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Article — Published Version

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Proceedings of the Royal Academy for Overseas Sciences

Provided in Cooperation with:

Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale)

Suggested Citation: Meyfroidt, Patrick et al. (2024) : Understanding agricultural and tree plantation frontiers emergence in Southern and Eastern Africa, Proceedings of the Royal Academy for Overseas Sciences, ISSN 2983-4880, Royal Academy for Overseas Sciences, Brüssel, Vol. 2, Iss. 1, pp. 29-39,
<https://doi.org/10.5281/zenodo.11065389> ,
<https://www.kaowarsom.be/en/publications/proceedings-royal-academy-overseas-sciences>

This Version is available at:

<https://hdl.handle.net/10419/302600>

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Understanding Agricultural and Tree Plantation Frontiers Emergence in Southern and Eastern Africa¹

by

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KEYWORDS. — Land Use; Southern Africa; Agricultural Investments; Forestry Investments; Tree Plantations; Frontier; Pioneer; Investor; Agriculture; Deforestation; Development; Sustainability.

SUMMARY. — The objective of this contribution is to investigate the processes that condition and shape the emergence of agricultural frontiers, *i.e.* regions with rapid development of natural resource exploitation and land-use changes, in territories considered as marginal in terms of agricultural productivity and global market connections. This research focuses on the dry forest and woodland regions of southern and eastern Africa, and in particular on northern Mozambique. We combined an ethnographic approach, based on interviews and participant observation over several years, exploring the role of successive “waves” of pioneers (commercial farmers and investors), a mapping of tree plantation expansion led by foreign investors, based on remote-sensing data, and a Bayesian decision-making model based on interviews of investors and agricultural operators from the farm level to the financial decision centres. Linking these approaches allows providing much-needed empirical evidence on land-use dynamics in a little-studied region — to nuance simplistic narratives on investments and investor dynamics in Africa — and establishing the basis for proactive governance of these dynamics. We show that current large-scale investments still cover only a small fraction of the landscapes, yet their impact goes well beyond these small footprints. Past investment waves and failures have led to the emergence of a new group of investors and commercial actors who may have more diversified land-use practices, with medium-scale farms, and more constructive ways of engaging with local populations than the typical large-scale monoculture “land grabbers”. Beyond this, we show a wide diversity of investors’ profiles and logic, presenting different trade-offs. Investors with an extensive track record continue to push the frontier expansion into natural environments. Yet, these actors are also those who are more likely to survive the challenging conditions for commercial agriculture in the region, and thus might have higher chances of stimulating employment and economic development, compared to newcomers who have no track record in the sector and region.

¹ Paper presented at the meeting of the Section of Human Sciences held on 16 March 2021. Text received on 29 December 2021 and submitted to peer review. Final version, approved by the reviewers, received on 26 September 2022.

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MOTS-CLÉS. — Utilisation des terres; Afrique australe; Investissements agricoles; Investissements forestiers; Plantations forestières; Frontière; Pionnier; Investisseur; Agriculture; Déforestation; Développement; Soutenabilité.

RÉSUMÉ. — *Comprendre l'émergence des frontières d'expansion agricole et de plantations en Afrique australe et de l'Est.* — L'objectif de cette contribution est d'étudier les processus qui conditionnent et façonnent l'émergence de frontières agricoles, c.-à-d. des régions avec un développement rapide de l'exploitation des ressources naturelles et de l'utilisation des terres, dans des territoires considérés comme marginaux en termes de productivité agricole et de connexions avec les marchés mondiaux. Cette recherche se concentre sur les régions de forêts sèches et savanes d'Afrique australe et de l'Est, en particulier le nord du Mozambique. Nous avons combiné: (i) une approche ethnographique basée sur des entretiens et une observation participative sur plusieurs années, explorant le rôle des «vagues» successives de pionniers (agriculteurs commerciaux et investisseurs), (ii) une cartographie de l'expansion des plantations forestières commerciales, basée sur des images satellitaires, et (iii) un modèle bayésien de prise de décision, basé sur des entretiens avec des investisseurs et entrepreneurs agricoles depuis le niveau de l'exploitation jusqu'aux centres de décision financiers. La combinaison de ces approches permet de dégager des éléments empiriques auparavant manquants à propos des dynamiques d'utilisation des terres dans une région peu étudiée — pour nuancer les discours simplistes concernant les investissements et les investisseurs en Afrique — et jette les bases d'une gouvernance proactive de ces dynamiques d'investissement. Nous montrons que les investissements à grande échelle ne couvrent encore qu'une petite fraction des paysages, mais que leur impact va bien au-delà de ces surfaces restreintes. Les vagues d'investissement précédentes et leurs échecs ont mené à l'émergence d'un nouveau groupe d'investisseurs et d'acteurs commerciaux qui peuvent avoir des pratiques d'utilisation des terres plus diversifiées, avec des fermes à moyenne échelle, et des façons plus constructives de gérer leurs relations avec les communautés locales que l'image typique de l'«accaparement des terres». Au-delà de cela, nous montrons qu'il existe une diversité importante de profils et logiques d'investisseurs, qui présentent différentes formes de compromis. Les investisseurs ayant une solide expérience continuent à promouvoir l'expansion des frontières dans les habitats naturels. Ces acteurs sont cependant les mieux à même de survivre aux conditions difficiles de l'agriculture commerciale dans la région et ont donc potentiellement plus de chances de stimuler l'emploi et le développement économique, en comparaison avec les nouveaux arrivants dans le secteur et la région.

Introduction

Intensive research efforts have been focused on describing and explaining the functioning of active deforestation frontiers in relation to agricultural expansion (Levers *et al.*, 2021). Yet, much less research has been conducted to unravel how these frontiers emerged from territories considered marginal in terms of agricultural productivity and connections to global markets. In this research, we aim to explain the processes that condition and shape the emergence of agricultural frontiers — *i.e.*, regions with rapid development of natural resource exploitation and land-use changes.

Our research focuses on the dry forest and woodland regions of southern and eastern Africa, with specific attention to northern Mozambique. This is a largely understudied region from the point of view of land-use dynamics, yet with key sustainability challenges. Most works on frontiers focus on reactive measures in already active, rampant frontiers. A major conclusion of these works is that even though public and private governance interventions can indeed have some effectiveness to reduce deforestation and foster more sustainable land uses, these corrective measures are generally hard to implement, face multiple obstacles and vested interests, and often remain fragile, contested, and reversible. Here we investigate how frontiers emerge, with the rationale that steering the course of frontiers towards a more sustainable outcome may be easier when these frontiers

emerge compared to when they are fully active, rampant and operated by powerful actors. We focus essentially on the decisions and dynamics of capitalized, medium to large-scale investors, domestic or foreign, who engage in commercial agriculture or forestry plantations. This is not to downplay or marginalize the importance of smallholders active in semi-subsistence family farming; quite the contrary, in the area these remain the most extensive forms of land use in the region. Yet, many works have focused on exploring smallholder dynamics in such landscapes, as well as on assessing the impact of large-scale land acquisition and investments on smallholders. Our premise is that an improved understanding of the commercial actors' and investors' logic, goals, and decision-making can help to foster more favourable outcomes for rural sustainable development in the region, including for smallholders. Our guiding questions are:

- How do frontiers of agricultural and forestry plantation activities emerge?
- Why do investors go where there is no commercial agriculture? Who are the actors who contribute to this process, what are their logic and decision-making process?
- How do these actors and processes shape land-use patterns and dynamics? What is the role of policies in steering and shaping frontiers?

Resource and Land-use Frontiers

The notion of frontiers on which we build emerged in the works of the American historian Frederick Jackson Turner, with his paper *The significance of the frontier in American history* (Turner, 1894). There, the “frontier” describes the waves through which colonists and so-called civilization progressed across America in the 19th century (fig. 1). In Turner’s view, this progress of people and civilization was not only critical for the development of the country in economic and political terms, but also foundational of the identity and values of the United States as a nation. This thesis by Turner has now been largely criticized, but the concept of “frontier” remains useful to understand such expansion dynamics.

Many authors have expanded on this notion of frontiers (Meyfroidt *et al.*, 2018). Frontiers have been described as a process of pushing back wilderness, to create a space for development by taming the natural world (Fold & Hirsch, 2009), as well as being spaces facing a rapidly expanding force, which constitute places of opportunities for a number of people (Imamura, 2015). Frontiers have also been described as places of resource extraction or exploitation (Barbier, 2010). The “resource” in these frontiers can be newly discovered, but can also be “reinvented”, *i.e.*, being given a new value due to technological, institutional, socio-economic, environmental or cultural changes (le Polain de Waroux *et al.*, 2018). This makes frontiers typical spaces of “territorialization”, *i.e.* spaces where institutional actors, including governments and corporations, turn places into “territories” they can understand, monitor, regulate, and exploit (Rasmussen & Lund, 2018). Through these processes, frontiers are also typically places of interface and friction between different worlds, *e.g.* subsistence and capitalist economies, different cultures, socio-political systems, and mode of relations to nature (Parker & Rodseth, 2005; Tsing, 2011). Frontiers typically develop in a non-linear way, with take-off or frontier emergence that can appear as “abrupt” or “surprising”, then accelerating towards rampant land-use dynamics (le Polain de Waroux *et al.*, 2018).



Fig. 1. — *American Progress* (John Gast, 1872). Painting in the public domain. Obtained from [https://commons.wikimedia.org/wiki/File:American_Progress_\(John_Gast_painting\).jpg](https://commons.wikimedia.org/wiki/File:American_Progress_(John_Gast_painting).jpg).

In this work, we build on all these views and articulate them around the notion of “resource frontier”, *i.e.* places with an imbalance between abundant natural resources and a comparative lack of production factors (capital, labour) to exploit these resources, inducing a rapid expansion of resource use as production factors flow in (Barbier, 2010; le Polain de Waroux *et al.*, 2018). This definition can be adapted to describe “agricultural frontiers” and “land-use frontiers”, when the resource is land suitable for agriculture or a broader set of land uses. “Deforestation frontier” is also a term frequently used to characterize places with rampant deforestation, generally overwhelmingly related to agriculture, but such agricultural expansion can also take place in other, non-forest ecosystems. Contemporary frontiers are increasingly driven by commodity production operated by large-scale, capitalized actors, giving rise to so-called “corporate” or “commodity” frontiers (le Polain de Waroux *et al.*, 2018). These commodity frontiers create specific challenges and impact on the environment, with deforestation and conversion of non-forest natural habitats, loss of biodiversity and carbon emissions, degradation of ecosystem services, as well as on the human side, being associated with large-scale land acquisition and land grabbing, exclusion and marginalization of smallholders, but also prospects for agricultural development, employment, productivity increases (Abeygunawardane *et al.*, 2022).

The Miombo Landscapes of Southern Africa, with a Focus on Northern Mozambique

This research took place in Miombo woodlands, a vegetation belt of tropical open dry forests and woodlands stretching across southern and eastern Africa. This biome holds vast expanses of low-disturbed forests and savannas, as well as densely-populated agricultural landscapes, dominated by smallholders practising forms of semi-subsistence farming, with a key role of food production for local consumption and a growing role of commercial production for local and sometimes more distant markets, as well as commercial timber exploitation in natural forests.

This region is considered in some prominent works, such as an impactful report from the World Bank in 2011 (Deininger *et al.*, 2011), as one of the world regions concentrating the largest reserves of land seen as currently unused or underutilized for agriculture, outside of the humid tropics considered as environmentally highly valuable. This narrative of “abundant land” and “potentially available cropland” has been challenged, however, as failing to account for multiple already-existing uses of lands, and thus trade-offs linked to potential agricultural expansion, intensification and consolidation, and the strong constraints on agricultural development (Gasparri, Kuemmerle, Meyfroidt, le Polain de Waroux & Kreft, 2016; Lambin *et al.*, 2013; Searchinger *et al.*, 2015). Agriculture linked to global markets is still limited in the region, but is growing rapidly with the involvement of external actors who are acquiring land-use rights and investing in production and processing activities. The tensions between these large and medium-scale investments and smallholder agriculture, as well as between agricultural development and environmental conservation, are high.

In contrast with the humid tropics, tropical dry forests and woodlands have been relatively neglected in the scientific agenda of land use, sustainability and conservation sciences, as well as in the general public awareness and public policies, despite their high biodiversity and carbon stocks, and their importance for ecosystem services and local livelihood (Ribeiro, Katerere, Chirwa & Grundy, 2020). Although in policy circles and public imagination deforestation frontiers often evoke images of humid tropics, such as the deforestation of the Amazon forest or of Indonesian lowland forests, tropical dry forests and woodlands are currently highly threatened ecosystems, with around one third of all the remaining tropical dry forests and woodlands being located in deforestation frontiers (defined as areas with >5 % of forest cover over 3x3 km cells, and an average annual percentage of forest loss of at least 0.5 % within a consecutive five-year period) (Buchadas, Baumann, Meyfroidt & Kuemmerle, 2022).

Our research takes a cross-scale approach, with some works covering the broader region of southern and eastern Africa, some of them focusing on the four provinces of northern Mozambique, and other works at a local scale such as those on the specific province of Niassa in the northwest of Mozambique (fig. 2).

Ethnographic Approach in Niassa: The Pioneers?

With these starting points in mind, we focused our initial steps on the province of Niassa, in northern Mozambique. Niassa province is usually described as the most remote, least accessible, and poorest province of Mozambique, the “forgotten province” in the national development concerns, but also as a region with abundant and fertile land, and thus a high potential

for agricultural development. Agriculture in the province is essentially performed by smallholders for subsistence and local markets, but a few commercial farmers and investors are present, and national and provincial governments have been trying to attract more foreign investors. There, we used an ethnographic approach to identify and understand who are these pioneers working in developing commercial activities in that difficult environment (Kronenburg García, Meyfroidt, Abeygunawardane & Siteo, 2022). The work presented here is based on qualitative, ethnographic fieldwork carried out in Niassa province and Mozambique's capital Maputo from February 2017 to December 2018. Information was gathered through seventy open interviews and informal conversations, on-site observations during visits to farms and other locations and events, as well as from documents and other materials collected during fieldwork or otherwise available. The majority of research participants were investors or actors of transnational land-use investment chains. We investigated why these pioneers arrived in Niassa, what brought them there, and for what purposes. These pioneers revealed that the current situation could be understood as resulting from previous waves of investors and pioneers. Actors from these past waves struggled and often failed, but left legacies.

At the end of the civil war in 1992, a first wave of white missionary farmers from South Africa came to Niassa. They came because this province was isolated, and they considered that they could help to spread the Christian religion, but also to develop agriculture. This proved to be a hard environment, in particular for families and children. Many of them failed and left, or abandoned agriculture and ventured into other activities. Then, around 1996, came another wave of white South African farmers. This wave emerged through an agreement between the South African government, which was willing to find new land abroad for white farmers as a way to smooth land reform in the post-apartheid context, and the Mozambican government willing to attract skilled farmers. These farmers came with their families, but they also struggled as they were expecting to find similar conditions as those they were used to in South Africa, with land already cleared, infrastructures, electricity, and utility distribution networks, all of which lacking in Niassa. They felt abandoned by both governments, and also left or abandoned agriculture. Around 2005 another wave came again, operated by forestry companies, with support from Sweden's government agency for development cooperation. This programme was also developed in collaboration with the Niassa government, with forestry being seen as an appropriate land use to develop in the province's abundant land with relatively low population density. For various reasons, including the lack of infrastructures and markets, but also conflicts with the local population, these forestry companies struggled and many of them moved away, selling their plantations to other actors by transferring their land-use rights and selling their equipment.

So, these successive waves all largely failed, but left legacies in the people and landscapes. This led to the emergence of a new wave, starting around 2012. The actors from this new wave are diverse but have some common features, *i.e.* they are somehow linked to previous waves, and they emerged from inside the region, not from abroad. Some of them are former employees from companies of the previous waves such as foreign farm managers previously hired to oversee operations in Mozambique and then willing to develop their own farm, while others are white collar workers (accountants, service providers) from forestry companies willing to invest some financial capital, or family members of farmers from the previous waves. They practise various land uses, with usually medium-scale farms of a few hundred to a few thousand hectares, mixing diverse forms of agriculture, including field crops, tree crops such as macadamia, fruit trees, coffee, as well as livestock and forestry. They reutilize certain physical

infrastructures left by previous waves, such as farm buildings and irrigation systems. But they also rely and build on a broader range of legacies from previous waves, including social networks, financial capital previously accumulated, well-delineated land with officially recorded land tenure, but also in the form of experience on business practices, ways of dealing with local populations to mitigate potential conflicts, and diversifying activities to minimize risks. We hypothesize that this building of legacies is an important component to explain the sudden emergence of frontiers.

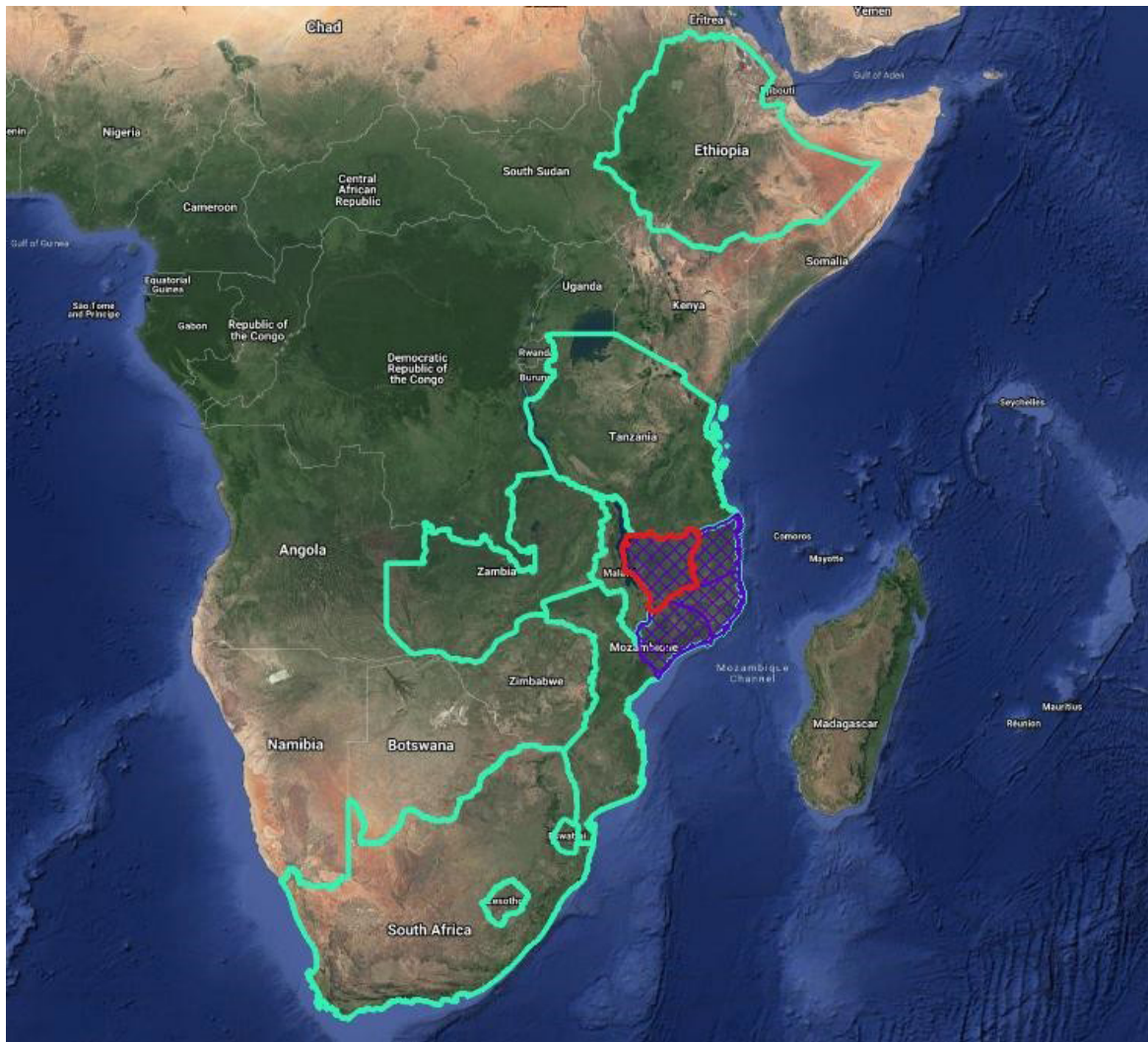


Fig. 2. — Study area with a cross-scale approach. In red, the province of Niassa, which is the focus of our ethnographic work. In purple, the four northern provinces of Mozambique (Niassa, Cabo Delgado, Zambezia, Nampula), which are the focus of our remote-sensing mapping work. In green, the countries (Ethiopia, Tanzania, Zambia, Mozambique, South Africa) which are the focus of our interviews and mixed methods' approach to understand transnational investors' decision-making. Author's elaboration (background map: Google Earth).

Mapping and Spatial Analyses of Tree Plantation Expansion in Northern Mozambique

Broadening our research beyond Niassa province, to the larger region of northern Mozambique, we complemented the ethnographic work with remote-sensing analyses to map land-use changes associated with these past and current waves. We focused first on mapping smallholders and large-scale cropland expansion in Gurué district, a 5,600 km² district which is one of the hotspots of commercial agriculture in northern Mozambique, in the Zambezia province neighbouring Niassa. This work revealed that between 2007 and 2017 small-scale cropland was still the major expanding form of agriculture, with the gross area of small-scale cropland expansion being around twenty times larger than the expansion of large-scale cropland (Bey *et al.*, 2020). Yet, the progression of large-scale cropland was notable, from *ca.* 9 km² in 2006 to *ca.* 58 km² in 2017. Most (65 %) of large-scale cropland expansion occurred into existing small-scale cropland, suggesting trade-offs or potential conflicts between large-scale and small-scale agriculture.

Broadening our research beyond Niassa province, we then mapped and analysed large-scale tree plantation expansion across the four provinces of northern Mozambique (382,000 km²), including both tree crops, such as macadamia, fruit trees, etc., and forestry plantation, such as eucalyptus and pine. This work has shown that tree plantations are still a relatively small land use in the region, when considering only the direct footprint, *i.e.*, they covered *ca.* 0.5 % of the landscape in 2017, expanding over *ca.* 175 km² between 2001 and 2017 (Bey & Meyfroidt, 2021). Yet, their impact on local development trajectories and their importance in local discourse are larger than these relatively small extents. About 70 % of the large-scale tree plantation expansion between 2001 and 2017 occurred on cropland, while the remainder occurred on natural forests and grasslands. Comparing these maps with cadastral records showed that over 40 % of plantation expansion occurred on lands not legally designated for this land use, with cadastral records being possibly inaccurate, imprecise, out of date, or simply non-existent.

Taking a Larger Perspective: Logics of Investment Decisions in Frontiers

From this, we expanded the perspective even further, investigating the logics of decision-making of investors over a broader geographic scope and a more diversified set of actors (Abeygunawardane *et al.*, 2022). We aimed here to reconstruct the logic of decision-making of transnational investors across the broader region of eastern and southern Africa, from Ethiopia to South Africa*. We focused on transnational forestry and agriculture companies and investors, in order to understand their decision to invest in one country and place in contrast with other places. We used a mixed methods' approach, building on semi-structured interviews with qualitative and quantitative data, as well as spatial quantitative analyses. We interviewed actors of the whole chain of decision-making ranging from local farm managers to country managers, regional managers, to Chief Investment Officers (CIOs) and Chief Executive Officers (CEOs). We performed ninety-four interviews over thirty-seven investments operated by twenty-nine investors across one hundred and twenty-one farm and plantation locations, cover-

* We do not present here the results for South Africa, as the investment context is very different there than in other countries.

ing 11 % of the total transnational agricultural and forestry investments made between 2000 and 2016 in Mozambique, Zambia, Tanzania, and Ethiopia. Based on resource frontiers and economic geography theories, we created a two-dimensional typology to characterize the location of each investment. The first dimension assesses the degree to which the investment place can be considered as a resource frontier, based on the proportion of land unconverted to agriculture, and the population density. The second dimension assesses the degree to which a place can potentially provide agglomeration economies, based on the accessibility to input and output markets and the presence of large-scale, capitalized agriculture. From this, we built a Bayesian network model to explain investment location choices based on the profile, priorities and decision-making logics of the investors. A Bayesian network is a probabilistic graphical model which encodes the joint probability distribution of a set of variables. It comprises (i) a causal diagram that represents the interdependencies between variables, and (ii) a set of conditional probability tables that quantify the strength of dependencies between these variables.

We showed that there was a wide variety of investors' profiles and logics (Abeygunawardane *et al.*, 2022). To pick just two examples, we identified one set of investors who had extensive track record in farming in the region, as measured by their skillset and market reach in certain crops. These investors with extensive track record and who focused more on high-value niche crops were more likely to invest in subsistence frontiers, those areas with abundance of unconverted land (resource frontiers) but lower potential for agglomeration economies. This is where they seek easily accessible land with the agroecological conditions they require for their specific production. In contrast, another group of investors, with essentially no experience in farming or land use, and in investments in that region, invested preferentially in those emerging commercial frontier areas (with still untapped resource potential but with the presence of other commercial activity), where they sought the generic advantages of proximity to infrastructure and markets, and thus the prospect of land gaining value over time. Such knowledge can critically inform the design and the creation of targeted investment opportunities and land-use planning.

Conclusion

Is the region of southern Africa an emerging or a failed frontier? The answers emerging from our findings are nuanced and complex. Some parts of the region are still far from presenting favourable conditions for the rapid emergence of a large-scale land-use frontier, but in other places, such an emergence is probably already happening. We have demonstrated that understanding past waves of investment and migration, and their legacy, can provide useful insights into current and future land-use dynamics. We hypothesize that the accumulation of these legacies can explain sudden, non-linear, and seemingly “abrupt” or “surprising” frontier emergence. We have also shown that there was a wide variety of investors in southern and eastern African frontiers, going well beyond the usual “speculators” or “land grabbers” narratives. This work provides some key insights that may help to design interventions fostering more sustainable development in the region.

First, we have shown that current large-scale investments still cover only a small fraction of the landscapes, yet they have already affected local populations much more prominently than their direct footprints. Smallholder agriculture currently has access to extremely limited amounts of financial capital, and thus in principle, improved agricultural and forestry invest-

ments might be crucial to smallholders to improve their land and labour productivity, stimulate employment in commercial activities such as product processing and others. However, current investments often fail to deliver benefits to rural populations, and it is therefore essential to understand how it is possible to make these investments more beneficial.

Secondly, we have shown that past investment waves and failures have led to the emergence of a new group of investors and commercial actors who may have more diversified land-use practices, more medium scales, and more constructive ways of engaging with local populations than the typical large-scale monoculture “land grabbers” who have been depicted in many studies. Investigating in more detail the impacts of these actors and activities on smallholders’ livelihood might show ways to guide investments towards more favourable outcomes.

Thirdly, we have shown a wide variety of investors’ profiles and logics presenting different trade-offs. Investors with an extensive track record continue to push the frontier expansion into natural environments. Yet, these actors are also those who are more likely to survive the challenging conditions for commercial agriculture in the region, and thus might have higher chances of stimulating employment and economic development, compared to newcomers who have no track record in the sector and region.

Nevertheless, many questions still remain. Our more recent and ongoing research, not presented here, aims to feed the insights from our empirical work into a theoretical modelling of frontiers as regime shifts (Rodríguez García, 2021), and to assess how strategic spatial planning approaches and land tenure and zoning policies can contribute to steering frontier development (Oliveira & Meyfroidt, 2022). Further research also builds on our remote-sensing progress to develop more detailed field-size maps of northern Mozambique, to be able to explore more deeply the dynamics of smallholder consolidation and marginalization, the emergence of medium-scale farms, and the interactions between smallholders and large-scale land investments. All this work is ongoing.

ACKNOWLEDGEMENTS

We thank the many colleagues who have helped on this work, as well as the many participants who have provided valuable insights and information through interviews and other ways. The research presented here is part of the European Research Council (ERC) Starting Grant (SG) project MIDLAND: erc-midland.earth.

REFERENCES

- Abeygunawardane, D., Kronenburg García, A., Zhan-li Sun, Müller, D., Siteo, A. & Meyfroidt, P. (2022). Resource frontiers and agglomeration economies: The varied logics of transnational land-based investing in Southern and Eastern Africa. *Ambio*, 51(6), 1535-1551.
- Barbier, E. B. (2010). *Scarcity and frontiers: How economies have developed through natural resource exploitation*. Cambridge: Cambridge University Press.
- Bey, A., Jetimane, J., Lisboa, S. N., Ribeiro, N., Siteo, A. & Meyfroidt, P. (2020). Mapping smallholder and large-scale cropland dynamics with a flexible classification system and pixel-based composites in an emerging frontier of Mozambique. *Remote Sensing of Environment*, 239, 111611.
- Bey, A. & Meyfroidt, P. (2021). Improved land monitoring to assess large-scale tree plantation expansion and trajectories in Northern Mozambique. *Environmental Research Communications*, 3(11), 115009.

- Buchadas, A., Baumann, M., Meyfroidt, P. & Kuemmerle, T. (2022). Uncovering major types of deforestation frontiers across the world's tropical dry woodlands. *Nature Sustainability*, 5(7), 619-627.
- Deininger, K., Byerlee, D., Lindsay, J., Norton, A., Selod, H. & Stickler, M. (2011). *Rising global interest in farmland: Can it yield sustainable and equitable benefits?* Washington D.C.: World Bank Publications (Agriculture and Rural Development).
- Fold, N. & Hirsch, P. (2009). Re-thinking frontiers in Southeast Asia. *The Geographical Journal*, 175(2), 95-97.
- Gasparri, N. I., Kuemmerle, T., Meyfroidt, P., le Polain de Waroux, Y. & Kreft, H. (2016). The emerging soybean production frontier in Southern Africa: Conservation challenges and the role of South-South telecouplings. *Conservation Letters*, 9(1), 21-31 [<https://doi.org/10.1111/conl.12173>].
- Imamura, M. (2015). Rethinking frontier and frontier studies. *Political Geography*, 45, 96-97.
- Kronenburg García, A., Meyfroidt, P., Abeygunawardane, D. & Siteo, A. (2022). Waves and legacies: The making of an investment frontier in Niassa, Mozambique. *Ecology and Society*, 27(1), 40.
- Lambin, E. F., Gibbs, H. K., Ferreira, L., Grau, R., Mayaux, P., Meyfroidt, P., Morton, D. C., Rudel, T. K., Gasparri, I. & Munger, J. (2013). Estimating the world's potentially available cropland using a bottom-up approach. *Global Environmental Change*, 23(5), 892-901 [<https://doi.org/10.1016/j.gloenvcha.2013.05.005>].
- le Polain de Waroux, Y., Baumann, M., Gasparri, N. I., Gavier-Pizarro, G., Godar, J., Kuemmerle, T., Müller, R., Vázquez, F., Volante, J. N. & Meyfroidt, P. (2018). Rents, actors, and the expansion of commodity frontiers in the Gran Chaco. *Annals of the American Association of Geographers*, 108(1), 204-225 [<https://doi.org/10.1080/24694452.2017.1360761>].
- Levers, C., Romero-Muñoz, A., Baumann, M., De Marzo, T., Fernández, P. D., Gasparri, N. I., Gavier-Pizarro, G. I., le Polain de Waroux, Y., Piquer-Rodríguez, M., Semper-Pascual, A. & Kuemmerle, T. (2021). Agricultural expansion and the ecological marginalization of forest-dependent people. *Proceedings of the National Academy of Sciences*, 118(44), e2100436118 [<https://doi.org/10.1073/pnas.2100436118>].
- Meyfroidt, P., Roy Chowdhury, R., de Bremond, A., Ellis, E. C., Erb, K.-H., Filatova, T., Garrett, R. D., Grove, J. M., Heinemann, A., Kuemmerle, T., Kull, C. A., Lambin, E. F., Landon, Y., le Polain de Waroux, Y., Messerli, P., Müller, D., Nielsen, J. Ø., Peterson, G. D., Rodríguez García, V., Schlüter, M., Turner, B. L. & Verburg, P. H. (2018). Middle-range theories of land system change. *Global Environmental Change*, 53, 52-67 [<https://doi.org/10.1016/j.gloenvcha.2018.08.006>].
- Oliveira, E. & Meyfroidt, P. (2022). Strategic spatial planning in emerging land-use frontiers: Evidence from Mozambique. *Ecology and Society*, 27(2), 5 [<https://doi.org/10.5751/ES-13001-270205>].
- Parker, B. J. & Rodseth, L. (Eds.) (2005). *Untaming the frontier in anthropology, archaeology, and history*. Tucson: The University of Arizona Press.
- Rasmussen, M. B. & Lund, C. (2018). Reconfiguring frontier spaces: The territorialization of resource control. *World Development*, 101, 388-399.
- Ribeiro, N. S., Katerere, Y., Chirwa, P. W. & Grundy, I. M. (Eds.) (2020). *Miombo woodlands in a changing environment: Securing the resilience and sustainability of people and woodlands*. Cham, Switzerland: Springer Nature.
- Rodríguez García, V. (2021). *Explaining agriculture and forest dynamics: From economic structures to agents' expectations*. PhD Thesis, Université catholique de Louvain.
- Searchinger, T. D., Estes, L., Thornton, P. K., Beringer, T., Notenbaert, A., Rubenstein, D., Heimlich, R., Licker, R. & Herrero, M. (2015). High carbon and biodiversity costs from converting Africa's wet savannahs to cropland. *Nature Climate Change*, 5(5), 481-486.
- Tsing, A. L. (2011). *Friction: An ethnography of global connection*. Princeton and Oxford: Princeton University Press.
- Turner, F. J. (1894). The significance of the frontier in American history. *Proceedings of the State Historical Society of Wisconsin* (Forty-first Annual Meeting, Dec. 14, 1893).