rural dwellers and a further 50 million urban people are estimated to depend on Miombo woodlands directly or indirectly for their livelihoods and food security (Ryan et al., 2016). Population growth and increasing demand for agricultural land, unsustainable land use practices, and climate change impacts (e.g. drought, fires) leave insufficient time for vegetation to regenerate naturally, posing a serious threat to biodiversity, the products and services of the Miombo woodlands, and the livelihoods depending on them (Gumbo et al., 2018).

The data for this study stem from a larger research project, "Landscape Forestry in the Tropics", which aimed to analyse policy approaches for improving livelihoods and forest management in three tropical countries: Ecuador, the Philippines, and Zambia. The current study focuses on forested landscapes located in three provinces in Zambia: Copperbelt, North-Western, and Eastern Provinces. A "landscape" in this study covers an area of 12×12 km^2 and includes the households that live within

or near the Miombo Woodlands (Kazungu et al., 2020). Within each province, we chose two landscapes without any restriction to access and use of forest resources, and two landscapes with a forest conservation strategy (Kazungu et al., 2020, 2021a, 2021b). This approach resulted in 12 landscapes selected across six districts, which represented different trends in forest cover change and socio-economic situation. These sites were selected following a systematic process that included a literature review, analysis of satellite imagery of the forested landscapes, scoping visits, and exploratory interviews with local officials and sub-chiefs (Kazungu et al., 2020, 2021a, 2021b). In each landscape, approximately 100 households were randomly selected for interviews, which were conducted using a structured questionnaire and covered information including household socio-demographics, land use and assets, use of forest resources, income sources from non-agricultural activities, and exposure to income shocks. The final study sample includes 1123 households after removing incomplete surveys. The map of the study sites is reported in Kazungu et al. (2021b).

The three provinces are characterized by different forest cover change situations. According to Global Forest Watch, the NWP had the largest area of tree cover lost during the period of 2001–2020 with 470 thousand ha deforested, while Copperbelt came in second with 335 thousand ha of tree cover loss (Global Forest Watch, 2021). Compared to the North-Western and Copperbelt Provinces, the Eastern Province experienced less tree cover loss of 54 thousand ha during the same period (Global Forest Watch, 2021).

The main land use activities of the people living in the 12 research landscapes include collection of forest products for cash and subsistence purposes, crop production, and, to a limited extent, livestock keeping, fishing, and supplemental non-farm activities. In rural Zambia, most households use hand hoes for everyday land clearing, as noted by Haggblade and Tembo (2003). However, when clearing new forest areas, many turn to slash-and-burn methods (Syampungani et al., 2016). For households not producing charcoal, the process of forest clearing often begins with charcoal burning, while for those that do, tree cutting is a continuous activity. The approach to land clearing is influenced by factors such as regional population density, household characteristics, and livelihood choices (Kazungu et al., 2020).

According to estimates from a previous study conducted in these research sites, households that live in or near the Miombo Woodlands earn about half of their total household income from forest products, around 35% from crop production, and 8.6% from livestock (Kazungu et al., 2021a). Income from forest products includes earnings from charcoal-making, firewood, forest foods (mushrooms, fruits, honey, and animals), medicinal plants, and structures and fibres (Kazungu et al., 2020). The share of fish and non-farm income is negligible contributing to total household income with 0.4% and 2.2%, respectively (Kazungu et al., 2021a).

Internal migration in Zambia and in the study provinces

Limited data exist on the internal movement of people across administrative boundaries inside Zambia. In 2010,[1] 16.8% of the Zambian population lived in districts other than where they were born (Central Statistical Office, 2012). Among the three study provinces, the highest in-migration rate was reported for the Copperbelt Province, with almost 22% of the population having been born in another province, followed by NWP, where 10.5% of the population were born in another province (Table 1). In the Eastern Province, the rate of in-migration was at 6.5% in 2010.

According to the Central Statistical Office, in 2015, migration of people to rural areas (i.e. rural in-migration) comprised 42.4% of total migration, out of which 20.8% was attributed to rural-rural migration and 21.6% to urban–rural migration (Central Statistical Office, 2016). This shows that rural in-migration in Zambia is substantial and could contribute to population pressure in forest frontiers. Among the three study provinces, the share of rural in-migration compared to total migration flows was highest in Eastern Province (46.5%), followed by NWP (44.6%) and Copperbelt Province (33.8%) (Central Statistical Office, 2016).

Estimation approach

The overall goal of our analysis is to test whether the impact of in-migration on land use indicators is statistically significant. The two land use indicators selected for this study are forest area cleared by households and the area planted with annual crops. From our previous study conducted in these research sites (Kazungu et al., 2021a), we know that forest area is mainly cleared for the cultivation of annual crops.

A multivariate tobit (mvtobit) model was used to explain forest cleared at the household level by two models estimated jointly in a system of equations. Mvtobit is chosen to account for the left-censoring (many 0 values) of the two dependent variables (Babigumira et al., 2014) and to address the cross-equation correlation between the two activities by estimating the two equations jointly. Given the censored nature of our dependent variables, use of OLS would have yielded inconsistent parameter estimates (Wooldridge, 2002). To ensure that the multivariate tobit model is more suitable to analyse our data, we conducted a likelihood ratio test with the null hypothesis that the correlation parameters from the two equations are equal to zero. Based on the test results (reported in the "Results from econometric analysis of households' forest clearing and land use decisions" section), we reject this null hypothesis at a 99% confidence level and use the mvtobit model. We estimate the model in Eq. 1 using the method of maximum likelihood (ML) (Barslund, 2015):

[1] This is the latest census for which data were published. The most recent census was conducted in 2022 but the results were not published at the time of this study.

Table 1 In-migration rates in the study provinces in 2010

	Population currently residing in Copperbelt province by province of birth								
	Central	Copperbelt	Eastern	Luapula	Lusaka	Northern	North-Western	Southern	Western
Number of people	54,531	1,487,913	38,717	75,808	51,520	105,906	51,517	29,597	11,119
Share of total population residing in Copperbelt, %	2.86	78.04	2.03	3.98	2.70	5.55	2.70	1.55	0.58
Total population residing in Copperbelt	1,906,628								
% of in-migrants in Copperbelt	21.96								
	Population currently residing in the Eastern province by province of birth								
	Central	**Copperbelt**	**Eastern**	**Luapula**	**Lusaka**	**Northern**	**North-Western**	**Southern**	**Western**
Number of people	8087	31,994	1,504,229	1857	43,704	6874	1314	8005	1940
Share of total population residing in Eastern, %	0.50	1.99	93.55	0.12	2.72	0.43	0.08	0.50	0.12
Total population residing in Eastern	1,608,004								
% of in-migrants in Eastern	6.45								
	Population currently residing in the North-Western province by province of birth								
	Central	**Copperbelt**	**Eastern**	**Luapula**	**Lusaka**	**Northern**	**North-Western**	**Southern**	**Western**
Number of people	4520	38,517	1843	2369	7508	3353	599,488	3640	8983
Share of total population residing in Eastern, %	0.67	5.75	0.27	0.35	1.12	0.50	89.45	0.54	1.34
Total population residing in Eastern	670,221								
% of in-migrants in Eastern	10.55								

Source: Own compilation based on Central Statistical Office (2012)

$$\begin{aligned} A_F^* &= XB_F + \varepsilon_F \\ A_{AC}^* &= XB_{AC} + \varepsilon_{AC} \\ A &= max(A^*, 0) \end{aligned} \tag{1}$$

A_F^* stands for forest area cleared by households, A_{AC}^* stands for area planted by annual crops, X are independent variables including in-migration, age, education and gender of household head, household size, number of dependents, number of household members of working age, tropical livestock units, distances to public forest and to the paved road, access to credit, nonfarm income, and landscape fixed effects, and B are estimated coefficients. The error term ε is bivariate normally distributed, and V is the variance–covariance matrix of error terms, where r_{FAC} stand for cross-equation correlation between equations F and AC:

$$\begin{aligned} \varepsilon &= (\varepsilon_F, \varepsilon_{AC})\prime \sim N(0, V) \\ 0 &= \begin{bmatrix} 0 \\ 0 \end{bmatrix}, V = \begin{bmatrix} r_F^2 & r_{FAC} \\ r_{FAC} & r_{AC}^2 \end{bmatrix} \end{aligned} \tag{2}$$

Selection of variables and their description

Our two dependent variables are forest area cleared by households in the 5 years prior to data collection and the area planted with annual crops at the time of the survey. The forest area cleared by households was derived based on the survey answers as follows. The survey included questions on the current land use type for each plot that the household has, and on the land use types on the same plot at three other points of time: the time of acquisition, 10 years and 5 years before the survey. Using this information, we calculated the total forest area cleared for crop production (primary and secondary forest) by the surveyed households (1) since the time of acquisition until the survey period, (2) in the last 10 years until the survey period, and (3) in the last 5 years until the survey period. Because we used cross-sectional data that provide a snapshot of information, we selected the latest land conversion from forests to cropland (i.e. in the past 5 years until now) as our primary dependent variable. Several other studies have also used self-reported forest clearing by households as a dependent variable (Babigumira et al., 2014; Vasco et al., 2020).

The zeros in the two dependent variables indicate that many households did not clear forest land or use land for annual crops during the 5-year period preceding the study. This may be due to households using already-cleared land for agricultural activities. Additionally, since the data was collected across regions with varying levels of forest cover and at different stages of forest transition, areas like the Eastern Province, where long-term deforestation has already occurred, offer less forest land to clear (Kazungu et al., 2021a). In these regions, in-migrant households are more likely to acquire agricultural land rather than clear forest land. These differences between the landscapes are accounted for in the mvtobit regression model by controlling for landscape fixed effects.

The predictor variable of interest is a binary variable "in-migrant" which is equal to 1 if the household has moved to the current location from another area, and 0 if

the household has always lived in the current location. On average, in-migrants in our study areas have lived in their current location for 13 years.

The selection of other independent (control) variables was done based on the literature review. Control variables in the regression model included household-level socio-demographic variables (age, gender, household size, education level), indicators for labour availability (number of dependents, number of household members of working age), income from alternative or non-land-based activities (non-farm income), livestock assets, access to credit and roads, distance to forests, and landscape-level fixed effects.

Household size, age of the household head, education level, and gender of the household head can affect households' labour supply decisions and are therefore relevant for explaining land use and forest clearing outcomes at the farm household level (Babigumira et al., 2014; Carr, 2004; Kazungu et al., 2021a; Ojeda Luna et al., 2020). Farm area and education have also been linked to increased deforestation on the Uluguru mountains in Tanzania (Mitinje et al., 2007). Another study in Tanzania conducted in the Bereku forest reserve reported that the effect of the distance from homestead to the forest and education was negative (Giliba et al., 2011). The negative impact of distance to forests on deforestation can be explained by an increased cost of collecting forest resources with increasing distance (Giliba et al., 2011). In the case of Zambia, household size, education level, access to road, distance to the village centre, and incomes from different activities were shown to influence the probability of deforestation, though the impact varied in different regions (Kazungu et al., 2021a).

Nonfarm income and employment in non-farm jobs present an alternative to land-based income activities and were shown to be negatively correlated with deforestation (Kazungu et al., 2021a; Vasco et al., 2020). Labour availability and dependency ratios can be important determinants of forest clearing and land use decisions in the areas at the opening or expansion stages of frontier development (Barbieri et al., 2021). We constructed several variables to control for labour availability and dependency, including number of household members of working age, number of dependents, and the household size in adult equivalent units (AEU).

As farm households usually combine different land-based activities to generate income for both cash and subsistence purposes (Barbieri et al., 2021), we control for livestock keeping measured in tropical livestock units (TLU), to see if it has an influence on forest clearing decisions of households in the study area. We use distance to paved road as a proxy for access to markets, while access to credit is included to check if households receiving credit were more likely to deforest larger areas of land. Finally, we control for landscape-level fixed effects using indicator variables to control for any unobserved differences in terms of socio-cultural, economic, and environmental context that are present between the 12 study landscapes.

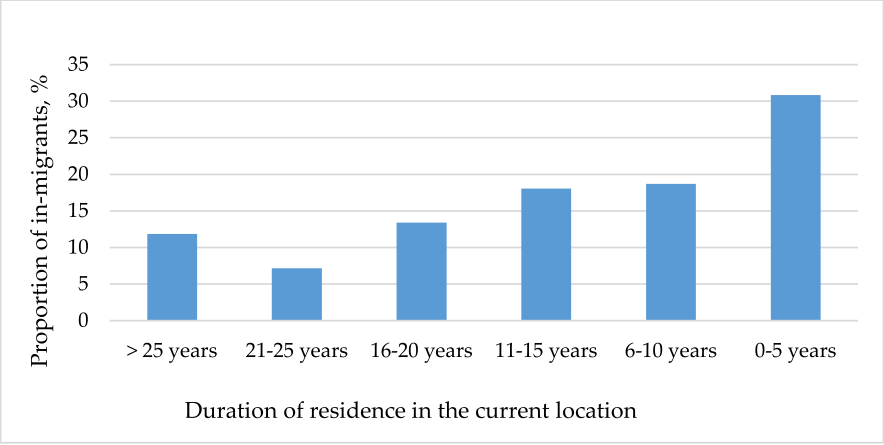

Fig. 1 Proportion of in-migrants (%) according to duration of residence in the current location. Source: Own estimations based on the household survey

Table 2 Distribution of in-migrants according to their provinces of origin

Province of origin	Copperbelt province	Eastern province	North-western province
Central	6.1%	3.2%	1.5%
Copperbelt	80.2%	6.5%	-
Eastern	0.5%	80.7%	-
Lusaka	2.8%	6.5%	-
Muchinga	0.5%	-	-
Northern	0.5%	-	-
North-Western	2.4%	-	96.9%
Southern	6.6%	-	-
Western	0.5%	3.2%	1.5%
Total	100%	100%	100%
Number of observations	394	355	371
Share of in-migrants per province	54.8%	11.3%	17.4%

Source: Own estimations based on the household survey

Results

In-migrants in Miombo woodlands, their origin, and reasons for migration

Out of 1123 households included in our sample, 321 (28.6%) reported that they have not always lived in their current location and moved here in many cases from another district. These 28.6% of households were categorized for our study as in-migrants.

Figure 1 shows the proportion of in-migrants according to their duration of residence in the current location. About 31% of in-migrants among the surveyed households have arrived in their current location within the 5 years prior to the survey. The share of in-migrants that have arrived within the 6 to 15 years prior to the survey was also larger than the share of in-migrants with longer durations of residence.

Table 2 shows the distribution of in-migrants in the three study provinces according to their area of origin based on the results of the household survey. Results show that the majority of in-migrants moved from other districts within the same province while the number of inter-province migrants was relatively small. For instance, about 80% of in-migrants in the Copperbelt and Eastern Provinces had come from other districts within the same provinces, while in NWP this number was equal to about 97%. The second largest source of in-migrants in the Copperbelt was Southern Province (6.6% of in-migrants), followed by Central Province (6.1%), which shares a long border with Copperbelt. Overall, the share of in-migrants in the study landscapes in Copperbelt was significantly higher compared to the other two provinces and constituted about 55% of surveyed households, while it was equal to 11.3% in the landscapes in the Eastern Province and 17.4% in the Northwestern Province.

A majority of the in-migrant households, 74.8% (240 households), indicated factors related to the availability of agricultural land, natural resources, or fertile soils as one of the top reasons for moving. Another often-cited reason for moving was related to family situation (97 households or 30.2%), including marriage, divorce, death of a family member, or a need to care for a family member.

Socio-demographic and land use variables

In-migrant households and the local population exhibited a number of differences according to socio-economic and land use characteristics (Table 3). For instance, in-migrant households had a slightly higher education level reported for the household head and a larger number of household members who completed high school. Among the demographic variables, in-migrants had a larger number of members who are of working age (between 15 and 65 years old), though the difference in the overall household size in adult equivalent units (AEU) and the number of dependents between the two groups was not statistically significant at 10% confidence level.

Regarding incomes, in-migrants reported higher earnings from forest-related and crop production activities, while non-migrants earned more from non-farm activities. In-migrants also reported higher incomes from charcoal, which might be related to larger areas of forest used by in-migrants. The difference between the two groups in terms of fish and livestock income was not significant. The overall amount earned from fish and non-farm activities was in general much smaller compared to earnings from other livelihood sources for both groups. Out of 1123 households interviewed for this survey, 641 (57%) did not earn any non-farm income, while 925 (82%) households did not earn any income from fishing. The total household income was higher for in-migrants (10747.15 ZMW) than for non-migrants (9277.62 ZMW).

In terms of assets, in-migrants owned a larger number of livestock and managed a larger total farm area and crop area compared to non-migrants. The results

Table 3 Differences between in-migrant and non-migrant households (*t*-test results)

Variable	In-migrant		Non-migrant		Difference		*t*-test results	
	Mean	SE	Mean	SE	Mean	SE	*p*	
Socio-demographics								
Age of household head	45.18	0.81	44.84	0.52	0.35	0.97	0.360	
Proportion of households with a male household head (%)[a]	87.85	1.82	79.80	1.42	8.05	2.31	0.000	***
Education of household head (1 = no education to 9 = university degree)	3.64	0.08	3.29	0.05	0.35	0.09	0.000	***
Number of household members (other than household head) who completed high school	0.20	0.03	0.11	0.01	0.09	0.03	0.002	**
Household size in AEU	4.73	0.11	4.64	0.07	0.10	0.13	0.227	
Number of dependents	2.93	0.10	2.86	0.06	0.07	0.12	0.274	
Number of household members of working age	3.22	0.10	3.08	0.06	0.15	0.11	0.086	*
Assets								
Total farm area, ha	4.67	0.49	2.70	0.12	1.96	0.36	0.000	***
Total crop area, ha	3.79	0.29	2.48	0.10	1.31	0.25	0.000	***
Mean patch area, ha	1.86	0.23	0.89	0.05	0.97	0.17	0.000	***
Tropical livestock units (TLU)	1.20	0.12	0.91	0.06	0.29	0.12	0.009	**
Location								
Distance to public forest, km	2.20	0.10	2.29	0.06	−0.09	0.12	0.231	
Distance to the paved road, km	3.21	0.24	2.78	0.18	0.43	0.33	0.094	*
Incomes								
Forest income, ZMW	5671.27	465.17	4527.96	285.42	1143.31	538.64	0.017	**
Charcoal income, ZMW	3124.92	394.25	1810.09	227.73	1314.83	437.92	0.001	**
Crop income, ZMW	3781.61	279.96	3227.59	127.19	554.02	267.90	0.019	**
Cash crop income, ZMW	2459.56	231.36	1715.92	97.74	743.64	212.78	0.000	***
Livestock income, ZMW	869.00	90.83	820.14	53.94	48.86	102.81	0.317	
Fish income, ZMW	34.11	5.77	38.37	4.17	−4.26	7.54	0.286	
Nonfarm income, ZMW	271.59	35.31	415.26	30.51	−143.67	53.15	0.004	**
Total household income, ZMW	10,747.15	585.78	9277.62	333.29	1469.53	644.08	0.011	**

Table 3 (continued)

Variable	In-migrant		Non-migrant		Difference		*t*-test results	
	Mean	SE	Mean	SE	Mean	SE	*p*	
Land use								
Forest cleared for crop production since 5 years, ha	0.47	0.06	0.21	0.03	0.26	0.05	0.000	***
Forest cleared for crop production since 10 years, ha	1.15	0.20	0.37	0.04	0.77	0.14	0.000	***
Area under fruit trees, ha	0.01	0.00	0.03	0.02	−0.02	0.03	0.227	
Area under annual crops, ha[b]	3.78	0.29	2.45	0.10	1.33	0.24	0.000	***
Area under maize, ha	1.77	0.18	1.17	0.05	0.60	0.14	0.000	***
Area under legumes, ha	1.52	0.34	0.63	0.05	0.89	0.23	0.000	***
Area under vegetables, ha	0.44	0.08	0.15	0.03	0.29	0.07	0.000	***
Area under cotton, ha	0.01	0.01	0.04	0.01	−0.02	0.01	0.023	**
Land titles								
Proportion of patches with no title, (%)[a,c]	83.33	1.20	93.66	0.48	−10.33	1.30	0.000	***
Proportion of patches with a permanent title (%)[a,c]	3.13	0.56	1.13	0.21	1.99	0.60	0.000	***
Proportion of patches with titling in process (%)[a,c]	2.60	0.51	0.55	0.15	2.05	0.53	0.000	***
Proportion of patches that have a farm permit from chiefs in customary lands (%)[a,c]	10.94	1.01	4.66	0.42	6.28	1.09	0.000	***
Proportion of households that have a permanent title, farm permit or title in process for at least on patch (%)[a]	16.82	2.09	5.86	0.83	10.96	2.25	0.000	***
Number of observations	321		802					

Source: Authors' estimation based on the household survey. SE stands for standard errors

[a]For this variable, a test on the equality of proportions is conducted

[b]Area under annuals includes maize, legumes, pulses, tuber, vegetables, other cereals, and cotton. Even though cotton is a perennial plant, it is often planted as an annual for pest control and therefore it is included under annuals here

[c]The number of observations for calculating land title proportions at the patch level is 3516 observations

*, **, and *** indicate *p*-values for the t test at 0.1, 0.05, and 0.001 confidence levels

in Table 3 show that even though in-migrants were managing an overall larger size of farm area (4.7 ha), only part of it was under crop production (3.3 ha). Some part of the remaining land was possibly used for livestock grazing or building homesteads, including a house and outbuildings, although our data from individual patches do not provide specific information on this. An average size of a patch managed by an in-migrant household (1.86 ha) was also significantly larger than for the case of non-migrants (0.89).

Land use indicators in Table 3 show that there were substantial differences between in-migrants and non-migrants in terms of forest clearing and land use strategies. In total, in-migrant households have cleared larger areas of primary and secondary forests compared to non-migrants when we consider the land use changes both since 10 and 5 years ago until now. Moreover, in-migrants had larger areas allocated to cash and high-value crops, such as vegetables and legumes (Table 3). These results are consistent with the substantially higher cash crop income reported by in-migrants.

Finally, there were significant differences between in-migrants and non-migrants when it came to having official land titles. The group of in-migrants had a statistically larger proportion of patches with permanent title, titling in process, and farm permits for land allocated by chiefs in customary lands (Table 3 and Fig. 2). It should be noted, however, that the overall share of patches for which households had any title was very small for both in-migrants and non-migrants. In total, 83% of patches used by in-migrants and 94% of patches used by non-migrants did not have any land title (Table 3 and Fig. 2).

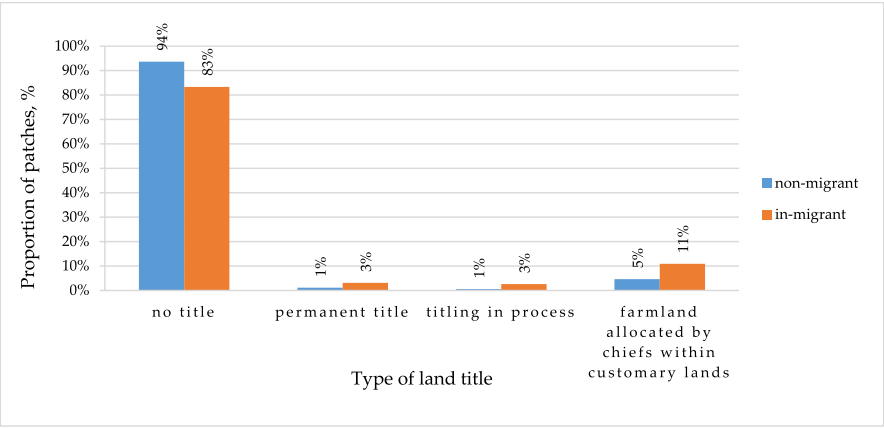

Fig. 2 Differences in land titles among in-migrants and non-migrants. Source: Own estimations based on the household survey. Total number of observations: 3516 patches

Results from econometric analysis of households' forest clearing and land use decisions

The results from multivariate tobit analysis with two dependent variables, the forest area cleared for crop production in the last 5 years and the area under annual crops, are presented in Table 4.

Table 4 The results of multivariate tobit analysis

	Forest cleared for crop production in the last 5 years, log		Area under annual crops, log	
	Coef	Std. Err	Coef	Std. Err
Household is an in-migrant (1 = Yes; 0 = No)	0.280***	0.087	0.082**	0.038
Age of household head	−0.005*	0.003	0.003**	0.001
Male household head (1 = Yes)	0.030	0.110	0.140***	0.044
Education of household head (1 = no education to 9 = university degree)	−0.050*	0.029	0.022*	0.012
Household size in AEU	−0.201*	0.116	0.012	0.018
Number of dependents	0.063	0.060	0.013	0.011
Number of household members of working age	0.170	0.118	0.030	0.020
Tropical livestock units (TLU)	0.037*	0.021	0.115***	0.009
Distance to public forest, km	−0.052*	0.029	−0.016	0.010
Distance to the paved road, km	0.000	0.013	−0.001	0.004
Received credit in the last year (1 = Yes)	−0.185	0.153	0.013	0.064
Nonfarm income, ZMW	4.34×10^{-5}	0.000	-2.63×10^{-6}	0.000
Lumpuma = Reference category				
Chizera	−0.592**	0.223	−0.600***	0.097
Mumbi	−1.495***	0.283	−0.534***	0.092
Mushili	−0.262*	0.153	−0.563***	0.075
Mushima	−1.345***	0.300	−0.283**	0.102
Ndake	−1.241***	0.259	−0.462***	0.095
Nkambo	−0.015	0.191	−0.372***	0.086
Nyalugwe	−0.909***	0.233	−0.752***	0.096
Nyampande	−1.565***	0.309	−0.422***	0.096
Sailunga	−0.614**	0.241	−0.109	0.102
Shibuchinga	0.204	0.153	−0.519***	0.077
Chibwika	0.044	0.203	−0.084	0.093
Constant	0.500*	0.272	0.871***	0.114
Number of observations	1123			
Wald chi (46)	729.80***			
Log-likelihood	−1470.420			
Likelihood ratio test	16.289***			

*, **, and *** indicate *p*-values at 0.1, 0.05, and 0.001 confidence levels. Standard errors in parentheses

The multivariate tobit regression results show that holding all other factors constant, being an in-migrant household was associated with 28% more forest area cleared for crop production during the last 5 years and an 8% increase in area cultivated with annual crops.

Both age of the household head and their education level had a negative impact on the forest area cleared within the last 5 years, and an opposite effect on the area of land planted by annual crops. Larger household size was associated with less forest area cleared. Additional indicators for household demand for cropland and labour, such as the number of dependents and the number of household members of working age, were also tested in regression models, yet neither was significantly associated with the area of forest cleared or with the area under annual crops. Having a male household head contributed to larger annual crop areas managed by household but had no significant impact on forest area cleared.

The impact of non-farm income was statistically significant for neither forest area cleared nor area under annual crops. An increase in livestock assets by one TLU was associated with about a 4% increase in forest area cleared, and a 1-km increase in the distance to public forests was linked to about a 5% decrease in forest area cleared. Access to credit did not have a statistically significant coefficient in both equations.

However, there were significant differences between the landscapes in terms of forest clearing as the coefficients for landscape fixed effects show in Table 4. The Lumpuma district (Copperbelt Province) was taken as a reference category because it had the highest mean forest area cleared within the last 5 years. Being in eight of the other landscapes was associated with less forest area being cleared compared to Lumpuma. Insignificant coefficients for Shibuchinga (Copperbelt Province) and Chibwika (North-Western Province) were possibly related to high mean forest area cleared comparable to those observed in the reference category, Lumpuma district.

Discussion

Past research has largely overlooked the extent and potential serious implications of in-migration to rural areas for environmental degradation in tropical forest frontiers. Without understanding the extent and drivers of internal migration movements to forested landscapes, as well as their consequences on forests, policies aiming at forest conservation and future land use change scenarios will be missing a crucial part of the picture.

The findings of this study provide unique quantitative evidence on the impacts of in-migration on forest clearing and land use at the micro scale in Zambia. First of all, we show that internal migration in some cases, for instance in the Copperbelt Province, can be quite substantial, whereby almost half of the interviewed households in forested landscapes had moved to their current location from another district (Table 2). An often-cited reason for in-migration was related to environmental factors. As in-migrants clear forested areas to sustain their livelihoods, the presence of in-migration itself already implies an increased forest area cleared compared to the situation with no in-migration. However, the comparison of in-migrants and non-migrants showed that the former, among other things, overall had larger areas

of farm land under use compared to non-migrants and earned higher incomes from cash-oriented forest and crop activities. Being an in-migrant was associated with larger areas cleared in the last 5 years and larger areas under annual crop production, too. Below we offer our interpretation of these key findings and discuss the implications for future policy and research.

The in-migration rates reported at a province level based on the last population census of 2010 and the rates calculated based on our household survey differ to a large extent, especially when it comes to the Copperbelt Province. One obvious reason is that in our survey, we capture in-migration that has occurred within the same province from one district to another, whereas the census data reported in Table 1 refer to migration between provinces. Furthermore, it is possible that in-migration to forested landscapes is in general higher than the overall in-migration rates at the province level because of the availability of land for clearing. Our results also reflect the fact that the Copperbelt Province is traditionally a destination for in-migrants from the Southern Province as well as provinces which are closely located to Copperbelt. On the other hand, the lower rate of in-migration reported in our study might be related to the selection of study landscapes, which are located farther from the provincial boundary and, therefore, may have fewer in-migrants than would be the case in areas adjacent to other provinces.

According to the survey results, around three-quarters of in-migrants cited environmental conditions in the areas of origin as their main reason for moving, which often involved lack of productive agricultural land with fertile soils or limited access to natural resources (e.g. forests). Past studies reported similar findings in SSA, where environmental problems such as soil degradation and deforestation affect migration in Niger (Afifi, 2011) and irregular rain patterns affect migration in Burkina Faso (Vinke et al., 2022). Considering that the threats of land degradation and climate change on rural livelihoods are expected to rise across the world (Call & Gray, 2020), our findings imply that internal migration due to environmental reasons is likely to increase in the future as well. The increasing trend in the rate of in-migration over the last three decades reported in the "In-migrants in Miombo woodlands, their origin, and reasons for migration" section supports this conclusion. Moreover, internal migration has been reported as a key determinant of land use change and resource management (Bhawana et al., 2017) and should be considered when assessing future landscape transitions.

The results from the multivariate tobit model show that being an in-migrant is associated with a substantially larger area of forest cleared over the last 5 years prior to the survey. It is expected that upon arrival to the forest frontier, an in-migrant household would clear up some forested land to set up their land-based activities. However, the share of in-migrants that arrived within the same period (five years before survey) is around 30%, with the rest of in-migrants having arrived much earlier than that. To check whether tenure insecurity might explain higher levels of land clearing among in-migrants, as was argued in the case of Burkina Faso (Etongo et al., 2015), we compared the land title ownership between the groups of in-migrants and non-migrants. The tests showed that the differences between the two groups are statistically significant—yet there is a larger proportion of in-migrants that have a form of title (Table 3 and Fig. 2). Although on

average, in-migrants seemed to hold land titles for a larger proportion of patches compared to the non-migrant population, perceived uncertainty about their land rights in the new location could have been one potential reason why in-migrants were more likely to acquire land titles. It should be noted that while statistically significant, the difference between the two groups is substantively moderate as many land patches are being used by both groups without any official land title (83% for in-migrants and 94% for non-migrants).

Our results further indicate that households with older household heads clear less forested area, which is consistent with the life-cycle theory that younger households are more likely to clear larger areas of forest as the households accumulate land over their life cycle (Babigumira et al., 2014). The effect of household size observed in our study, namely that it is negatively related to forest clearing, also can be explained by the same theory as younger households at an earlier stage of their life cycle have fewer children and dependents compared to older households (Babigumira et al., 2014).

We further tested for differences between the two groups in terms of incomes earned from various activities. Higher incomes from cash crops and charcoal indicate that in-migrants on average tend to be more commercially oriented in their land-based activities. The overall larger farm sizes observed for in-migrants in the current study could be associated with higher charcoal incomes and slightly larger livestock assets reported by in-migrants. In addition to charcoal being a key source of cash income in our study landscapes (Kazungu et al., 2020), authors' field observations indicate that income from cash crops was being invested in hired labour for further charcoal production. In sum, higher incomes from cash crops and charcoal were associated with larger areas of forests cleared and larger farm sizes, which overall resulted in higher total household incomes for the case of in-migrants. Differences in livelihood choices of in-migrants and non-migrants in forested landscapes are also noted in other studies. In contrast to in-migrants who tend to rely more heavily on agricultural income in Ethiopia, the non-migrants earn a higher share of their income from forest (Chanie & Aleme, 2021). In a study conducted in Indonesia, Widianingsih et al. (2016) state that while local Malayan and migrant households mainly generate their income from converting forest to small plantations, the local indigenous households remain heavily dependent on the collection of forest products. Ignaciuk et al. (2021) report that in-migrants engaging in cash crop production are responsible for increasing deforestation in Uganda and are more likely to cut trees than locals. They argue that efforts to better integrate in-migrants in recipient communities while enhancing their knowledge on local ecological conditions and forest governance rules could help tackle unsustainable land use practices related to internal migration (Ignaciuk et al., 2021).

The impact of non-farm income was statistically significant on neither forest area cleared nor annual crop area, possibly because its availability in our study landscapes remained very limited. Observations in other parts of SSA paint a similar picture where the lack of non-farm employment is what limits the livelihood options of rural people to charcoal making and shifting cultivation (Rudel, 2013) and may intensify forest clearing practices (Mulley & Unruh, 2004).

The present study was not without limitations, which in part are related to the fact that we use household data from a larger research project (LaForeT) that was not originally designed to study in-migration. First of all, as the in-migrant status is assigned at the household level using a cross-section dataset, it was not possible to report the total number of in-migrants nor the number of people that out-migrated at the village or landscape level. Furthermore, the outcomes of in-migration on dependent variables could be due to some unobserved characteristics of in-migrants which led them to migrate in the first place, but we did not control for this in our regression model.

Conclusions

The main goal of this study was to examine the impact of in-migration on forest clearing and land use in tropical forest frontiers in Zambia. Our results indicate that internal migration to forested landscapes can be substantial and that in-migrants clear more forested land compared to non-migrants, from which they reported higher earnings from charcoal and cash crops compared to the local population.

Our findings highlight significant changes in Zambia's forested landscapes, based on quantitative evidence. These changes are primarily driven by environmental factors, with an increasing influx of migrants into forest frontiers. This migration is leading to the establishment of new land use practices, which in turn contribute to further deforestation. If rising in-migration in the future leads to further forest clearing in migrant-receiving areas, the cycle can repeat itself where increasing population pressure and deforestation lead to environmental degradation and migration to other forested landscapes. To address this chain, future policy should deal with the root causes of internal migration, such as by investing in landscape restoration and sustainable agricultural intensification in the areas of origin. Moreover, if the practice of destructive land use changes such as deforestation by in-migrants is due to their lack of knowledge in recipient communities, it is vital for policy-makers to accelerate their efforts to better inform and integrate migrant populations. Further research is required to gain a broader understanding of the extent of in-migration to forest frontiers and to identify the reasons behind different land use practices and forest clearing decisions made by migrants, including the role of perceived tenure security.

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Declarations

Conflict of interest The authors declare no competing interests.

References

Adger, W. N., Arnell, N. W., Black, R., Dercon, S., Geddes, A., & Thomas, D. S. G. (2015). Focus on environmental risks and migration: Causes and consequences. *Environmental Research Letters, 10*, 060201. https://doi.org/10.1088/1748-9326/10/6/060201

Afawubo, K., & Noglo, Y. A. (2019). Remittances and deforestation in developing countries: Is institutional quality paramount? *Research in Economics, 73*, 304–320.

Afifi, T. (2011). Economic or environmental migration? The push factors in Niger. *International Migration, 49*, e95–e124.

Babigumira, R., Angelsen, A., Buis, M., Bauch, S., Sunderland, T., & Wunder, S. (2014). Forest clearing in rural livelihoods: Household-level global-comparative evidence. *World Development, 64*, S67–S79.

Barbieri, A. F., Guedes, G. R., & Onofre dos Santos, R. (2021). Land use systems and livelihoods in demographically heterogeneous frontier stages in the amazon. *Environmental Development, 38*, 100587. https://doi.org/10.1016/j.envdev.2020.100587

Barslund, M. (2015). MVTOBIT: Stata module to calculate multivariate tobit models by simulated maximum likelihood (SML). Statistical Software Components S456875, Boston College Department of Economics.

Bhawana, B., Wang, T., & Gentle, P. (2017). Internal migration and land use and land cover changes in the middle mountains of Nepal. *Mountain Research and Development, 37*, 446. https://doi.org/10.1659/MRD-JOURNAL-D-17-00027.1

Bilsborrow, R. E. (2002). Migration, population change, and the rural environment. *ECSP Report 26 (8)*, 69–94.

Black, R., Crush, J., Pederby, S., Ammassari, S., McLean Hilken, L., Mouillesseux, S., Pooley, C., & Rajkotia, R. (2006). Migration and development in Africa: An overview. African Migration & Development Series No. 1. Southern African Migration Programme, Waterloo.

Call, M., & Gray, C. (2020). Climate anomalies, land degradation, and rural out-migration in Uganda. *Population and Environment, 41*, 507–528.

Carr, D. L. (2004). Proximate population factors and deforestation in tropical agricultural frontiers. *Population and Environment, 25*, 585–612. https://doi.org/10.1023/B:POEN.0000039066.05666.8d

Carr, D. (2009). Population and deforestation: Why rural migration matters. *Progress in Human Geography, 33*, 355–378. https://doi.org/10.1177/0309132508096031

Central Statistical Office. (2012). 2010 Census of Population and Housing National Analytical Report. Lusaka.

Central Statistical Office. (2016). 2015 Living Conditions Monitoring Survey (LCMS) Report. Central Statistical Office, Lusaka, Zambia.

Chamberlin, J., Jayne, T. S., & Sitko, N. J. (2020). Rural in-migration and agricultural development: Evidence from Zambia. *Agricultural Economics, 51*, 491–504. https://doi.org/10.1111/agec.12567

Chanie, M., & Aleme, T. (2021). Internal migration, rural livelihood strategies and sustainable forest management: Evidence from Bench Maji, Kaffa and Sheka Zones, South West Ethiopia. *Environmental & Socio-Economic Studies, 9*, 20–31. https://doi.org/10.2478/environ-2021-0015

Codjoe, S. N. A., & Bilsborrow, R. E. (2012). Are migrants exceptional resource degraders? A study of agricultural households in Ghana. *GeoJournal, 77*, 681–694. https://doi.org/10.1007/s10708-011-9417-7

Etongo, D., Djenontin, I. N. S., Kanninen, M., Fobissie, K., Korhonen-Kurki, K., & Djoudi, H. (2015). Land tenure, asset heterogeneity and deforestation in Southern Burkina Faso. *Forest Policy and Economics, 61*, 51–58.

Frost, P. (1996). The ecology of miombo woodlands. In B. Campbell (Ed.) *The Miombo in Transition: Woodlands and Welfare in Africa*. Centre for International Forestry Research, Bogor, pp 11–57.

Gemenne, F. (2011). Why the numbers don't add up: A review of estimates and predictions of people displaced by environmental changes. *Global Environmental Change, 21*, S41–S49. https://doi.org/10.1016/j.gloenvcha.2011.09.005

Giliba, R. A., Boon, E. K., Kayombo, C. J., Chirenje, L. I., & Musamba, E. B. (2011). The influence of socio-economic factors on deforestation: A case study of the Bereku Forest Reserve in Tanzania. *Journal of Biodiversity, 2*, 31–39.

Global Forest Watch. (2021). *Tree cover loss in Zambia*. Accessed on 24/12/2021 from www.globalforestwatch.org

Gumbo, D. J., Dumas-Johansen, M., Muir, G., Boerstler, F., & Xia, Z. (2018). *Sustainable management of Miombo woodlands – Food security, nutrition and wood energy*. Food and Agriculture Organization of the United Nations, Rome.

Haggblade, S., & Tembo, G. (2003). *Conservation farming in Zambia.* EPTD Discussion Paper 108. Environment and Production Technology Division, International Food Policy Research Institute, Washington.

Handavu, F., Chirwa, P. W., & Syampungani, S. (2019). Socio-economic factors influencing land-use and land-cover changes in the Miombo woodlands of the Copperbelt province in Zambia. *Forest Policy and Economics, 100*, 75–94.

Hecht, S., Yang, A. L., Basnett, B. S., Padoch, C., & Peluso, N. L. (2015). *People in motion, forests in transition: trends in migration, urbanization, and remittances and their effects on tropical forests.* Occasional Paper 142. CIFOR, Bogor.

Hettig, E., Lay, J., & Sipangule, K. (2016). Drivers of households' land-use decisions: A critical review of micro-level studies in tropical regions. *Land, 5*, 32.

Ignaciuk, A., Kwon, J., Maggio, G., Mastrorillo, M., & Sitko, N. J. (2021). Harvesting trees to harvest cash crops: The role of internal migrants in forest land conversion in Uganda. *FAO*. https://doi.org/10.4060/cb7072en

Kalaba, F. K., Quinn, C. H., & Dougill, A. J. (2013). Contribution of forest provisioning ecosystem services to rural livelihoods in the Miombo woodlands of Zambia. *Population and Environment, 35*, 159–182.

Kalaba, F. K. (2013). *Forest ecosystem services, rural livelihoods and carbon storage in Miombo woodland in the Copperbelt region of Zambia*. PhD Thesis, University of Leeds.

Kalinda, T. (2014). Multiple shocks and risk management strategies among rural households in Zambia's Mazabuka District. *Journal of Sustainable Development, 7*, 52–67.

Kazungu, M., Zhunusova, E., Yang, A. L., Kabwe, G., Gumbo, D. J., & Günter, S. (2020). Forest use strategies and their determinants among rural households in the Miombo woodlands of the Copperbelt Province, Zambia. *Forest Policy and Economics, 111*, 102078. https://doi.org/10.1016/j.forpol.2019.102078

Kazungu, M., Ferrer Velasco, R., Zhunusova, E., Lippe, M., Kabwe, G., Gumbo, D. J., & Günter, S. (2021a). Effects of household-level attributes and agricultural land-use on deforestation patterns along a forest transition gradient in the Miombo landscapes, Zambia. *Ecological Economics, 186*, 107070. https://doi.org/10.1016/j.ecolecon.2021.107070

Kazungu, M., Zhunusova, E., Kabwe, G., & Günter, S. (2021b). Household-level determinants of participation in forest support programmes in the Miombo landscapes, Zambia. *Sustainability, 13*, 2713. https://doi.org/10.3390/su13052713

Lee, E. S. (1966). A theory of migration. *Demography, 3*, 47–57. https://doi.org/10.2307/2060063

Makondo, C. C., & Thomas, D. S. (2019). Environmental change and migration as adaptation in rural economies: Evidence from Zambia's rural–rural migration. *Migration and Development*, *10*(3), 1–29. https://doi.org/10.1080/21632324.2019.1646534

Mertens, B., Sunderlin, W. D., Ndoye, O., & Lambin, E. F. (2000). Impact of macroeconomic change on deforestation in South Cameroon: Integration of household survey and remotely-sensed data. *World Development, 28*, 983–999. https://doi.org/10.1016/S0305-750X(00)00007-3

Mitinje, E., Kessy, J., & Mombo, F. (2007). Socio-Economic factors influencing deforestation on the Uluguru mountains, Morogoro, Tanzania. *Discovery and Innovation, 19*, 139–148. https://doi.org/10.4314/dai.v19i1-2.15780

Mulley, B. G., & Unruh, J. D. (2004). The role of off-farm employment in tropical forest conservation: Labor, migration, and smallholder attitudes toward land in western Uganda. *Journal of Environmental Management, 71*, 193–205. https://doi.org/10.1016/j.jenvman.2004.02.002

Nicoletti, A., Melde, S., Guadagno, L., Bilsborrow, R. E. (2022). Human mobility in the context of environmental and climate change: Recent data collection tools from the International Organization for Migration to address key methodological and conceptual issues. *International Migration*, 13043. https://doi.org/10.1111/imig.13043

Ojeda Luna, T., Eguiguren, P., Günter, S., Torres, B., & Dieter, M. (2020). What drives household deforestation decisions? Insights from the Ecuadorian lowland rainforests. *Forests, 11*, 1131. https://doi.org/10.3390/f11111131

Rudel, T. K. (2013). The national determinants of deforestation in sub-Saharan Africa. *Philosophical Transactions of the Royal Society B: Biological Sciences, 368*, 20120405.

Ryan, C. M., Pritchard, R., McNicol, I., Owen, M., Fisher, J. A., & Lehmann, C. (2016). Ecosystem services from southern African woodlands and their future under global change. *Philosophical Transactions of the Royal Society B: Biological Sciences, 371*, 20150312. https://doi.org/10.1098/rstb.2015.0312

Serdeczny, O., Adams, S., Baarsch, F., Coumou, D., Robinson, A., Hare, W., Schaeffer, M., Perrette, M., & Reinhardt, J. (2017). Climate change impacts in Sub-Saharan Africa: From physical changes to their social repercussions. *Regional Environmental Change, 17*, 1585–1600.

Sitko, N. J., & Jayne, T. S. (2014). Structural transformation or elite land capture? The growth of "emergent" farmers in Zambia. *Food Policy, 48*, 194–202. https://doi.org/10.1016/j.foodpol.2014.05.006

Sunderlin, W. D., & Pokam, J. (2002). Economic Crisis and Forest Cover Change in Cameroon: The Roles of Migration, Crop Diversification, and Gender Division of Labor. *Economic Development and Cultural Change, 50*, 581–606. https://doi.org/10.1086/342358

Syampungani, S., Chirwa, P. W., Akinnifesi, F. K., Sileshi, G., & Ajayi, O. C. (2016). The Miombo woodlands at the cross roads: Potential threats, sustainable livelihoods, policy gaps and challenges. In E. Chidumayo & D. Gumbo (Eds.), *The dry forests and woodlands of Africa: Managing for products and services* (pp. 305–332). Earthscan/Routledge.

Thung, P. H., Juniwaty, K. S. (2018). Missing links in the forest-migration nexus: An analysis of trends, literature and data sources. Center for International Forestry Research (CIFOR). https://doi.org/10.17528/cifor/006796

Üllenberg, A., Minah, M., Rauch, T., & Richter, D. (2017). Zambia: Towards inclusive and sustainable rural transformation. *SLE Discussion Paper, 2017 (4)*. https://doi.org/10.18452/18008

Unruh, J., Cligget, L., & Hay, R. (2005). Migrant land rights reception and 'clearing to claim' in sub-Saharan Africa: A deforestation example from Southern Zambia. Wiley Online Library. *Natural Resources Forum, 29* (3), 190–198.

Vasco, C., Valdiviezo, R., Hernández, H., Tafur, V., Eche, D., & Jácome, E. (2020). Off-farm employment, forest clearing and natural resource use: Evidence from the Ecuadorian Amazon. *Sustainability, 12*, 4515. https://doi.org/10.3390/su12114515

Vinke, K., Rottmann, S., Gornott, C., Zabre, P., Nayna Schwerdtle, P., & Sauerborn, R. (2022). Is migration an effective adaptation to climate-related agricultural distress in sub-Saharan Africa? *Population and Environment, 43*, 319–345. https://doi.org/10.1007/s11111-021-00393-7

Vinya, R., Syampungani, S., Kasumu, E. C., Monde, C., & Kasubika, R. (2011). Preliminary study on the drivers of deforestation and potential for REDD+ in Zambia. A Consultancy Report Prepared

for Forestry Department and FAO under the National UN-REDD+ Programme of Lands & Natural Resources, Lusaka, Zambia.
Widianingsih, N., Theilade, I., & Pouliot, M. (2016). Contribution of forest restoration to rural livelihoods and household income in Indonesia. *Sustainability, 8*, 835. https://doi.org/10.3390/su8090835
Wooldridge, J. M. (2002). *Econometric analysis of cross section and panel data*. The MIT Press, London.
Wu, Y., Entwisle, B., Sinai, C., & Handa, S. (2021). Migration and fuel use in rural Zambia. *Population and Environment, 43*(2), 181–208.

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