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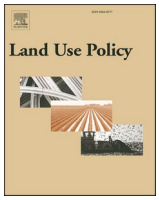
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"Too poor to migrate": A narrative of labor migration and land fragmentation in Uganda

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ABSTRACT

Land fragmentation is a growing concern among smallholders in developing countries. As families grow and split off, per-capita land size declines significantly. Fragmented land holdings can have ramifications on agricultural production and labor migration. We investigate the relationship between land fragmentation and short-term labor migration using longitudinal household data from Uganda. We collate data from four periods of the Living Standard Measurement Study – Integrated Survey in Agriculture (LSMS-ISA) between 2013 and 2020. We use the two-way fixed effects estimator to estimate the effects of land fragmentation on migration. We find that land fragmentation is negatively correlated with labor migration. The relationship is more pronounced among rural, poor, and male-headed households compared to urban, rich, and female-headed households, respectively. We also conducted Focus Group Discussions (FGDs) with members of smallholder families in Southwest Uganda to qualitatively confirm the empirical findings. Results show that the negative relationship between land fragmentation and labor migration is mediated by the negative impacts of fragmented holdings on agricultural productivity. Public policies and programs that focus on land redistribution or consolidation may want to pay close attention to the consequences of fragmented holdings on agricultural production and smallholders' migration behavior.

1. Introduction

Land fragmentation – defined as the division of land holdings owned or operated by a single household into multiple, discrete, and non-contiguous parcels – is a major obstacle for agricultural and economic development (Ntihinyurwa and de Vries, 2021; Demetriou, Stillwell and See, 2013; Knippenberg, Jolliffe and Hoddinott, 2020). Land is perhaps the most valuable asset for smallholders in low- and middle-income countries (LMICs). With a rapidly growing population and similarly paced urbanization, per-capita land available for agriculture has decreased significantly in recent decades (Gao and O'Neill, 2020; Jayne et al., 2003; Turner et al., 2021). Consequently, land fragmentation has become a growing concern for smallholders in developing countries where agriculture is the mainstay of rural livelihood. Land fragmentation's perceived negative effects have driven policymakers and legislators to implement land consolidation policies in many parts of East Asia, Europe, and Sub-Saharan Africa. In this article, we address this very important issue from a migration perspective using Uganda as a case study. Recent labor migration trends amid declining agricultural productivity across Sub-Saharan Africa underscore the urgency of understanding the interplay between land use policies, agricultural performance, and broader economic development. Addressing these dynamics is essential for formulating effective strategies that support sustainable rural livelihoods and economic development.

Fragmented holdings can affect rural livelihoods in multiple ways; existing evidence shows that land fragmentation affects household food security, household socioeconomic status, and women's empowerment (Djurfeldt, 2020; Knippenberg et al., 2020; Tran and Vu, 2019) through its impact on agricultural production and productivity (Looga et al., 2018; Manjunatha et al., 2013; Ntihinyurwa and de Vries, 2021; Qiu et al., 2020; Rahman and Rahman, 2009; Van Hung et al., 2007). One strand of literature has documented positive effects of fragmented holdings on crop diversity and productivity (Cholo et al., 2019; Ciaian et al., 2018; Looga et al., 2018; Ntihinyurwa et al., 2019; Paul and wa

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Gĩthĩnji, 2018; Qiu et al., 2020) as well as smallholders' resilience to weather shocks (Veljanoska, 2018), but others have found a negative relationship between land fragmentation and agricultural productivity (Alemu et al., 2017; Manjunatha et al., 2013; Tran and Vu, 2019). A rich body of literature has consistently documented an inverse relationship between land size and productivity (see Bevis and Barrett, 2020; Desiere and Jolliffe, 2018; Omotilewa et al., 2021, and earlier papers cited there in), which has fueled policy debate on land fragmentation vs. consolidation. While the debate on the true impacts of land fragmentation on agricultural productivity is still unsettled, others have examined the role of land fragmentation on migration, especially in the context of growing populations and increasing trends of rural to urban migration (Bezu and Holden, 2014; Holden and Otsuka, 2014; Mwesigye et al., 2017; Mwesigye and Matsumoto, 2016; Tumwesigye et al., 2023).

In the face of mounting social, political, and environmental instabilities such as land tenure insecurity, recurring conflict, and climate variability, rural migration can be a vital coping and adaptation strategy for smallholder farmers in LMICs (Andrianandrasana et al., 2025; Maystadt et al., 2024; Salerno et al., 2024). Although an increasing number of scholars have investigated the relationship between land ownership and migration in recent years, the question of how land fragmentation affects labor and non-labor migration differently remains a missing piece of the puzzle. We fill this knowledge gap by 1) empirically estimating the relationship between land fragmentation and short-term labor (and non-labor) migration using household-level longitudinal data, and 2) gathering qualitative accounts of Ugandan farmers and scholars of agriculture through Focus Group Discussions (FGDs).

We examine the 'land fragmentation-migration' relationship using longitudinal data from a nationally representative household and agriculture survey from Uganda, the Living Standard Measurement Study-Integrated Survey in Agriculture (LSMS-ISA). We find that land fragmentation is negatively correlated with labor migration but has no statistically significant relationship with non-labor migration. The negative relationship between land fragmentation and labor migration only holds for male-headed, rural, and poor households (those belonging to the bottom 40 % of the consumption expenditure distribution). We conclude that land fragmentation makes poor households poorer, and the liquidity constraint reduces labor migration for members of poor households. FGDs with farmers and agricultural scholars who come from peasant families corroborate our empirical finding that fragmented holdings likely reduce labor migration among smallholders by reducing agricultural revenue.

Studying land fragmentation and migration is of significant policy importance in Uganda and the sub-Saharan Africa (SSA) region because the region is marred with fragmented land holdings and unprecedented rates of rural-to-urban migration (Call and Gray, 2020; de Brauw et al., 2014; Kafle et al., 2020). The effect of land fragmentation on poverty, income, migration, and agricultural productivity is an important policy issue in Uganda, along with many countries in SSA. In recent times, land fragmentation has been a recurring policy issue in SSA countries (Djurfeldt, 2020). For example, Kenya, Tanzania, Ethiopia, and Rwanda have implemented land consolidation programs to discourage fragmentation. While Uganda has yet to implement a land consolidation program, the country's leadership is concerned about the consequences of land fragmentation on rural poverty, displacement, and low agricultural yield, and has appealed against land fragmentation. The leadership believes that primitive inheritance rights encourage land subdivision and that continued fragmentation of the land leads to a vicious circle of rural poverty by reducing agricultural assets and productivity (Ashaba, 2023), and some existing evidence corroborates this claim (Ministry of Agriculture Animal Industry and Fisheries, 2020). As the debate on how land fragmentation affects migration is unraveling, policymakers and development partners are equally interested in understanding the causes and consequences of labor and non-labor migration from rural areas (African Union, 2014).

This paper makes important contributions to the literature on land use practices and migration. First, while the migration literature acknowledges the effect of population increase and land scarcity on migration, we directly examine the empirical relationship between land fragmentation and the migration decision of farming households. Second, we distinguish labor and non-labor migration and provide evidence that land fragmentation affects labor and non-labor migration differently. Third, we complement the empirical findings with qualitative accounts of members of peasant families in Uganda who are the primary subject of this analysis.

The rest of the paper is organized as follows. Section 2 provides a study background and discusses the conceptual framework. Sections 3 and 4 describe the econometric methods and data, respectively. Section 5 discusses the results. Section 6 provides potential mechanisms and robustness checks. Section 7 concludes with the relevant policy implications.

2. Background and conceptual framework

2.1. Background

Land tenure systems of present-day Uganda date back to the early 1900s between the British government and the Kingdom of Buganda. The "Mailo" agreement was the earliest land reform that distinguished native land from the "Crown" Land. In 1962, Uganda gained independence and implemented several land reform policies. However, in 1975 President Idi Amin's administration announced all Ugandan land as public land, essentially converting *Mailo* and freehold landowners into hundred-year leaseholders. After that, President Museveni's administration amended land laws again in 1988, 1995, and 1998. The Land Act of Uganda 1998 identifies four land tenure systems in the country: Customary, *Mailo*, Freehold, and Leasehold land tenure systems.

The *customary* tenure system grants access to land based on the customs, rules and regulations of the community or tribe possessing the land. This system does not grant land title to the holders, but they are granted sustained access to it. The *Mailo* tenure system, established by the British in the early 1900s, grants user rights to the tenants of land owned by landlords. This system is commonly practiced in the Central region of the country. Under the *freehold* system, landowners have both the titles and user rights indefinitely and they can sell, lease, transfer, or divide the land in any way they want. Finally, under the *leasehold* tenure system, the land is owned by the landlord or the state, which grants the tenants user rights for a specific period (Kyomugisha, 2008). Tenants are not allowed to divide the land in any tenure system but the freehold system.

The land tenure system in Uganda is further complicated due to political and ethnic fragmentation marred by violence. From its independence from the British, pending Amin's regime, land rights were driven by politics, ethnic bias, confusion over jurisdiction, and land-grabbing (Okafor, 2023). Lately, the government has undertaken several land tenure and title distribution programs with logistical support from the United Nations agencies and the World Bank, as the country has been more politically stable (Global Land Tool Network, 2024; Kasooha, 2022). More recent amendments to the land laws are targeted towards providing more people with access to land and reducing administrative burdens. The current legislation recognizes that each member of the family receives a portion of the inherited land by formalizing traditional land rights. It also provides an accelerated transition to freehold land tenure. However, these amendments have faced criticisms as the government does not have the resources and technical capacity to implement them (Hunt, 2004).

The current administration under President Museveni has been very

consistent and vocal about the negative implications of land fragmentation (Presidential Initiatives, 2024). The administration is concerned that land fragmentation has decreased productivity and even rendered people homeless due to poverty.[1] The National Land Use Policy document (2006), which serves as a guiding document for land legislation programs, identifies land fragmentation as one of the biggest impediments to Uganda's sustainable development efforts. The Ministry of Land, Housing, and Development agrees that land fragmentation drives soil degradation, reduces productivity, and increases poverty and inequality. In response, the government has implemented land consolidation programs, canceled fraudulent land titles, and run awareness campaigns against fragmentation (Lwasa, 2024). As the government is democratizing land access and rights through attainable land governance, understanding the consequences of land fragmentation has become even more important.

2.2. Conceptual framework

The most common causes of land fragmentation in developing countries include a rapidly growing population, egalitarian inheritance practices, ill-formulated land redistribution policies, and underdeveloped land markets (Ali et al., 2019; Demetriou et al., 2013; Holden and Otsuka, 2014; Niroula and Thapa, 2005). As families grow and households multiply, the family's land is almost always dissected into fragments to be shared among siblings or kin. As households split, the heads of households redistribute their land to their children, usually among sons. Daughters are not allotted the land as they are expected to get married and join their husbands' families, who also split their lands among their sons. As this is a common practice in patriarchal societies such as Uganda (Mfitumukiza et al., 2024), women can be disproportionately affected by land fragmentation. The problem is further exacerbated by a tendency to equally divide different types of land with varying biophysical characteristics (e.g., ruggedness of terrain, fertility, etc.) among heirs, which leaves households with numerous geographically dispersed plots that are small and varying in shape as well as land quality (Demetriou et al., 2013; King and Burton, 1982). This practice of egalitarian division is reflected in many land redistribution policies that tend to fragment equal sizes of different classes of land quality for a fair distribution among households. In addition to declining per-capita land availability due to population growth, the absence of functional land markets and the prevalence of customary laws and norms impede the utilization of the land for its comparative advantage (Sjaastad, 2003). This has serious repercussions for smallholders as they rely primarily on agriculture.

Sub-optimal sizes or shapes of fragmented land can reduce agricultural output and productivity (Manjunatha et al., 2013; Rahman and Rahman, 2009; Van Hung et al., 2007; Wan and Cheng, 2001). Spatially dispersed parcels can increase farming costs by increasing travel time between parcels, labor costs, the cost of operating farm machinery, and other parcel management expenses (Ali et al., 2019; Knippenberg et al., 2020; Tan et al., 2008). In some cases, fragmented holdings can prevent farmers from using farm machinery (Foster and Rosenzwig, 2011). As the absence of fully functional land markets makes it difficult for households to rent or buy consolidated plots, farm income declines due to production inefficiencies and high production costs (Manjunatha et al., 2013; Tran and Vu, 2019). In addition, researchers have also documented a negative relationship between rangeland fragmentation and tenure security for pastoralist and agro-pastoralist communities in Africa (Demetriou et al., 2013; Drew and Knutsson, 2025).

Owing to a wide range of consequences, the effect of land fragmentation on household welfare and migration decisions remains understudied. While land fragmentation can increase access to land for newly split-off households, it can also lead to decreased per-capita land area. Similarly, while a greater number of plots can increase crop diversity, it can also imply a decrease in the volume of production of a specific crop. Thus, while improved access to land (through fragmentation of parental land) may incentivize farmers to remain in agriculture, a decreased per-capita land area and lower volume of production can potentially push people out of agriculture. As the population increases, land becomes more fragmented, and agricultural production and productivity decline, migration may be a way out of poverty for smallholders. Even though migration can be induced by push factors in the origin (such as limited land availability and lack of viable livelihood opportunities), pull factors in the destination (such as better employment opportunities and higher wages), or both factors (de Brauw et al., 2014; Kafle et al., 2020; Mwesigye et al., 2017), the increased liquidity constraints due to fragmented holdings can force farmers and farm workers to delay or deter migration.

As such, land fragmentation may have different effects on migration depending on overall household welfare and the type of migration. For poor households, who primarily rely on agriculture, fragmented holdings may reduce labor migration by reducing agricultural revenue and pushing them further into a poverty trap, thus making them unable to migrate. Wealthier households are more likely to afford the financial costs of migration (for labor, education, or other purposes) and possess or acquire the skills required to make the transition away from agriculture (Abramitzky, Boustan and Eriksson, 2013; Bezu and Holden, 2014; Bezu and Barrett, 2012; Kosec et al., 2018).

The literature on Uganda suggests that rural to urban migration is common, though the reasons for migration appear to vary and are often debated (Brewer et al., 2022). Research in Uganda shows that with increasing land scarcity, farmers in some of the most densely populated areas sell their land, migrate to other areas, and either buy land in sparsely populated areas where land is cheaper or settle on unoccupied land (Mwesigye and Matsumoto, 2016). However, smallholders in rural areas who face restrictive liquidity constraints and are unable to sell their native land either due to a lack of user rights or the absence of land markets usually cannot afford to migrate. For example, research has shown that smallholders in Uganda are less likely to migrate in response to weather shocks, which also reduces agricultural productivity (Bertoli et al., 2022; Kubik and Maurel, 2016).

Against this context, we hypothesize that land fragmentation reduces labor migration among poor households but may increase non-labor migration, especially among wealthier households.

3. Methodology

We use a mixed-method approach to examine the relationship between land fragmentation and migration. First, we estimate the effects of land fragmentation on migration econometrically. Then, we use a focus group discussion to complement the econometric results.

3.1. Econometric method

We use the two-way fixed effects (TWFE) estimator to estimate the relationship between land fragmentation and migration. Let Y_{it} be the proportion of migrant members in household i in year t. Let F_{it} be the number of plots (or land fragmentation index), X_{it} be a vector of control covariates, $Year_t$ be survey year fixed effects, μ_i be household fixed effects and ε_{it} be the idiosyncratic error term.

$$Y_{it} = \beta F_{it} + \theta X_{it} + Year_t + \mu_i + \quad \varepsilon_{it} \tag{1}$$

We estimate Eq. (1) with a panel fixed effects estimator controlling for time-fixed effects and household-fixed effects. The parameter of interest is β, which shows the relationship between land fragmentation and migration.

In Eq. (1), endogeneity arises if there are unobserved variables that are correlated with both land fragmentation and migration. We assume

[1] In a 2024 interview, the Prime Minister of Uganda said to his fellow citizens "Stop land fragmentation: It is dangerous to your families…"

that such unobserved variables are time-invariant and therefore purged by the fixed effect estimator i.e., $E(\varepsilon_{it}|F_{it}, X_{it}, Year_t, \mu_i) = 0$. Therefore, β is identified in Eq. (1).

3.2. Heterogeneous effects

The relationship between land fragmentation and migration may be different for different sub-samples. For example, poor households, female-headed households, and ethnic minority households may be affected differently than rich households, male-headed households, and the majority population group. To address this, we estimate Eq. (1) with TWFE for male-headed vs female-headed households, rural vs urban households, and poor vs non-poor households.

Additionally, land fragmentation may have different effects on short-term seasonal migration and long-term permanent migration. We address this by redefining migration using the number of months a migrant lived away from the household in the preceding 12 months of the survey. We estimate the relationship between land fragmentation and short-term migration (1–3 months), medium-term migration (4–6 months), and long-term migration (7–9 months and 10–12 months).

3.3. Quantitative data

The quantitative data were collated from the Living Standard Measurement Study – Integrated Survey in Agriculture (LSMS-ISA) from Uganda. The LSMS-ISA survey is conducted by the Uganda National Bureau of Statistics (UBOS) with technical and logistical support from the World Bank. The survey has recorded data on land ownership, land size, and title at the parcel level. Information on household socioeconomics, demographics, migration, as well as consumption expenditures is also recorded. Longitudinal data are available for seven different periods between 2009 and 2019, but this analysis uses data from the last four survey periods only, namely: 2013/14, 2015/16, 2017/18, and 2019/20. Data from the first three survey waves matched poorly with the last four waves and were excluded from the analysis.

Table 1 presents the structure of the data – the number of agricultural households surveyed and those included in the final analysis for each round of survey. Not all surveyed households from the first wave are included in the final panel due to missing data and attrition. As the rate of attrition and exclusion is less than 2 % of surveyed households, we do not conduct an attrition analysis.

3.3.1. Defining and operationalizing migration

Migration is defined at the household level; a household is considered a migrant household if at least one household member lived away from the household for at least one month in the 12 months preceding the survey. The survey collects data on the number of months household members lived away from the households in the last 12 months. We use this information to construct outcome variables for the duration of migration. The first outcome variable is the household level indicator of migration (1 if one or more migrants, 0 otherwise). Many households have more than one migrant member, but the binary categorization of migration misses the intensity of migration. We use the number of migrants per household as the second outcome variable to account for the intensity of migration. Third, the duration of migration also differs across migrants and households. We use the average number of migrant months (household level) as the third outcome variable. In addition, migrants are categorized into four distinct groups based on the duration of migration: 1–3 months, 4–6 months, 7–9 months, and 10–12 months. These groups are used in heterogeneity analysis.

Fig. 1 shows the distribution of the duration of migration for migrant households over time. In all survey years, the most common duration for which at least one migrant member is away is between seven and nine months, with over half the households experiencing the absence of at least one member for seven to nine months in the 2019/20 period. The migration period longer than ten months is the least common category in all survey years. The proportion of households with at least one member away for less than three months, as well as those between four and six months, is both similar in magnitude and relatively steady over the survey years.

Table 1
Sample size.

Survey year	Number of agricultural households	
	Surveyed	Final panel
2013/14	2143	2143
2015/16	2137	2132
2017/18	2338	2317
2019/20	2178	2141

Source: Authors' illustration

3.3.2. Defining and operationalizing land fragmentation

Land fragmentation is measured using the number of parcels cultivated by the household and the Simpson index. The Simpson index is a commonly used metric of land fragmentation that takes into account the number of parcels, parcel size, and the total land area (Monchuk et al., 2010).

$$Simpson\ Index = 1 - \frac{\sum_{i=1}^{n} a_i^2}{A^2}$$

where n is the number of parcels, a_i is the size of parcel i., and A is the total land size of the household. The index ranges between 0 and 1; a value close to zero indicates consolidated land, whereas a value close to one indicates highly fragmented land.

3.4. Focused Group Discussions (FGD)

To verify our quantitative results, we conducted two Focus Group Discussions (FGDs) in Uganda in August 2023. Limited resources precluded a nationally representative pool of FGDs. We conducted semi-structured FGDs to encourage informal deliberations on land fragmentation, crop yields, income, short–term migration, and the impacts of climate change. The first FGD consisted of 12 farmers (seven females, five males) from six different villages and six different producer groups in Kabale district, which is located in South-West Uganda, approximately between 30^0 0'E and 1^0 15'S. We chose Kabale as a good case study area for FGDs because of its ragged terrain, long history of land fragmentation, and migration.

The second FGD was conducted with 12 students (six males, six females) of Agricultural Sciences at Mbarara University of Science and Technology (MUST). The students were asked to speak on behalf of their families back home and represent their villages. They joined a semi-structured discussion on crop and animal production, labor migration, effects of climate change, farming behaviors, and the perception of security and mobility in their villages. All 12 students were fourth-year students pursuing a Bachelor of Science in Agriculture and Livelihoods at MUST and represented *Bulisa*, *Kitgum*, *Mubende*, *Ateptong*, *Kwania*, *Jinja*, and *Ntoroko* districts of Uganda. We interviewed students from different regions instead of farmers from the respective regions due to resource limitations. Interviewing students allowed us to capture heterogeneity across regions most cost-effectively. Also, recruiting college students to elucidate the view of diverse demographic groups on the rural economy is not a new practice. For example, Talhelm et al. (2014) used college students to better understand the behaviors of wheat and rice farmers in China.

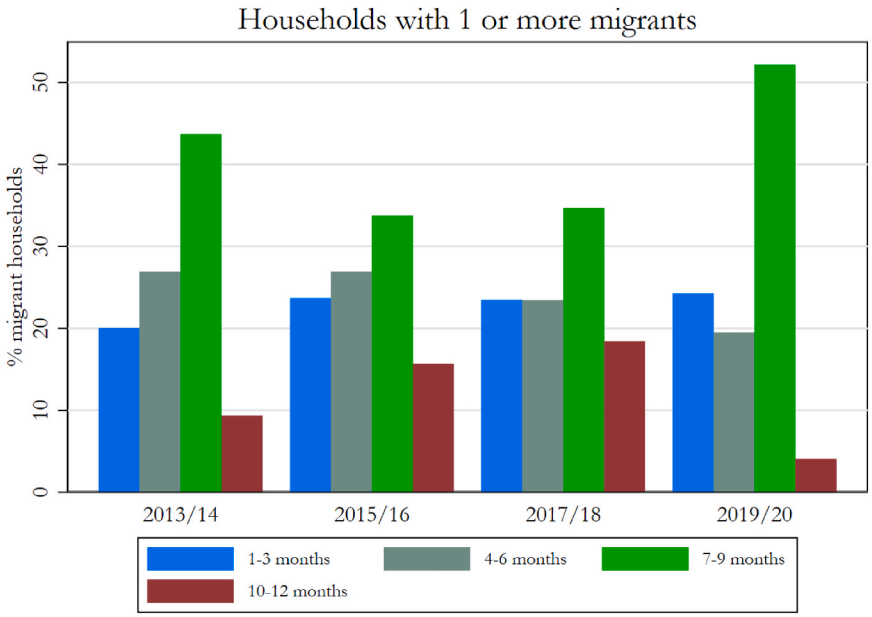


Fig. 1. Distribution of migrant households over time.

Table 2
Summary statistics of migration variables.

Variables	Survey year			
	2013/14	*2015/16*	*2017/18*	*2019/20*
Household has at least one migrant (1 =Yes, 0 =No)	0.428	0.454	0.416	0.281
	(0.495)	(0.498)	(0.493)	(0.449)
Number of households	**2143**	**2137**	**2318**	**2141**
Contingent having any migrant				
Household has a labor migrant (1 =Yes, 0 =No)	0.160	0.206	0.172	0.156
	(0.366)	(0.404)	(0.378)	(0.363)
Number of labor migrants (#)	0.177	0.247	0.206	0.171
	(0.428)	(0.550)	(0.501)	(0.423)
Labor migrant months (#)	0.179	0.224	0.189	0.149
	(0.549)	(0.568)	(0.527)	(0.434)
Household has an education migrant (1 =Yes, 0 =No)	0.532	0.536	0.489	0.465
	(0.499)	(0.499)	(0.500)	(0.499)
Number of education migrants (#)	0.949	0.989	0.832	0.809
	(1.219)	(1.286)	(1.144)	(1.208)
Education migrant months (#)	0.989	1.046	0.809	0.913
	(1.288)	(1.377)	(1.134)	(1.332)
Household has other economic migrants (1 =Yes, 0 =No)	0.175	0.207	0.260	0.167
	(0.380)	(0.406)	(0.439)	(0.373)
Number of other economic migrants (#)	0.229	0.281	0.379	0.216
	(0.597)	(0.653)	(0.797)	(0.561)
Other economic migrant months (#)	0.221	0.273	0.397	0.165
	(0.744)	(0.781)	(0.979)	(0.460)
Number of households	**917**	**970**	**965**	**602**

Notes: Point estimates are means. Standard deviations are in parentheses.

4. Results and discussion

4.1. Descriptive results

Table 2 presents summary statistics of migration variables for four different survey years between 2013/14 and 2019/20. About 43 % of sample households had at least one migrant member in 2013/14. The share of migrant households increases to 45 % in 2015/16 but decreases thereafter to 42 % in 2017/18, and to 28 % in 2019/20.[2] Among migrant households, migration for education is more common than other types of migration. For example, while about 53 % of migrant households have at least one member who migrated for education in 2013/14, only 16 % of households have members who migrated for labor, and around 17 % have members who migrated for other economic reasons in the same period. Similar patterns are reflected in the number of migrants and the number of migrant months. On average, migrant households have one education migrant, 0.18 labor migrants, and 0.22 other economic migrants. In the twelve months preceding the survey, members who migrated for education lived away from their households for approximately one month, but labor migrants and other economic migrants lived away from their households for 0.18 months and 0.22 months, respectively.

Table 3 presents summary statistics of explanatory variables for the four different survey years. The first panel presents land ownership details. The proportion of households that possess a user certificate for any plot of land varies between 19 % and 34 % over the survey period. On average, agricultural households in Uganda have consistently owned just over one hectare of land between 2013/14 and 2019/20. Land fragmentation is not uncommon in Uganda. The land fragmentation index in the sample is around 0.34, indicating a moderate level of fragmentation. Agricultural households in the sample own about two plots on average. Assuming that most inherited plots are acquired through land fragmentation, we also consider the 'average number of years household plots were acquired through inheritance' as a proxy for land fragmentation. For a given year, a value close to zero means that household plots were fragmented in the same year. Density plots for survey years 2013/14 and 2015/16 (Figure A1 in the Appendix) show that the majority of plots were inherited recently, suggesting increasing land fragmentation in recent years.

The second panel in Table 3 presents household demographics. The

[2] The reduction in migration during the 2019/20 period may be explained by the COVID-19 pandemic. This is taken care of in the analysis by including time dummies. Nevertheless, we replicated the analysis by excluding the 2019/20 data and found qualitatively similar results, indicating that COVID-19's effects were already taken care of by the survey-period dummy. The new results are presented in supplementary Tables S1, S2, S3.

Table 3
Summary statistics of explanatory variables.

Variables	Survey year			
	2013/14	*2015/16*	*2017/18*	*2019/20*
Land ownership				
User certificate for any plot (1 =yes, 0 =no)	0.233	0.191	0.340	0.324
	(0.423)	(0.393)	(0.474)	(0.468)
Land size (hectare)	1.271	1.232	1.114	1.316
	(1.893)	(2.391)	(2.270)	(2.533)
Land fragmentation index	0.348	0.338	0.330	0.340
	(0.277)	(0.275)	(0.277)	(0.273)
Number of plots (#)	2.223	2.151	2.195	2.168
	(1.217)	(1.160)	(1.190)	(1.161)
Household demographics				
Household size (number)	5.9	5.2	5.5	5.5
	(2.93)	(2.87)	(2.75)	(2.68)
Number of children (0–14 years)	2.8	2.3	2.5	2.5
	(2.06)	(1.89)	(1.87)	(1.86)
Number of youth (15–25 years)	1.8	1.7	1.7	1.7
	(1.41)	(1.34)	(1.36)	(1.33)
Number of adult (25–64 years)	1.03	0.99	1.03	1.06
	(0.824)	(0.830)	(0.811)	(0.807)
Number of elderly (>65 years)	0.21	0.20	0.24	0.26
	(0.481)	(0.476)	(0.503)	(0.528)
Head's age (years)	46.9	45.9	48.2	49.4
	(15.62)	(15.9)	(15.55)	(15.52)
Head is female (1 =yes, 0 =no)	0.316	0.328	0.341	0.345
	(0.465)	(0.469)	(0.474)	(0.475)
Head is married (1 =yes, 0 =no)	0.751	0.759	0.749	0.737
	(0.433)	(0.428)	(0.434)	(0.440)
Rural household (1 =yes, 0 =no)	0.854	0.863	0.841	0.871
	(0.353)	(0.344)	(0.366)	(0.335)
Consumption expenditure (,000 shilling/person/month)	8.144	9.537	9.726	9.680
	(13.862)	(15.462)	(24.530)	(9.441)
Asset index	−0.547	−0.469	−0.414	−0.449
	(1.518)	(1.595)	(1.788)	(1.697)
Highest member's education level				
Junior high or lower	0.717	0.699	0.658	0.663
	(0.450)	(0.459)	(0.474)	(0.473)
Secondary school	0.185	0.194	0.231	0.233
	(0.388)	(0.395)	(0.421)	(0.423)
College or higher	0.098	0.107	0.111	0.104
	(0.297)	(0.310)	(0.314)	(0.305)
Number of households	**2143**	**2137**	**2318**	**2141**

Notes: Point estimates are means. Standard deviations are in parentheses.

average household size is about six, and it remains constant over time. Among the six members, about three are children under the age of 14, two are youth between the ages of 15 and 25, and one is an adult between the ages of 25 and 64. The average number of elderly members above 65 years of age is about 0.2. Most households are headed by an adult over 45 years of age. The share of female-headed households increased over time from 32 % in 2013/14–35 % in 2019/20. More than 73 % of household heads are married. The majority of households in the sample are rural, with the number of rural households growing over time from 85 % in 2013/14–87 % in 2019/20. The next two variables, consumption expenditure and asset index, indicate household socio-economic status. Consumption expenditure is reported in real Ugandan shillings monthly per capita in 2009/10 currency. Monthly per-capita consumption increases from 8,14,400 shillings in 2013/14–9,68,000 shillings in 2019/20. Another measure of socio-economic status is the asset index, which aggregates 28 different durable assets and housing quality indicators (see Appendix Table A1 for the complete list of assets) using principal component analysis. The asset index is negative in all survey periods but improves over time.

The last panel in Table 3 presents the maximum level of education completed by household members (maximum household education). A significant majority of households have members who have completed junior high school or lower grades at best. Over time, the highest level of education attained by household members increased slightly. While the share of households with at least one member completing junior high school or lower grades decreases from 72 % in 2013/14–66 % in 2019/20, the share of households with at least one member completing secondary school or higher grades increases from about 28 % in 2013/14 to around 34 % in 2019/20.

4.2. Land fragmentation and labor migration

Table 4 presents two-way fixed effects (TWFE) results on the relationship between land fragmentation index and labor migration. We run TWFE estimator for three different measures of migration and control for covariates that include log-transformed consumption expenditure, dummies for asset-based poverty levels, household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, youth, and working age adults, and a dummy for rural residence) and survey year fixed effects.

Panel A in Table 4 presents the relationship between the number of plots and labor migration. Cultivating an additional plot of land (indication of land fragmentation) decreases the probability of labor migration by 0.8 % points, the number of labor migrants per household by 0.009, and the number of labor migrant months by 0.01 months. The magnitude of the effects is close to zero, though statistically different from zero, but our focus here is on the direction of the effect.

In Panel B, we present the relationship between the land fragmentation index and labor migration. An increase in the land fragmentation index also decreases the probability of labor migration by 2.4 % points ($p > 0.1$), decreases the number of labor migrants per household by about 0.02 ($p > 0.1$), and the number of labor migration months by 0.045 months ($p < 0.1$), although the coefficients on the first two columns are not statistically significant.

Table 5 presents the land fragmentation–migration relationship or female-headed households vs male-headed households. The survey data has about 33 % of female-headed households. Land fragmentation has no statistically significant effects on labor migration among female-headed households. However, the relationship is negative and significant among male-headed households. Additionally, an increase in the number of plots decreases the probability of labor migration, the number of migrants, and the duration of labor migration. In male-headed households, dividing one's land into an additional plot decreases the probability of labor migration by 1.2 %, the number of labor migrants by 0.02, and the number of labor migrant months by 0.015 months (Table 5, Panel A columns 4–6). Similarly, an increase in the land

Table 4
Land fragmentation and labor migration (two-way fixed effects).

	Household has a labor migrant	Number of labor migrants	Labor migrant months
	(1)	*(2)*	*(3)*
Panel A			
Number of plots	−0.0082**	−0.0094*	−0.010*
	(0.0042)	(0.0050)	(0.0059)
Control covariates	Yes	Yes	Yes
Observations	**9676**	**9639**	**9639**
Panel B			
Land fragmentation index	−0.024	−0.023	−0.045*
	(0.018)	(0.021)	(0.024)
Control covariates	Yes	Yes	Yes
Observations	**9346**	**9309**	**9309**

Notes: Standard errors are in parentheses. Level of significance *$p < 0.1$, **$p < 0.05$, and ***$p < 0.01$. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and household and survey year fixed effects.

Table 5
Land fragmentation and labor migration by head's gender (two-way fixed effects).

	Female-headed households			Male-headed households		
	Household has a labor migrant *(1)*	Number of labor migrants *(2)*	Labor migrant months *(3)*	Household has a labor migrant *(4)*	Number of labor migrants *(5)*	Labor migrant months *(6)*
Panel A						
Number of plots	0.0025	0.0071	0.0085	−0.012**	−0.016***	−0.015**
	(0.0083)	(0.011)	(0.016)	(0.0048)	(0.0058)	(0.0058)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**3177**	**3164**	**3164**	**6499**	**6475**	**6475**
Panel B						
Land fragmentation index	−0.00064	0.026	−0.011	−0.032	−0.045*	−0.052**
	(0.034)	(0.049)	(0.062)	(0.021)	(0.024)	(0.023)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**3057**	**3044**	**3044**	**6289**	**6256**	**6256**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and household and survey year fixed effects.

fragmentation index also decreases the probability of labor migration in male-headed households by 3.2 %, the number of labor migrants by 0.045, and the duration of labor migration by 0.052 months, albeit the decrease in probability of labor migration is not statistically significant.

Results in Table 5 are consistent with the findings from the in-person surveys. Most respondents we spoke with during Focus Group Discussions (FGDs) mentioned that female-headed households are less dependent on agriculture than male-headed households (as the former relies more on casual labor), so land fragmentation is of less importance to female-headed households than to male-headed households.

Table 6 presents the relationship between labor migration and land fragmentation for rural and urban households. The negative relationship between labor migration and land fragmentation holds for rural households only as the relationship is not statistically significant for urban households. Among rural households, dividing one's land into one more plot decreases labor migration by 0.95 %, the number of labor migrants by 0.011, and the duration of migration by 0.012 months. An increase in land fragmentation index also decreases the probability of labor migration by 2.1 %, the number of labor migrants by 0.014, and the duration of labor migration by 0.044 months, though the first two coefficients are not statistically significant.

Results in Table 6 are also corroborated by the accounts of migration patterns reflected in our FGDs. We did not interview anyone in urban settings, but all respondents we spoke with in rural villages confirmed that rural residents are unable to afford migration due to declining agricultural production because of land fragmentation and other reasons.

Results in Tables 4, 5, and 6 indicate that the relationship between land fragmentation and labor migration may be mediated by liquidity constraints. As explained in the conceptual framework section of this paper, agricultural households that are already poor can fall further into a poverty trap due to land fragmentation, which reduces agricultural production and farm revenue.

4.3. Land fragmentation and non-labor migration

We complement the analysis of land fragmentation and labor migration by providing additional analysis of the relationship between land fragmentation and non-labor migration. Non-labor migration includes migration for education and migration for other economic reasons (these are unspecified economic reasons other than labor and education). Table 7 presents the relationship between land fragmentation and non-labor migration. Table 8

Unlike labor migration, land fragmentation is not significantly correlated with non-labor migration. An increase in land fragmentation (both the number of plots and the fragmentation index) increases the probability of education migration by 2 %, but it is not statistically significant at a 10 % level of significance. Land fragmentation is

Table 6
Land fragmentation and labor migration for rural vs urban households (two-way fixed effects).

	Rural households			Urban households		
	Household has a labor migrant *(1)*	Number of labor migrants *(2)*	Labor migrant months *(3)*	Household has a labor migrant *(4)*	Number of labor migrants *(5)*	Labor migrant months *(6)*
Panel A						
Number of plots	−0.0095**	−0.011**	−0.012*	0.018	0.026	0.014
	(0.0044)	(0.0053)	(0.0064)	(0.019)	(0.021)	(0.022)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**8316**	**8295**	**8295**	**1360**	**1344**	**1344**
Panel B						
Land fragmentation index	−0.021	−0.014	−0.044*	−0.0043	−0.024	−0.026
	(0.020)	(0.022)	(0.026)	(0.060)	(0.072)	(0.068)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**8050**	**8029**	**8029**	**1296**	**1280**	**1280**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and household and survey year fixed effects.

negatively correlated with the number of migrants and positively correlated with the duration of migration, but neither of these relationships is statistically significant. Likewise, land fragmentation is negatively correlated with migration for other economic reasons, but the relationship is not statistically significant.

4.4. Qualitative observations from Uganda through Focus Group Discussions (FGDs)

The FGDs revealed the dynamics of migration and provided the current socio-political situation of Uganda. The scholars confirmed that trends such as land fragmentation, climate change, lack of production, challenges in farming, education, and technology all contribute to rural to urban migration. The group agreed that short–term migration generally occurs either to gain education/special skills or to seek employment. However, the group overwhelmingly acknowledged that poor farmers generally fail to migrate due to costs associated with migration, lack of information, and apprehensions of uncertainty. One of the FGD discussants stated as follows:

"Yes, the poor will remain poor. I think also people who have attained education with exposure to the outside world are more likely to migrate than those who have not. People in my village have not got education but have money therefore can afford to migrate…."

Another discussant added,

"(even after getting less land)… poorer farmers are rigid because of fear to start afresh, some people do not migrate because of pride…….they are used to free food in the village, poor accommodation and living standard……"

The discussion sessions with the farmers revealed issues with farming, land fragmentation, productivity, and management. The general sentiment was summarized by the need for more farmland. The discussant summarizes,

"(due to fragmentation) our land is very small, so if you need land for expansion you must migrate and look for vacant land…and also lack of favorable services, our soils are infertile, family wrangles and conflicts, loans/debts is making agricultural very difficult."

However, the participants also clarified that there was big disparity in land holding and the villages were plagued by unequal distribution. The session lead summarized,

"The challenge we have here is that we have monopolists who buy land, they have accumulated a lot of wealth, for them even 50 ft by 100 ft [size of land] they can buy at 40 million, for (us) common people it is difficult to buy ……."

Table 8
Land fragmentation and migration (two-way fixed effects).

	Households had at least one member away for […] in the last 12 months				
	1–3 months *(1)*	4–6 months *(2)*	7–9 months *(3)*	10–12 months *(4)*	> 1 months *(5)*
Panel A					
Number of plots	0.012	0.0041	0.027*	0.0068	−0.0098
	(0.013)	(0.013)	(0.016)	(0.011)	(0.019)
Control covariates	Yes	Yes	Yes	Yes	Yes
Observations	**9639**	**9639**	**9639**	**9639**	**9639**
Panel B					
Land fragmentation index	−0.039	−0.029	0.097	−0.0044	−0.076
	(0.048)	(0.053)	(0.063)	(0.045)	(0.068)
Control covariates	Yes	Yes	Yes	Yes	Yes
Observations	**9309**	**9309**	**9309**	**9309**	**9309**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and survey year fixed effects.

However, several members of the group unanimously stated that,

"actually most people do not move because of that (lack of land). Migrating to another place requires you to plan and that includes finances……and we simply cannot afford that…" Data from the FGDs in Kabale show that more affluent farmers prioritize sending children to urban areas for education, even under difficult economic conditions*:*

"Our children's education is a priority: we would rather spend everything we have on them but help them go to good schools" said a respondent in Kabale. Hence, we had expected to see a positive and significant empirical relationship between land fragmentation and migration for education. However, we found that even though the relationship is positive, it is not statistically significant.

The FGD leaders concluded that land fragmentation among the less wealthy households makes them apprehensive and less productive to the extent that even if they wish, they cannot migrate. As such, labor migration among the needy appears to have lessened due to the fragmentation phenomenon.

Table 7
Land fragmentation and non-labor migration (two-way fixed effects).

	Education migrants			*Other economic migrants*		
	Household has a migrant *(1)*	Number of migrants *(2)*	Migrant months *(3)*	Household has a migrant *(4)*	Number of migrants *(5)*	Migrant months *(6)*
Panel A						
Number of plots	0.0022	−0.0050	0.0045	−0.0054	−0.011	−0.010
	(0.0056)	(0.012)	(0.012)	(0.0052)	(0.0079)	(0.0089)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**9676**	**9639**	**9639**	**9676**	**9639**	**9639**
Panel B						
Land fragmentation index	0.022	−0.0029	0.072	−0.0080	−0.026	−0.030
	(0.021)	(0.046)	(0.048)	(0.019)	(0.030)	(0.036)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**9346**	**9309**	**9309**	**9346**	**9309**	**9309**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and survey year fixed effects.

5. Potential pathways and robustness checks

5.1. Pathways

What explains the negative relationship between land fragmentation and labor migration? And the positive relationship with migration for education? Liquidity constraints could be one potential pathway. Migration is costly, and most small-scale farmers face severe liquidity constraints. Land fragmentation reduces agricultural productivity (and revenue), which further reduces smallholders' disposable income, making it much more difficult for them to support the cost of migration. Considering that migration is a household decision, poor households, which usually face more restrictive liquidity constraints, are likely to decide against labor migration. We *test* this by investigating the change in the 'land fragmentation-migration' relationship along the distribution of consumption expenditure. We do this by estimating equation 2 with the two-way fixed effects estimator separately for three different socio-economic groups based on their position along the consumption expenditure distribution – bottom 40 %, middle 40 %, and top 20 %. Results are presented graphically in Fig. 2.

In Fig. 2, the vertical lines represent the 90 % confidence intervals for the estimated coefficients from the regression of migration variables on the land fragmentation index. The horizontal line corresponds to zero, and the coefficient estimates that cross the horizontal line are not statistically significant at the 10 % level of significance. Results show that the negative relationship between labor migration and land fragmentation only holds for poor households (bottom 40 % in consumption expenditure distribution). The relationship is not statistically significantly different from zero for households in the middle 40 % and the top 20 % of the consumption distribution. This result is consistent for all three migration variables – share of migrant households, number of migrants, and number of migrant months. Results in Fig. 2 indicate that fragmented land holding reduces farming households' disposable income by reducing agricultural productivity/agricultural revenue. This reduction in disposable income forces poor farming households to delay or refrain from migration altogether, which is manifested as a negative relationship between land fragmentation and migration.

5.2. Robustness checks

We run multiple specifications for robustness checks. First, we run a pooled OLS (POLS) estimator, pooling all the survey periods together and running an OLS regression. We control for time dummies, but household fixed effects over time cannot be controlled for. By design, this estimator is more efficient than TWFE, but it may not be unbiased. Results are presented in Table A2 (labor migration) and Table A3 (non-labor migration) in the Appendix. POLS results are similar to those of TWFE in that land fragmentation and labor migration are negatively correlated, but the relationship is not statistically significant for non-labor migration.

Next, we run a Two-Way Mundlak (TWM) regression to estimate the land fragmentation and migration relationship. TWM is both an unbiased and efficient estimator, which is equivalent to TWFE, but it can be used to estimate the effects of time-invariant variables as well (Wooldridge 2021). Since land fragmentation does not change much over time, we run TWM as a robustness check for the TWFE estimator. Results are presented in Table A4 (labor migration) and Table A5 (non-labor migration) in the Appendix. TWM results, too, are similar to TWFE results, indicating that our main results are robust to alternative specifications.

6. Conclusion

We use data from four different periods of the Living Standard Measurement Study – Integrated Survey in Agriculture (LSMS-ISA) from Uganda between 2013 and 2020 and employ a two-way fixed effects estimator to estimate the relationship between land fragmentation and labor migration, as well as non-labor migration (education and other economic purposes). We use pooled OLS and two-way Mundlak estimators for robustness checks. We find that land fragmentation is

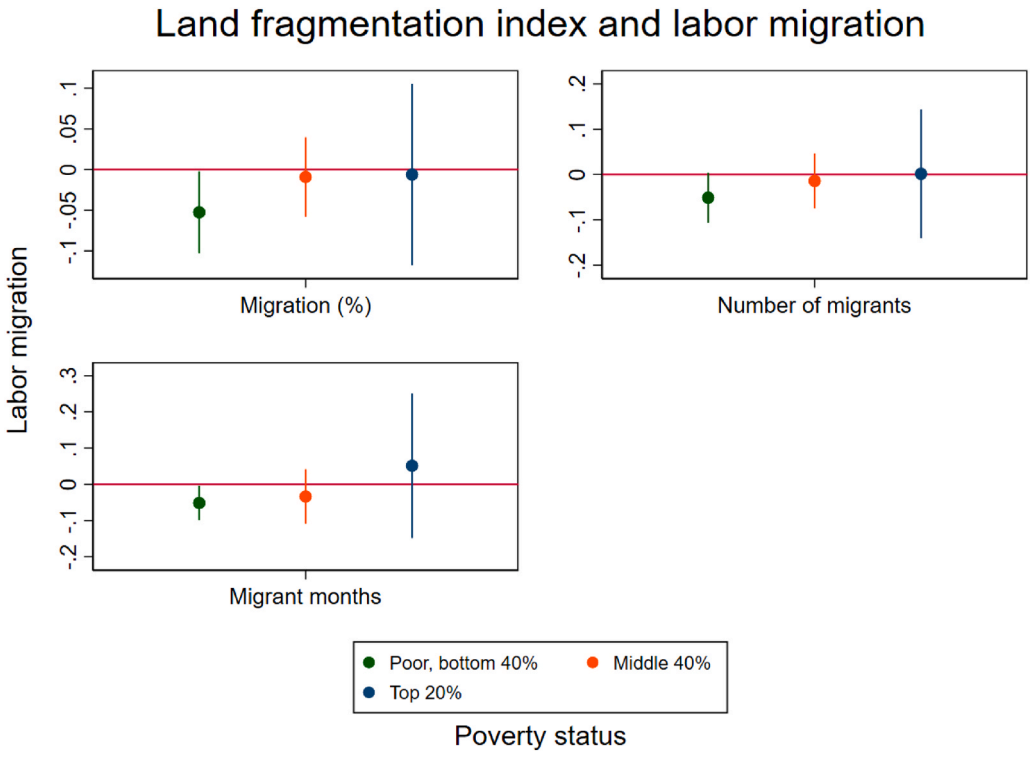


Fig. 2. Effects of land fragmentation on labor migration (Notes: Each point represents the coefficient estimate from regression of migration variable on land fragmentation index. Each line represents the 90 % confidence interval).

negatively correlated with labor migration, and the relationship is more pronounced among rural households, poor households, and male-headed households than rich households, urban households, and female-headed households. We find no significant relationship between land fragmentation and non-labor migration (education and other economic reasons), even though the relationship is positive. These findings are robust to alternative specifications.

We complemented the empirical findings with specially designed focus group discussions with Ugandan farmers from six different villages in Kabale district in South-West Uganda, as well as with undergraduate students from across the country studying at Mbarara University of Science and Technology (MUST). To keep the responses as close as possible to those of farmers, student interviewees were asked to respond on behalf of their families back home. The qualitative observations in FGDs are similar to those of empirical findings. We unpack the potential underlying mechanisms as we show that the negative relationship between land fragmentation and labor migration holds for poor agricultural households only (bottom 40 % in the consumption expenditure distribution). We argue that land fragmentation's effects on labor migration are mediated by the negative impacts of fragmented holdings on agricultural productivity.

Our findings have important implications for land governance and rural development policy. They suggest that land fragmentation may constrain labor mobility and income diversification, particularly among poor and rural households. Public policy and development programs that focus on land redistribution or consolidation may want to pay close attention to the consequences of fragmented holdings on agricultural production and smallholders' migration behavior. Our efforts provide unique evidence on how land fragmentation negatively affects migration, thereby impeding social and rural development agendas. Our data-driven results reiterate the need for funding, legislation, and policy interventions to address land fragmentation issues in Uganda and other countries in sub-Saharan Africa.

Our results, however, may not be used to justify the ongoing efforts of land consolidation in Uganda and other SSA countries (Asiama et al., 2021) for two reasons. First, our analysis does not investigate how land consolidation affects migration and other livelihood outcomes, and second, it is not clear how land consolidation can be implemented on customary lands that have no clear property rights. Instead, a more effective approach based on our findings may be to address the liquidity constraints that prevent poor households from migrating. This could involve creating targeted microfinance programs or subsidies to reduce migration costs. Additionally, policies aimed at improving agricultural productivity on small, fragmented plots—such as enhancing access to better inputs or extension services—could raise household incomes, providing the capital needed for migration.

We recommend several potential avenues for future research. First, longitudinal studies spanning several years are needed to understand the long-term, intergenerational effects of land fragmentation on migration patterns. These studies could also examine the long-term effects of land consolidation on agricultural productivity and household welfare, as well as explore gender dynamics in shaping land-related migration decisions. Second, future work would benefit from employing more granular spatial data, such as the distance between parcels, and conducting formal causal mediation analyses to empirically test the role of agricultural productivity as the primary mechanism linking land fragmentation to migration decisions. Finally, comparative studies across Sub-Saharan Africa could shed further light on whether these mechanisms are context-specific or broadly generalizable, informing regional land use strategies.

CRediT authorship contribution statement

Kashi Kafle: Writing – original draft, Software, Funding acquisition, Formal analysis, Conceptualization. **Naureen Fatema:** Writing – original draft, Investigation. **Shahriar Kibriya:** Writing – original draft, Funding acquisition, Conceptualization. **Yuanhang Wang:** Writing – review & editing, Software, Formal analysis, Data curation, Conceptualization. **Ronald Twongyirwe:** Writing – original draft, Methodology, Investigation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

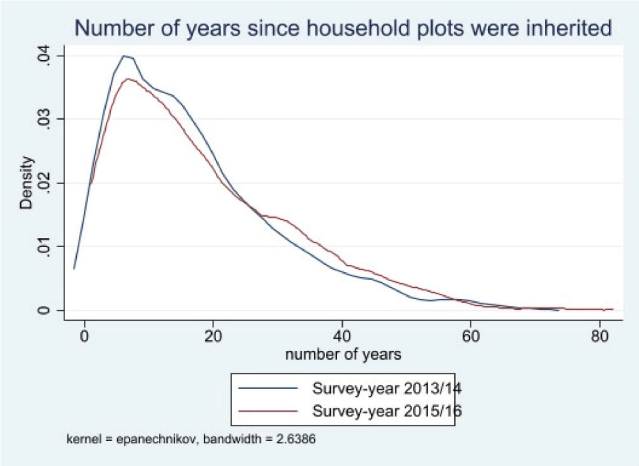


Figure A1. Number of years since household plots were inherited

Table A1
Variables to create the asset index

Household durable assets	Housing quality characteristics	Agricultural assets
Number of…	*(1 =yes, 0 =no)*	*Number of…*
Household appliances	Home ownership	Chicken
Television	Number of rooms	Cattle
Radio	Uses modern cooking fuel	Goat
Generator	Has improved roof	Pig
Solar panel	Has improved wall	Horse
Bicycle	Has improved floor	Land area
Motorcycle	Has improved toilet	
Car	Has access to electricity	
Boat	Has access to internet	
Cellphone		
Computer		
Jewelry		

Source: Authors' illustration

Table A2
Land fragmentation and labor migration (pooled OLS)

	Household has a labor migrant	Number of labor migrants	Labor migrant months
	(1)	*(2)*	*(3)*
Panel A			
Number of plots	−0.0073***	−0.0086***	−0.0069*
	(0.0026)	(0.0032)	(0.0036)
Control covariates	Yes	Yes	Yes
Observations	**9676**	**9639**	**9639**
Panel B			
Land fragmentation index	−0.029**	−0.036**	−0.035**
	(0.012)	(0.015)	(0.016)
Control covariates	Yes	Yes	Yes
Observations	**9346**	**9309**	**9309**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and survey year fixed effects.

Table A3
Land fragmentation and non-labor migration (pooled OLS)

	Education migrants			*Other economic migrants*		
	Household has a migrant	Number of migrants	Migrant months	Household has a migrant	Number of migrants	Migrant months
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*
Panel A						
Number of plots	0.0037	0.0077	0.013	−0.0039	−0.011**	−0.013***
	(0.0040)	(0.0099)	(0.010)	(0.0028)	(0.0045)	(0.0048)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**9676**	**9639**	**9639**	**9676**	**9639**	**9639**
Panel B						
Land fragmentation index	0.023	0.022	0.081*	−0.019*	−0.050***	−0.065***
	(0.017)	(0.040)	(0.043)	(0.012)	(0.019)	(0.022)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**9346**	**9309**	**9309**	**9346**	**9309**	**9309**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and survey year fixed effects.

Table A4
Land fragmentation and labor migration (two-way Mundlak regression)

	Household has a labor migrant	Number of labor migrants	Labor migrant months
	(1)	*(2)*	*(3)*
Panel A			
Number of plots	−0.0085**	−0.0095**	−0.010*
	(0.0039)	(0.0047)	(0.0055)
Control covariates	Yes	Yes	Yes
Observations	**9676**	**9639**	**9639**
Panel B			
Land fragmentation index	−0.026	−0.025	−0.046**
	(0.017)	(0.020)	(0.022)
Control covariates	Yes	Yes	Yes
Observations	**9346**	**9309**	**9309**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and survey year fixed effects.

Table A5
Land fragmentation and non-labor migration (two-way Mundlak regression)

	Education migrants			*Other economic migrants*		
	Household has a migrant *(1)*	Number of migrants *(2)*	Migrant months *(3)*	Household has a migrant *(4)*	Number of migrants *(5)*	Migrant months *(6)*
Panel A						
Number of plots	−0.00088	−0.0076	0.0023	−0.0071	−0.012	−0.012
	(0.0058)	(0.013)	(0.014)	(0.0051)	(0.0077)	(0.0086)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**9676**	**9639**	**9639**	**9676**	**9639**	**9639**
Panel B						
Land fragmentation index	0.014	−0.0056	0.073	−0.021	−0.048	−0.054
	(0.021)	(0.049)	(0.051)	(0.019)	(0.030)	(0.035)
Control covariates	Yes	Yes	Yes	Yes	Yes	Yes
Observations	**9346**	**9309**	**9309**	**9346**	**9309**	**9309**

Notes: Standard errors are in parentheses. Level of significance *p < 0.1, **p < 0.05, and ***p < 0.01. Control covariates include log (consumption expenditure), dummies for asset poverty levels (bottom 40 %, middle 40 %, and top 20 %), household head's characteristics (age, gender, marital status, education), household demographics (household size, number of children, number of youth, number of working age adults, dummy for rural residence), and survey year fixed effects.

Appendix B. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2025.107844.

Data availability

Data will be made available on request.

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