Food and Agriculture
Organization of the
United Nations

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FAO AGRICULTURAL DEVELOPMENT ECONOMICS
WORKING PAPER 21-08

ISSN 2521-1838

October 2021

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The role of migrants in forest land conversion in Uganda

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Rome, 2021

Required citation:

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 Agricultural Development Economics Working Paper 21-08. Rome, FAO. https://doi.org/10.4060/cb7072en

ISSN 2664-5785 [Print]

ISSN 2521-1838 [Online]

ISBN 978-92-5-135068-3

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Abstract

This working paper explores the linkages between forest conservation, agricultural land expansion and internal migration in Uganda. The analysis, based on three waves of individual panel data and highly refined spatial data on tree loss, sheds light on how internal migration and commercial agriculture shape deforestation patterns across Uganda. The results suggest that cash crop producers and inter-district migrants engaged in agriculture in the recipient parishes are responsible for a significant rise in deforestation. In particular, the migrants that undertake cash-crop activities are associated with an increasing pattern of deforestation compared to both the migrants not engaged in cash crop production and the locals producing cash crops. This is plausibly because migrants lack contextual knowledge of ecological conditions and local social rules governing the forest, and thus are more prone than locals to cut trees for agricultural purposes. A mediation analysis confirms that cash crop production is a big channel through which migration increases deforestation. Taken together, these findings call for improved coordination between policies on forest, agriculture, land use and migration. In particular, innovative legal frameworks governing land-use, agricultural training programs and ad-hoc policies of integration are critical to support migrants in recipient areas and avoid additional pressure on forest cover.

Keywords: tree loss, internal migration, cash crops, commercial agriculture, agricultural expansion, natural resource conservation.

JEL codes: Q12, Q18, Q23, Q55.

Acknowledgements

This paper was prepared by the Economics and Policy Analysis of Climate Change (EPIC) team in the Agrifood Economics Division (ESA) of the Food and Agriculture Organization of the United Nations (FAO) as part of the FAO's work plan under Strategic Objective "Increase the resilience of livelihoods" (SP5).

The authors would like to thank Kathryn Clark, Food Security and Livelihood Coordinator at the FAO Representation in Uganda (FAOUG), Priya Gujadhur, Deputy FAO Representative (FAOUG), Nelly Bedijo, Programme Associate (FAOUG), and Sergio Rivero Acha, Energy and Environment Consultant (FAOUG), who provided great support and inputs.

Finally, we would like to thank Ana Paula de la O Campos, Economist (ESA, FAO) and Marco V. Sánchez, Deputy Director (ESA, FAO) for the editorial review; as well as Daniela Verona (ESA, FAO) for layout support and publishing coordination.

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1 Introduction

The alarming global rates of deforestation observed in the last decades raise serious concerns for the future of the planet, especially if deforestation continues to advance at current rates. Data from FAO (2020) indicate that about 420 million hectares (ha) of forest have been lost since 1990, with an estimated annual tree loss of 10 million ha per year from 2015 to 2020. Deforestation has been particularly severe in the tropics, resulting in massive habitat damages, biodiversity loss and desertification. Statistical analysis based on current rates of population growth and forest resource consumption project very pessimistic scenarios about the probability of human survival without facing a catastrophic collapse in a few decades (Bologna and Aquino, 2020).

Worldwide recognition of the importance of forests for the well-being of the planet is reflected in the increasing number of global and national commitments to halt or reverse forest loss. However, policy commitments to reduce forest loss and forest degradation are often at odds with national economic growth and development objectives, particularly for countries that are undergoing structural transformation associated with changes in agriculture, industrial development, urbanization, and social pressures for more food, settlements and job opportunities. The dynamics underlying the deforestation process involve all these factors. However, the trade-offs inherent in any structural transformation process are context specific, and are shaped by local institutional, economic, infrastructural, and biophysical components.

The trade-off between a sustainable development and the preservation of the forest is particularly challenging to find in countries where agriculture is the dominant source of livelihood and economic activities. Indeed, large-scale commercial agriculture and subsistence agriculture account for over 70 percent of deforestation in tropical and sub-tropical countries (FAO, 2016). In Africa, the conversion of tropical forest to agricultural land is primarily being small-scale agricultural producers, with commercial agriculture accounting for about one third of deforestation (FAO, 2016). Despite the adverse effects of agriculture on deforestation, African governments recognize the importance of improving the agricultural sector performance in order to trigger economic growth and poverty reduction. National policies have been, indeed, developed in Africa to support the integration of farmers into commercially oriented agricultural value chains as a means for increasing farmer incomes and welfare (Martiniello and Azambuja, 2019). However, if the development of these value chains have adverse effects on forest cover, such agricultural policies may be producing unintended consequences that are contrary to national policy objectives related to the conservation of the unique African tropical forests.

The difficult trade-off between agricultural development and deforestation is further complicated where improvements in agricultural value chains act as migration pull factors for people seeking rural livelihood opportunities, with potential negative consequences for forests. For example, in addition to clearing forest to accommodate agricultural production, agricultural migrants in Africa also frequently clear trees in order to strengthen their claims to the land under customary land tenure systems, leading to relatively higher rates of forest clearing among migrants (Unruh *et al.*, 2005). Moreover, a lack of contextual knowledge of local ecological and climate conditions increases the risk that agricultural migrants will adopt unsustainable land management practices which tend to degrade farmland over time (Codjoe and Bilsborrow, 2012). Finally, the relationship between agricultural migration and deforestation may be associated with a difference in resource endowments relative to host populations. In some cases, rural migrants are relatively better-off than their local counterparts, and are therefore able to mobilize the resources and labour to clear large tracts of land and manage larger production systems (Chamberlin *et al.*, 2020). Conversely, in some cases migrants are relatively poorer than their local counterparts, and extract forest resources at a greater rate in order to meet short-term consumption needs (Broad, 1994). However, the relationship between agricultural migration and deforestation is not trivial and predetermined. There is evidence that when migrants are well-integrated into hosting communities, there is no reason for them to be considered 'exceptional resource degraders', and their impact on deforestation may only occur through an increase in population density in the receiving areas (Black and Sessay, 1997).

In this paper, we make use of three waves of socio-economic survey data derived from the UNPS (2009) to expand our understanding of the influence of internal migration and commercial agriculture in shaping deforestation patterns across Uganda. We focus on Uganda for several reasons. First, an average of 122 000 ha of forest area has been lost in the country every year from 1990 to 2015, amounting to a loss of around 63 percent of its forest cover in this period (MWE, 2016). Second, in 2019 over 75 percent of the Ugandan population still lived in rural areas where agriculture is the main contributor to livelihoods. Third, immigrants in Uganda (both internal and international) are strongly involved in crop production activities and play important roles in major crop value chains (de Hass, 2017). Migration towards fertile and productive lands to cultivate within the country have been facilitated by the availability of easily accessible lands, initially forested and vacant, but gradually converted to agriculture (Twongyirwe *et al*., 2018). Finally, the Ugandan government has implemented a number of policies in the last two decades to incentivize commercial agricultural production. In particular, the National Agricultural Policy was formulated with the aim to guide the agricultural sector towards the modernization of agriculture and sustainable development (MAAIF, 2013). The principal mission of this policy is to transform subsistence farming to sustainable commercial agriculture. Under this policy framework, incentives to increase the production of traditional cash crops such as coffee, cotton, tea and tobacco, the promotion of smallholder integration within commercial agricultural circuits and investments in value chain development, have resulted in a large increase in both quantity produced and area under most cash crops. Assessing potential downside risks on deforestation associated with such policies is therefore fundamental to support Uganda along its sustainable development pathway.

In this work, we merge socio-economic data with data on deforestation to explore the interrelationship between rural migration, the development of commercial agricultural sector, and forest cover loss. Specifically, using an individual fixed-effect panel model as explained in Torres-Renya (2007), we test the role of cash crop producers and inter-district migrants on the tree loss in the parish of residence, while controlling for several other household-level and parish-level contributing factors of deforestation, including population density, proximity to markets and protected areas. Also, we investigate the agricultural channel, specifically producing cash crops, as one major channel through which inter-district migration affects deforestation. Our analysis aims to support the identification of policy strategies to reduce the adverse impacts of agricultural commercialization initiatives on Uganda's critical natural resources; and identify policy options that maximize migrant's benefits on recipient areas while minimizing downside risks of migration related to over-exploitation of resources and deforestation.

Our results indicate that cash crop producers are associated with a rise in deforestation by 16 percent. Similarly, an inter-district migrant engaged in agriculture increases tree loss by 31 percent in the parish of residence. An in-depth analysis on migration shows that the migrants associated with a significant tree loss are those producing cash crops, while among cash crop producers, the migrants have a higher impact on deforestation compared to locals. Finally, a mediation analysis confirms that producing cash crops is a major mediator factor between inter-district migration and deforestation in Uganda. Taken together, our findings suggest that improved coordination between policies on forest, agriculture, land use and rural development is required to reach progress towards sustainable development. Meanwhile, clear legal frameworks governing land-use and access, as well as agricultural training programs and ad hoc policies of integration are critical to support migrants in recipient areas and avoid additional pressures on forest cover.

2 Background

2.1 Patterns and drivers of deforestation in Uganda

Forests cover 31 percent of the world's land area and serve as a vital component to global biodiversity (FAO, 2020). Despite worldwide recognition on the importance of forest conservation, deforestation and forest degradation continue to take place globally especially in tropical forests. FAO (2020) estimates that about 420 million ha of forests have been lost since 1990, with the rate of deforestation estimated at 10 million ha per year from 2015 to 2020. Uganda's forests are no exception to this predicament.

In Uganda, where the economy is primarily based on agriculture, over 90 percent of the population heavily relies on natural resources to meet their daily needs, putting pressure on the nation's forests (NEMA, 1998; Mwavu and Witkowski, 2008). Forests in Uganda are an important asset for the country, providing a multitude of benefits including climate change mitigation, habitat for native flora and fauna, the provision of a wide range of wood and non-food forestry products, soil and water protection, and cultural benefits. However, alarming rates of deforestation in Uganda have led to an average of 122 000 ha of forest area being lost every year from 1990 to 2015, amounting to a loss of around 63 percent of its forest cover in this period. Consequently, the nation's forest coverage saw a sharp decline from 24 percent of the total land area in 1990 to merely 9 percent in 2015 (MWE, 2016). As a response, the Ugandan government has carried out a number of policies and institutional reforms to address this issue and protect the country's forests, including the implementation of the National Forestry Policy 2001, the enactment of the National Forestry and Tree Planting Act 2013, the establishment of the Forest Sector Support Department, the National Forestry Authority (NFA), the Environmental Protection Police Unit, and the continued formulation of district level Forestry Services arrangements (Josephat, 2018). Despite these efforts and interventions, Ugandan tree loss continues to accelerate.

One of the main drivers of deforestation in the country is the conversion of forest land to agricultural land (Twongyirwe *et al.*, 2011). This is especially evident in the case of forests on private lands (Omeja *et al.*, 2016), due to holder's perceptions of higher returns from conversion of forests to farmland as opposed to retaining them as forests. Large areas of forests in the central region and Masindi and Hoima districts have been converted to agricultural land, particularly into sugarcane plantations. Much of these trends of land conversion is perpetuated by migrants from the West Nile and the Democratic Republic of the Congo who settle near forests in the border districts and eventually clear them (UNHCR, 2019). Forests in the Kibaale district have been reported to face high levels of forest degradation due to migrants from the Kabale and Kyenjojo districts that extensively transformed previously rich natural forests into agricultural lands (MWE, 2016). The NEMA (2012) has identified small-scale farmers (88 percent of Uganda's population), migrants, and private large-scale farming enterprises of palm oil and sugarcane as the key agents of agricultural expansion into both protected and non-protected forest areas.

Another key driver of deforestation is the high population density and the subsequent conversion of land for urban settlements and the increased felling of trees for timber, firewood, and charcoal. The annual population growth rate of Uganda exceeded 3.7 percent in 2018, which is among the highest in the world. Approximately 96 percent of the population relies on firewood and charcoal for cooking (UBOS, 2006), and thus Uganda's population growth is putting continuous pressure on the country's forest resources. According to the Ministry of Water and Environment, deforestation is intensified in areas with higher population densities. In districts such as Mukono, Mpigi and Luwero, large areas of forests were reportedly cleared in the last decade due to increased populations (MWE, 2016).

Land tenure insecurity further complicates the matter. A large range of studies looking into land use change in tree-covered landscapes have found that land tenure is a crucial determinant of landscape dynamics (Gobin, Campling and Feyen, 2001; Wear and Flamm, 1993; Spies *et al*., 1994; Turner *et al*., 1996, Dale *et al*., 1993), and land tenure security is a key component in land management. In Uganda, the Uganda Constitution of 1995, the Land Act of 1998, and the National Forestry Policy of 2001 specify four general legal land tenure systems: customary, freehold, *mailo* (where the registered land owner perpetually holds the land, but is subject to customary and statutory rights of lawful and bona fide occupants) and leasehold land (Mwavu and Witkowski, 2008). Yet ambiguous ownership and insecure land tenure systems have negative implications for forest lands in Uganda. In particular, customary land tenure systems have been found to result in a general weak collective management of woodlands, and the rates of conversion of land use to agricultural lands are higher in land under such systems when compared to land under freehold and *mailo* tenure systems (Place and Otsuka, 2000). Indeed, what was originally a form of clan or tribal land, land under customary tenure is presently shifting towards individual ownership in certain parts of Uganda (Place and Otsuka, 2002), leading to claims of land ownership being based more on occupancy as opposed to communal usage, where occupancy is demonstrated through use/cultivation (Place and Otsuka, 2000). The relationship between migration, land ownership, and deforestation, remains complex to discern. For example, focusing on a longitudinal survey on Uganda, Mwesigye *et al*. (2017) show that communities observing higher levels of rural-to-rural immigration are also associated to higher private land ownership and more functional land markets. However, the literature lacks information about what the underlying driving forces of this relationship are, and whether the type of activity of the immigrants may affect the level of deforestation in the recipient areas.

Extensive distance from markets and protected areas are also drivers of deforestation. There is evidence from northern Uganda that when modelling the role of household-specific location with respect to both markets and forests, the distance to markets influence fuelwood extraction patterns of households, with households furthest from the markets and closest to forests being more likely to be autarkic in terms of fuelwood collection (Miteva *et al*., 2017). Similar results are found in several other studies (Robinson, Williams and Albers, 2002; Kohlin and Amacher, 2005; Robinson, Albers and Williams, 2008; Robinson and Lokina, 2011). Distance from protected areas are also a determining factor in the decision-making process of households in terms of forest exploitation. Central Forest Reserves (CFR), managed by the National Forestry Authority (NFA) and Local Forest Reserves (LFR), managed by local governments have been established with the objective of safeguarding forest resources and the environmental services they provide (NFA, 2011; NPA, 2013). It has been reported by the MWE (2016) that there is a significant difference in the level of deforestation within protected areas and forests on private lands. Empirical work evaluating the effectiveness of protected area policies in deterring deforestation predominantly suggest that such policies are generally effective in delaying forest loss (Andam *et al*., 2008; Gaveau *et al*., 2009; Pfaff *et al*., 2009; Sims, 2010; Joppa and Pfaff, 2010; Ferraro and Hanauer, 2011; Miteva *et al*., 2012), but at the same time, a number of studies put forward that the impacts of protected areas are heterogeneous and vary through time and space (Andam *et al*., 2008; Ferraro and Sims, 2011; Nelson and Chomitz, 2011; Pfaff *et al*., 2011). The MWE (2016) reports that the drivers of deforestation in protected areas are mainly illegal charcoal burning and firewood cutting while the drivers of deforestation in non-protected forest areas are largely derived from agricultural expansion, ranching and human settlements. As such, understanding the spatial behaviour of households in relevance to their proximity and/or distance to markets and natural resources can help tackle unintended consequences for non-protected forest areas (Miteva *et al*., 2017).

Lastly, poverty is often highlighted as a factor leading to heavy dependence on forests in Uganda (Twongyirwe *et al*., 2018). In 2016, 70 percent of the population lived on USD 3.20 (2011 Purchasing Power Parity) a day (World Development Indicators, 2020). The conventional poverty-environment argument is that the lack of alternative sources of income drives the poor to sustain their livelihoods from forestry resources, further depleting the already exploited forest land (Mwavu, 2007). Counterargument states the poor are less likely to contribute to forest clearance relative to wealthier people, as they lack the capital to pay for materials and labour needed to do so (Angelsen and Kaimowitz, 1999).The rich would also directly gain from timber commercialization and large scale plantations, despite indirect benefits, in terms of employment, profit reinvestment and multiplier effects, may also be perceived by the poor (Angelsen and Wunder, 2003). This also lingers as a challenge for the government, which faces difficult decisions that may eventually lead to serious environment costs and repercussions to the nation's natural ecosystems.

2.2 Agriculture and migration in Uganda

Uganda is a country with great potential for agricultural productivity, with its relatively favourable climate and soil conditions. Agriculture is a key sector in the nation's economy. According to the Uganda National Household Survey 2016/17, agriculture contributed about 25 percent of the gross domestic product (GDP) and employed approximately 65 percent of the labour force in 2016/17 (MAAIF, 2016). The promotion of commercial agriculture has been at the forefront of Uganda's agricultural policy in the last decades. This has created a range of incentives for producing cash crops, with potential adverse implications on forests, and has created incentives for people to migrate to areas where cash crop value chains have developed.

Yet, its dynamic economic history has hindered a sustainable development pathway. Up until the beginning of the 1960s, policies had been set to devise cooperatives for farmers to sell cash crops such as cotton, coffee, tobacco and maize, among others. But political turmoil, corruption, and a lack of resources from the 1970s onward have deteriorated farmers' incomes from commercial agriculture. Technological improvements slowed, improved efficiency was not sought, roads were left damaged, inflation rates surged, and producer prices dropped. All of these factors played into lower agricultural production levels in the 1980s (Matthews *et al*., 2007).

More recently, the Uganda's National Agriculture Policy was formulated with the aim of guiding all agriculture related sub-sector plans, policy frameworks and strategies towards the modernization of agriculture and a sustainable agricultural development (MAAIF, 2013). The aim of this policy is to transform subsistence farming to sustainable commercial agriculture. Its core objectives involve improvements in food security and household income through coordinated interventions that focus on enhancing sustainable agricultural productivity, providing employment opportunities, and promoting domestic and international trade. In terms of operationalization, the plan calls for a commercialization of the agricultural sector through value chain development, commodity specialization in profitable enterprises through agro-zoning and a support to private and public sector initiatives aimed at establishing agro-processing industries.

Within this policy framework, several agricultural interventions have been implemented in the country to revitalize the commercial agricultural sector and support the production of traditional cash crops. The 1987 Rehabilitation and Development Plan (RDP), for example, called for efforts to increase production of traditional cash crops, including coffee, cotton, tea and tobacco. Following the RDP, the government has been supporting farmers with a number of interventions, including the supply of planting materials for cotton and tea production, as part of the 2010 Poverty Eradication campaigns, and the provision of incentives to cotton farmers to increase on acreage of cotton while supporting cotton value chains (Nabwiiso, 2018). The Value Chain Roadmap for sunflowers was also set up to address imbalances between the competitive contract farming segment and an underdeveloped independent farming channel. Its main steps include improving availability of inputs, better positioning of the sunflower sector for attracting investment, enhance capabilities for value transformation and strengthening enterprise capabilities (Dalipagic and Elepu, 2014; ITC, 2020). Governments, corporate agri-business and development institutions have also supported sugarcane as a suitable commodity to promote the integration of smallholders within commercial agricultural circuits so as to improve the prospects of rural development and rural poverty reduction (Martiniello and Azambuja, 2019). Partially due to these incentives and investments on cash crops production, both the production and the area under most cash crops have largely increased since 1990, and in some case have doubled or more than doubled, according to FAOSTAT database estimates (FAO, 2021). Conversely, staple crops do not exhibit similar patterns as cash crops. The area under staples has remained mostly stable in the last twenty years (mostly due to a shift in land from plantains to maize and cassava).

Meanwhile, migration has been an integral part of Uganda's history. While in this analysis we focus on internal migrants, both internal and international migrants have played a major role in shaping the country's agricultural and specifically cash crop economy (de Hass, 2017). In the colonial period, labourers moved from the northwest and southwest to the sugarcane plantations in central and eastern Uganda (Lyons, 1996). Other migrants, particularly from the southwest, settled as labourers on private coffee farms, especially in the Masaka district (Rutabajuka, 1989). The forms of migration have varied during the period of political instability in the 1970s and 1980s, but in more recent years the role of migrants in commercial agriculture has been further documented. Migrants engaged in agriculture usually move from one side of the country to another, attracted by fertile lands and relatively profitable opportunities in the agricultural sector, both as labourers and as producers when they hold land. The sugarcane industry in the Budongo region of Western Uganda, for example, has seen rapid growth starting from the 1990s, partially caused by the influx of migrant labourers, (Twongyirwe *et al*., 2018). Similar patterns are found near the Kibale National Park in tea plantations (Gewald *et al*., 2012). Yet the expansion of sugarcane farming as well as the tea plantations have been highlighted as one of the major drivers of deforestation in the respective areas (Twongyirwe *et al*., 2018; Gewald *et al*., 2012).

As such, migration and the agricultural activities of migrants interplay as drivers of deforestation in Uganda, further exacerbating the issue. Findings from Twongyirwe *et al*. (2018) that investigate deforestation patterns in western Uganda imply that migrants have a higher tendency to inhabit forested areas and exploit the nearby natural resources to sustain their livelihoods or clear the forest for small-scale farming, while locals are more likely to settle further away from forests. According to an informant from the study, locals were less prone to cut down trees due to cultural inclinations and the perception of such practices as being immoral. In some cases, migrants have also shown to fail to consider the long-term effects of resource extraction and land use, and this is most probably because they expect that their period of stay in the destination area will be temporary (Codjoe and Bilsborrow, 2012). In addition, Hartter *et al*. (2014) suggests that migration to areas near forest lands are not necessarily driven by economic benefits but rather by significant push and pull factors that arise in different scales. These involve social and cultural components as well as environmental changes occurring along the borders of the forests. Yet this is still a largely debated issue as some argue that increased economic opportunities near protected forest areas disproportionately attract migrants (Newmark and Hough, 2000; Wittemyer *et al*., 2008). This continued debate emphasizes the importance of understanding the underlying factors that drive migrants to actions linked to deforestation, which in turn can provide a better context for the development of appropriate forest protection measures.

3 Data and variables

The analysis relies on a set of socio-economic survey and geo-spatial data. The main dependent variable captures the level of tree loss in a given parish and derives from the Global Forest Change Database developed by the University of Maryland (Hansen *et al.,* 2013). This database captures the area of major tree loss across the globe for the period 2001 to 2018 at 30 meters of spatial resolution. Using this data, a time-varying indicator on tree loss equal to the sum of the area of tree loss occurring in the year of the survey and the first year after the survey was constructed. Subsequently, this variable was merged with the individual survey data using the parish of individual's residence available in the survey. The survey panel data derives from the Uganda National Panel Survey 2009–2010, 2010–2011, and 2011–2012 (UNPS, 2009). The UNPS data has been designed and implemented by the UBOS, with support from the project of the World Bank Living Standard Measurement Survey-Integrated Surveys on Agriculture. The UNPS data is representative at the national, urban/rural and regional levels. In each wave, the UNPS collects information about approximately 18 000 individuals belonging to 3 200 households. UNPS captures a wealth of information on demographics, migration, housing, markets and services, employment and agricultural activities, both at individual, household and plot-level. The agricultural module includes information on access to land and type of land tenure, plot area, land use and agricultural practices, supplemented by a wide range of information on planted and cultivated crops, fruits and legumes.

This survey provides a large set of relevant individual-level information for studying migration, such as birth district/country, previous district/country of residence, number of years living in the current residence and new district of residence for the members no longer living in the household. Based on this information, we build our main migration variable as a dummy equal to 1 if an individual moved from a district to another internally to Uganda within two years before the survey. We use migration lagged with respect to tree loss for two main reasons. First, because after migration has occurred, it may take some time before a migrant could have any significant effect on deforestation, especially when this effect occurs via indirect channels. Second, because this lag helps to reduce potential endogeneity issues, mainly due to reverse causality between migration and deforestation. As migration may drive deforestation, it could also be the case that deforested lands may already attract migrants that are looking for cleared lands to use for agricultural purposes or for opportunities in areas that are growing and urbanizing. Furthermore, we constrain our analysis to the individuals older than ten years, to account only for the people who may have an active role on deforestation.

A second important indicator for this analysis is the type of agricultural activity conducted by the household to which the individual belongs. For this reason, we construct two household-level dummies, a first one activating when the household engages in cash crop production, consisting in the cultivation of at least one crop among coffee, cotton, tobacco, tea, sugarcane, and sunflower. A second dummy activates if the household is involved in staple crop production, including the production of cassava, finger millet, maize, sorghum, wheat and sweet potatoes.[1] To account for differences in tenure security which may affect the likelihood of deforestation, we compute an additional dummy indicator taking a value equal to 1 if the households own or manage at least one plot under the customary system. We also include a set of further controls

[1] For the purpose of ease of reading, from here onward we will discuss the type of cultivation as associated to the individual rather than the household.

that may change individuals' attitudes toward deforestation. First, we include a dummy indicator on education activating if the head of the household completed at least primary education. To account for service availability and proximity to markets, we add the distance in kilometres of the household from the nearest market. Furthermore, using the latitude and longitude provided by the UNPS, the socio-economic data is merged with two additional sets of geo-spatial data. First, an indicator on population density at parish level obtained from the WorldPop database, which delivers yearly estimates for population density for Africa at 1 km of spatial resolution (Tatem, 2017). To account for non-linearity in the impact of population, the specification also includes the squared value of the population density. Second, to control for spatial heterogeneity caused by the enforcement of forest protection laws, we build an additional indicator on the distance from protected areas using a geo-spatial dataset delivered by the National Forest Authority of Uganda (see, among others, Musinguzi *et al*., 2012). Finally, we build an additional dummy variable indicating whether the household is below the poverty line in the year of the survey, already computed by the UNPS implementers following the international standard of poverty line (USD 1.90 per day).

3.1 Descriptive statistics

Based on how migration is defined as above, (inter-district) migrants represent approximately 2.5 to 3.6 percent of the total observations across the years 2010–2012 (see Table A1 in the Annex). International migrants, i.e., individuals whose previous residence was outside Uganda, represent only an exiguous percentage of the total observations (less than 0.1 percent). Since international migrants may be under-represented in this survey, we focus our analysis on internal migrants, and, from now on, we refer to inter-district migrants as migrants, unless specified differently.

Table A2 in the Annex reports a set of summary statistics indicating that migrants tend to be younger compared to the rest of the population, with an average age equal to 22 to 25 years, and thus more than three years younger than the non-migrant population. Approximately 40 percent of migrants are male, while male individuals among non-migrants are about 50 percent. Migrants, on average, report higher levels of wealth, as measured by the poverty dummy, compared to non-migrants. The percentage of migrants living in poor households ranges between 11 and 24 percent, depending on the wave under consideration, while the share of non-migrants living in poor households reaches 30–31 percent in the last two waves. Migrants are also slightly less engaged in agriculture compared to non-migrants, who have more than 80 percent of their household relying on agriculture for their livelihood. The vast majority of the people involved in agriculture, both migrants and non-migrants, base their production system on staple crops (more than 95 percent). Finally, the percentage of migrants living in cash-crop producer households ranges between 33 and 38 percent across the waves, which is a slightly lower percentage compared to that of non-migrants – approximately between 34 and 41 percent.

4 Methodology

The starting point of our analysis is the exploration of deforestation drivers, with a key focus on migration and cash cropping activity. We do so, using the following panel fixed-effect model:

$$TL_{p,y^+} = \beta_0 + \beta_1 M_{i,h,p,y^-} + \beta_2 C_{h,p,y} + \boldsymbol{\beta}_3 \boldsymbol{X}_{h,p,y} + \alpha_i + \gamma_y + \varepsilon_{i,y} \quad (1)$$

where TL_{p,y^+} is the total tree loss (in log) in the parish p in the time interval y^+=[$y, y+1$], with y = 2010, 2011 and 2012; M_{i,h,p,y^-} is a dummy equal to 1 if individual i (older than ten years old) belonging to household h and living in parish p has moved from a district to another up to two years before the survey, i.e., in the time interval y^-=[$y-2, y$]; $C_{h,p,y}$ is a household-level dummy equal to 1 if the household produces cash crops in year y; $\boldsymbol{X}_{h,p,y}$ is a vector of time-varying controls that are likely to influence the tree loss. The model also includes the individual fixed effects α_i, to control for unobservable time-invariant individual characteristics, and the time dummies γ_y , to control for temporal changes or common shocks in a given year, and error terms $\varepsilon_{i,y}$ clusterized at the individual level.

We further condition the migration status to age and household absolute poverty status, to assess whether specific social and demographic migrant characteristics are associated with higher or lower levels of deforestation. As aforementioned, time-varying controls such as the staple crop dummy, the customary tenure dummy, the head-education dummy, the population density and its square, the distance from the closest market (in log), and the distance from protected areas (in log) are included.

After having tested the influence of migration on deforestation, along with other potential drivers, we explore the role of cash crop production as a possible channel through which migration affects deforestation. We begin by asking: (i) whether the migrants engaged in cash crop production are more highly associated with deforestation compared to non-migrant cash crop producers; (ii) whether, among the migrants, the cash crop producers are more highly associated with deforestation compared to migrants that are non-cash crop producers. To test these hypotheses, we estimate the following model specification:

$$TL_{p,y^+} = \beta_0 + \beta_1 M_{i,h,p,y^-} + \beta_2 C_{h,p,y} + \beta_3 M_{i,h,p,y^-} * C_{h,p,y} + \boldsymbol{\beta}_4 \boldsymbol{X}_{h,p,y} + \alpha_i + \gamma_y + \varepsilon_{i,y} \quad (2)$$

where the term $M_{i,h,p,y^-} * C_{h,p,y}$ is the interaction between the migration dummy and the cash cropping dummy characterizing households producing cash crops.

A possible significant interaction between migration and cash cropping, however, is not sufficient to establish a causal link between migration, cash cropping and deforestation. To deeply investigate whether cash cropping is a channel through which inter-district migration affects deforestation we perform a mediation analysis, which is a methodology that aims at disentangling the mechanism through which the independent variable is impacting the dependent variable. The mediation analysis relies on the inclusion of a third explanatory variable, i.e. the mediator. This approach allows to test whether the independent variable influencing the independent variable through the mediator or through other channels (Imai *et* *al.,* 2010). Following this approach, we first examine whether and how being a migrant is associated with the likelihood of living in a cash crop producing household and second, we assess whether and how cash cropping, as predicted by migration and a number of other factors, affects deforestation. More precisely, we first estimate, through an Ordinary Least Squares model, the equation:

$$C_{h,p,y} = \theta_0 + \theta_1 M_{i,h,p,y^-} + \boldsymbol{\theta}_3 \boldsymbol{Y}_{h,p,y} + \alpha_i + \gamma_y + \varepsilon_{i,y} \quad (3)$$

where, $\boldsymbol{Y}_{h,p,y}$ is a vector of variables possibly influencing cash cropping. These include a poverty dummy equal to 1 if household h is below the absolute poverty status; a dummy equal to 1 if the head has completed at least primary education; the land size in hectares (in log). The model also includes $\alpha_i, \gamma_y, \varepsilon_{i,y}$ that are respectively, individual fixed effects, time dummies and error terms clusterized at the individual level.[2] Then, we use the predicted values from Eq. 3 to fit deforestation with a panel fixed-effect model as in Eq. 1:

$$TL_{p,y^+} = \beta_0 + \beta_1 M_{i,h,p,y^-} + \beta_2 \hat{C}_{h,p,y} + \boldsymbol{\beta}_3 \boldsymbol{X}_{h,p,y} + \alpha_i + \gamma_y + \varepsilon_{i,y} \quad (4)$$

where $\hat{C}_{h,p,y}$ is the predicted cash crop variable.

Since cash cropping is hereby considered as the channel through which migration may affect deforestation, we constrained the analysis to only individuals engaged in agriculture through production (31 424 observations). Finally, while our main units of analysis are individuals, we perform a specular analysis at household-level by collapsing the individual database at the level of the households, substituting the individual migration dummy with a household migration variable equal to the share of household members older than ten years migrated in the current residence within two years before the survey.

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[2] As a robustness check, since the dependent variable $C_{h,p,y}$ of our first step regression is binary, we also use the following xtlogit model with fixed effects:

$$f(C_{h,p,y} | M_{i,h,p,y^-}, \boldsymbol{Y}_{h,p,y}, \boldsymbol{\theta}, \alpha_i) = p_{i,h,p,y}^{C_{h,p,y}} (1 - p_{i,h,p,y})^{1-C_{h,p,y}},$$

with $p_{i,h,p,y} = \Pr(C_{h,p,y} = 1 | M_{i,h,p,y^-}, \boldsymbol{Y}_{h,p,y}, \boldsymbol{\theta}, \alpha_i) = \frac{1}{1+e^{-\theta_1 M_{i,h,p,y^-} - \theta_3 Y_{h,p,y} - \alpha_i}}$.

5 Results and discussion

Consistently with the hypotheses motivating this work, we divide the results section in three sub-sections. The first sub-section explores the drivers of deforestation, with a major focus on inter-district migration and involvement in cash crop production. The second sub-section investigates the interplay of migration and cash cropping on deforestation. This illustrates the extent to which migrants producing cash crops are more likely to induce deforestation compared to non-migrants producing cash crops or to migrants not producing cash crops. Finally, in the third sub-section, the role of cash cropping as one main channel through which migration impacts deforestation is explored.

5.1 Deforestation drivers: exploring the effect of migration and cash cropping

Overall, the results from the baseline specification suggest that inter-district migration has a significant and positive effect on deforestation (Table 1). In terms of magnitude, an individual migrating from a district to another significantly increases tress loss of 31 percent compared to a local individual (column 1). The remaining part of the table presents the results of the panel fixed-effect model conditioned to household poverty status and age (10–29 years, 30–49 years and over 50 years of age). The coefficients resulting from the estimates suggest that migrants are significantly associated with higher tree loss when younger or in working age, i.e., in the age intervals 10–29 and 30–49, and when living in households with an average income above the poverty line. In contrast, the poorest and oldest migrants (over 50 years of age) do not have a significant influence on deforestation. Taken together, the above findings suggest that the migrants affecting deforestation are mainly those in active age and actively engaged in economic activities, possibly linked to deforestation. These results also exclude the fact that poor migrants may play any significant role in deforestation, and suggest that the observed deforestation may derive from commercial agricultural activities, such as the cultivation of cash crops.

Results on the set of controls confirm that commercial agriculture has a strong impact on deforestation. Individuals cultivating cash-crops increase tree loss by about 16 percent, while individuals in households producing staple crops are associated with lower levels of deforestation compared to the average impact of agricultural households in the country. These results are in line with the FAOSTAT database, which underscore how the area under cash crops in Uganda has more than doubled since 1990, while the area under staples has remained mostly stable (FAO, 2021). From a policy perspective, the findings suggest that the recent agricultural interventions and actions aimed at developing commercial agriculture may have inadvertently led to some downside effects, such as the extensification of commercial crops, at the expense of forest cover.

Coefficients associated with population density and its squared value confirm that population is linked to a non-linear effect on deforestation. In particular, the results indicate that the tree loss increases almost monotonically when the population density increases up to its own 90th–95th percentile, and then decreases along its right tail. This is most probably due to population pressure on forests and natural resources mostly increase in the areas that are developing or urbanizing, while areas with highest population density are those where major deforestation has already occurred. Individuals residing in areas farther away from the market are also linked to higher tree loss. There are two potential reasons for this result. As a first explanation, it is likely that at larger distances from the market, individuals have less access to consumption goods, and average prices are usually higher, as they involve higher input and transportation costs. This may induce individuals to exploit natural resources, such as the forests, to compensate this when markets are not easily accessible. A second potential explanation may be that lower levels of deforestation occur in proximity to the markets, that are mostly located in villages and cities, as these places already have a low level of tree cover. Individuals belonging to households with higher level of education, proxied by the primary education dummy, are also associated to higher levels of tree loss, in line with what was found when conditioning on the poverty status. Holding land under customary land tenure correlates positively with deforestation, indicating that the adverse effects on long-term sustainable investments in agriculture may derive from land tenure instability. Finally, individuals closer to protected areas are associated with higher deforestation. This is likely a spatial effect since forests are more often located around protected areas, and the enforcement of forest protection is not always sufficient to prevent deforestation in the nearby zones. The result is in line with recent evidence on tree loss around protected areas (Belachew *et al*., 2018).

The above results are confirmed when collapsing the individual database at household-level, and when substituting the migration dummy with an indicator measuring the share of migrants living in the household and above ten years old (see Table A3 in the Annex).[3]

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[3] It has to be acknowledged that keeping the dependent variable at parish-level while the regressors at individual/household level may be problematic from a methodological perspective. This indeed means that we are explaining the tree loss variability, constant within parishes, but varying across the parishes and years, with explanatory variables that vary at individual level. However, when collapsing at the parish level, the reported coefficient fails to pass the pre-determined threshold of significance. This may be an indication that such variability within the parishes matters to explain deforestation.

Table 1. Drivers of deforestation in Uganda

	(1) Tree loss	(2) Tree loss	(3) Tree loss	(4) Tree loss	(5) Tree loss	(6) Tree loss
Migrant (1=yes)	0.315***					
Migrant X poor		-0.200				
Migrant X no poor			0.481***			
Migrant with age between 10–29 years (1=yes)				0.283**		
Migrant with age between 30–49 years (1=yes)					0.523***	
Migrant with age over 50 years (1=yes)						0.097
Cash crops (1=yes)	0.157***	0.158***	0.157***	0.158***	0.158***	0.158***
Staple crops (1=yes)	-0.584***	-0.596***	-0.595***	-0.583***	-0.592***	-0.591***
Population density	0.109***	0.109***	0.109***	0.109***	0.109***	0.109***
Population density squared	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***
Customary land	0.252***	0.247***	0.250***	0.251***	0.250***	0.249***
Primary education	0.125**	0.130**	0.126**	0.126**	0.128**	0.129**
Distance from market	1.686***	1.704***	1.691***	1.692***	1.695***	1.699***
Distance from protected areas	-1.716***	-1.708***	-1.710***	-1.715***	-1.713***	-1.711***
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	31 424	31 424	31 424	31 424	31 424	31 424
F-test	193.0	193.6	192.6	194.2	193.4	193.8
p-value	0	0	0	0	0	0

Notes: The table reports the estimated coefficients obtained using OLS with individual level fixed effects and year dummies. Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered at individual level.

Source: Authors' own elaboration.

5.2 Cash cropping-migration interactions

Interacting the migration dummy with the household cash crop dummy, the analysis finds that migrants producing cash crops have a differential and higher impact on deforestation compared to migrants not involved in cash crop production (Table 2). The effect in terms of tree loss varies from a non-significant 18 percent for migrants belonging to households that do not produce cash crops, to a significant 54 percent for migrants living in households producing cash crops.

Also, our findings confirm the evidence suggesting migrants as more prone to cut down trees or over-exploit land for agricultural purposes compared to locals (Twongyirwe *et al*., 2018; Unruh *et al.,* 2005). When computing the marginal effects on tree loss for migrants and non-migrant cash crop producers, this analysis indicates that both categories significantly contribute to deforestation, but the impact on deforestation increases from 15 percent for local cash crop producers to 51 percent for the migrant cash crop producers.

Tables A5 and A6 in the Annex confirm that migrant households producing cash crops report a higher marginal impact compared to those not producing cash crops.[4]

Table 2. Interactions of cash cropping with migration

Marginal effects of migration for cash crop producers and non-cash crop producers	
Migrant	
No cash crop producers	0.179
Cash crop producers	0.538***
Marginal effects of cash crop producers for migrants and non-migrants	
Cash crop producers	
Non migrant	0.151***
Migrant	0.510***
Observations	31 424

Notes: The table reports the marginal effect obtained using OLS with individual level fixed effects and year dummies. Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered at individual level. The estimated coefficients are reported in Table A4 of the Annex.

Source: Authors' own elaboration.

5.3 Cash cropping as a channel through which migration affects deforestation

Results of the mediation analysis suggest that cash crop activities are one main channel through which migrants affect deforestation. Specifically, the first stage (Table 3) indicates that migrants are significantly more likely to belong to households engaged in cash crop production. This likely derives from the fact that cash crop production offers a pathway into commercial agriculture, and thus individuals seeking opportunities in agriculture may migrate towards locations where cash crop opportunities exist (Chapoto *et al*., 2013). Furthermore, the results from the first stage indicate that poor households are less likely to produce cash crops, while the land size is associated with an increase in the likelihood of producing cash crops.

[4] Also, among cash crop producers, the impact on deforestation increases with the share of migrants in the household, but the impact is significant for shares of migrants of 25 percent and 50 percent.

Notice also that, while inter-district migrants are more likely to belong to households producing cash crops but not staple crops, the opposite evidence emerges when considering intra-district migrants, i.e., migrants moving within the same district, who are more likely to be engaged in staple crops rather than cash crops (see Table A7 in the Annex). This is plausibly because longer-distance migration, in this context, implies higher costs, which are not affordable for the poorest segment of the population, and thus migrant engagement in profitable economic activities, such as cash crops, compensate initial costs.

The second step of the mediation analysis (Table 4) shows that the cash crop indicator is significantly associated with increases in tree loss. Taken together, these findings suggest that cash crop production is a significant mediating factor between migration and deforestation. These results are partially confirmed for the household level analysis (see Tables A8 and A9 in the Annex).

Table 3. Cash crop as mediator factor between migration and deforestation (1st step)

	(1) Cash crops	(2) Cash crops
Migrant (1=yes)	0.034*	0.428**
Primary education	-0.012	-0.191*
Poor (1=yes)	-0.043***	-0.291***
Land size	0.070***	0.792***
Individual FE	Yes	Yes
Year dummies	Yes	Yes
Model	OLS-FE	Conditional Logit-FE
Observations	31 066	7 694
F-test	80.65	-
p-value	0.00	0.00

Notes: The table reports the estimated coefficients obtained using OLS (column 1) and a conditional logit with fixed effects (column 2), both including individual level fixed effects and year dummies. Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors of the OLS model are clustered at individual level.

Source: Authors' own elaboration.

Table 4. Cash crop as mediator factor between migration and deforestation (2nd step)

	(1) Tree loss	(2) Tree loss
Predicted cash crops	0.656**	0.187*
Staple crops (1=yes)	-0.237	-0.236
Migrant (1=yes)	0.283***	0.278***
Primary education	0.150***	0.152***
Population density	0.104***	0.104***
Population density (squared)	-0.00126***	-0.00126***
Customary land (1=yes)	0.263***	0.263***
Distance from the market	-1.706***	-1.706***
Distance from protected areas	1.715***	1.713***
Individual FE	Yes	Yes
Year dummies	Yes	Yes
First-step model	OLS-FE	Conditional Logit-FE
Observations	30 852	30 852
F-test	192.3	192
p-value	0.00	0.00

Notes: The table reports the Estimates estimated coefficients of the OLS model with fixed effects using, as main explanatory variable the cash crop variable indicator as predicted by a first step with OLS fixed effects (column 1) and conditional logit with fixed effects (column 2). Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors of the second step are clustered at individual level.

Source: Authors' own elaboration.

6 Policy implications

This work has shown that the expansion of cash crop activities, pushed by national agricultural policies of development, significantly drive deforestation in Uganda. Internal migration also plays a role in inducing deforestation, and involvement in cash crop activities represents a major channel through which migrants affect deforestation. To avoid devastating consequences on the ecosystem and on food and livelihoods, it is crucial to reduce downside effects of agricultural commercialization on the forests and to promote more positive interactions between agriculture and forest conservation.

The trade-off between agricultural development and natural resource protection requires policies and programmes aimed at stimulating sustainable agriculture while ensuring a high level of forest management and protection. This may imply the need for improved coordination between policies on forests, agriculture, land use and migration. As commercial agriculture is a principal driving force of deforestation, effective regulation of change as well as social and environmental safeguards are needed. Integrated land-use planning should also be promoted, as it provides a strategic framework for balancing land uses at the national, subnational and landscape scales. This should include meaningful stakeholder participation to ensure the legitimacy of land-use plans and stakeholder buy-in for their implementation and monitoring.

Equally important are clear legal frameworks governing land-use change, including secure land-tenure systems that recognize rights to use land and incentivize longer-term investments in sustainable technologies. Also, to improve production and achieve food security, agricultural intensification and other measures such as social protection should be favoured to the expansion of agricultural areas at the expense of forests (FAO, 2016). Finally, promoting the development of forest product value chains would be fundamental to strengthen the role of the forest itself as a vehicle of economic development.

As far as migration is concerned, ad-hoc policies promoting the integration of migrants in hosting areas and training activities enhancing the knowledge of soil, suitable crops and agricultural practices are necessary to ensure a sustainable exploitation of resources and an efficient land-use allocation. Similarly, agricultural laws that regulate the harvesting of forest resources on both private and public land, and that prohibit practicing agriculture on land designated for forestry are fundamental to avoid over-exploitation of natural resources and mismanagement of agricultural lands. Forest reserve boundaries should be clearly demarcated, and land-use clearly declared, to avoid deliberate or accidental encroachment. Finally, national strategies should be designed to promote the development of urban or rural off-farm sectors, so to expand and diversify employment opportunities in sectors other than agriculture and support economic growth.

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Annex

Table A1. Percentage of internal and international migrants over the population

	2010	2011	2012
Observations	18 302	17 144	18 396
% inter-district migrants	3.65	3.41	2.57
% intra-district migrants	4.67	3.60	3.42
% international migrants	0.09	0.08	0.03

Notes: The percentages of migrants only include migrants older than ten.

Source: Authors' own elaboration.

Table A2. Summary statistics on socio-demographic characteristics of migrant and non-migrant population

	2010		2011		2012	
	Inter-district migrants	Rest of the population	Inter-district migrants	Rest of the population	Inter-district migrants	Rest of the population
Age	22.11	28.12	22.31	28.25	25.29	29.03
% male individuals	41.46	48.17	36	47.45	42.42	47.45
% individuals living in poor households	11.8	22.31	22.97	31.14	24.41	30.58
% individuals living in households engaged in agriculture	60.31	83.75	70.93	83.27	63.3	82.62
% individuals living in cash crop producer households	33.82	34.57	36.47	39.78	38.3	41.58
% individuals living in staple crop producer households	93.38	97.49	95.11	97.02	96.8	97.05

Source: Authors' own elaboration.

Table A3. Deforestation drivers, household level analysis

	Tree loss
Share of migrants within the HH	0.981***
Cash crops (1=yes)	0.181*
Staple crops (1=yes)	-0.561*
Primary education	0.043
Population density	0.096***
Population density squared	-0.001***
Customary land (1=yes)	0.153
Distance from the market	1.144**
Distance from protected areas	-1.128*
Household FE	Yes
Year dummies	Yes
Observations	6 097
F-test	39.75
p-value	0.000

Notes: The estimates are obtained through an OLS model, with household level fixed effects and year dummies. Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered at household level.

Source: Authors' own elaboration.

Table A4. Interactions of cash cropping with migration

	Tree loss
Migrant (1=yes)	0.179
Cash crops (1=yes)	0.151***
Migration x cash crops	0.359**
Staple crops (1=yes)	-0.582***
Primary education (1=yes)	0.251***
Population density	0.125**
Population density squared	0.109***
Customary land (1=yes)	-0.001***
Distance from the market	1.691***
Distance from protected areas	-1.713***
Individual FE	Yes
Year dummies	Yes
Observations	31 424
F-test	178
p-value	0

Notes: The estimates are obtained through an OLS model with household level fixed effects and year dummies. Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered at individual level.

Source: Authors' own elaboration.

Table A5. Marginal impacts of migration shares on tree loss for cash crop producer and non-producer households

Migrant share within the households	(1)
No cash crop producers	0.746*
Cash crop producers	1.408***
Observations	6 097

Note: Levels of significance are * p<0.1, ** p<0.05, *** p<0.01.

Source: Authors' own elaboration.

Table A6. Marginal impacts of cash crop producers at different shares of household migrants

Cash crop producers, household migration share at:	(1)
25%	0.337*
50%	0.502*
75%	0.668
100%	0.833
Observations	6 097

Note: Levels of significance are * p<0.1, ** p<0.05, *** p<0.01.

Source: Authors' own elaboration.

Table A7. Likelihood of intra- and inter-district household migrants to be engaged in cash and staple crops production

	(1) Cash crops	(2) Staple crops	(3) Cash crops	(4) Staple crops
Migrant (1=yes, inter-district)	0.034*	-0.007		
Migrant (1=yes intra-district)			0.008	0.020***
Primary education (1=yes)	-0.012	-0.006**	-0.012	-0.007**
Poor (1=yes)	-0.043***	-0.001	-0.043***	-0.000
Land size	0.070***	0.005***	0.070***	0.005***
Individual FE	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Observations	31 066	31 066	31 066	31 066
F-test	80.65	6.74	80.15	7.60
p-value	0.00	0.00	0.00	0.00

Notes: The table reports the estimated coefficients obtained using OLS with individual level fixed effects and year dummies. Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered at individual level.

Source: Authors' own elaboration.

Table A8. Cash crop as mediator factor between migration and deforestation, household level analysis (1st step)

	(1) Cash crops	(2) Cash crops
Share of migrants within the HH	0.153*	2.539**
Poor (1=yes)	-0.0361**	-0.272*
Primary education (1=yes)	-0.0120	-0.218
Land size	0.0765***	0.850***
Individual FE	Yes	Yes
Year dummies	Yes	Yes
Model	OLS-FE	Conditional Logit-FE
Observations	6 021	1 587
F-test	14.61	–
p-value	0.00	0.00

Notes: The table reports the estimated coefficients obtained using OLS (column 1) and a conditional logit with fixed effects (column 2), both including individual level fixed effects and year dummies. Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors of the OLS model are clustered at individual level.

Source: Authors' own elaboration.

Table A9. Cash crop as mediator factor between migration and deforestation, household level analysis (2nd step)

	(1) Tree loss	(2) Tree loss
Share of migrants within the HH	0.886**	0.910**
Predicted cash crops	0.549	0.120
Staple crops (1=yes)	-0.423	-0.416
Primary education (1=yes)	0.062	0.061
Population density	0.094***	0.094***
Population density squared	-0.001***	-0.001***
Customary land (1=yes)	0.157	0.161
Distance from the market	1.170**	1.171**
Distance from protected areas	-1.119	-1.125
Household FE	Yes	Yes
Year dummies	Yes	Yes
First step model	OLS-FE	Conditional Logit-FE
Observations	5 985	5 985
F-test	39.31	39.26
p-value	0.00	0.00

Notes: The table reports the estimated coefficients obtained using a OLS including individual level fixed effects and year dummies but with the value of the cash-crop predicted from a OLS with fixed effects (column 1) and conditional logit with fixed effects (Column 2). Levels of significance are * p<0.1, ** p<0.05, *** p<0.01. Standard errors of the second step model are clustered at individual level.

Source: Authors' own elaboration.

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Food and Agriculture Organization of the United Nations
Rome, Italy

ISBN 978-92-5-135068-3 ISSN 2664-5785

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CB7072EN/1/10.21