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THE LINKAGES BETWEEN MIGRATION AND ENVIRONMENTAL CHANGE IN ETHIOPIA: EMPIRICAL EVIDENCE FROM RURAL SENDING AND RECEIVING AREAS

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SUMMARY

The linkages between human migration and environmental change are becoming more relevant in light of projected changes and the increasing number of people exposed. Changing rainfall patterns and land degradation will increase the livelihood pressure on many communities and natural resource-dependent livelihoods in the Global South are particularly vulnerable. Major scientific progress has been made in recent years to advance the knowledge base and our conceptual understanding of the linkages between environmental change and migration, showing that the relationship is highly complex, multicausal and context-specific. However, significant knowledge gaps on how environmental change and migration are linked and deterministic narratives in public and scientific debates persist.

Using the example of rural Ethiopia, I investigate two different regions: First, the northern Ethiopian highlands – a hotspot of out-migration, frequent droughts, food insecurity, severe land degradation and changing rainfall patterns. Second, the southwestern rainforests – a hotspot of in-migration known for its richness in forests, biodiversity and ethnicities – where rapid changes in rural livelihoods and decline in forest cover were observed in recent years. I draw on plenty of empirical evidence, which I collected in both case study sites, and apply qualitative and quantitative methods to contribute to an improved understanding of environment-migration linkages. In this thesis, I address the following overarching questions: (i) How do environmental and non-environmental factors interact in shaping environment-related migration in farming households? (ii) What are the pathways through which environment-related migration emerges and what leverages exist to reduce migration needs? (iii) How does in-migration, together with non-migration related factors, influence livelihood transitions and environmental degradation?

In chapter 1, I delineate the state of research on the influence of environmental change on out-migration and the influence of in-migration on the environment. I sketch the current debates and particularly highlight the factors potentially determining this relationship. Furthermore, I carve out the research gaps I address in the thesis and provide an overview of the thesis objectives and its structure. In chapter 2, I introduce my case study sites and illustrate their different features in terms of rural livelihoods and their social, economic, institutional and natural contexts. Chapter 3 provides a concise overview of the various – partially novel – methods I used to analyze my vast empirical data.

In chapter 4, I present empirical evidence from the northern highlands – the migrant-sending area. In a first step (chapter 4.2), I describe a qualitative, multisite study which integrates 42 interviews in farming households, 18 focus group discussions and 20

migrant interviews in six different villages to grasp factor interactions driving migration in farming households. By applying Qualitative Comparative Analysis (QCA), I reveal that two causal factor interactions are decisive for migration by members of farming households: Migration experience within the household in combination with either the usage of the more stable summer rainy season (Kiremt) or non-farm in-situ diversification. I argue that favorable rainfall conditions and additional income sources outside of agriculture increase household economic resources and, together with migrant networks, increase migration abilities. Consequently, it is not the most vulnerable who will engage in migration.

As a subsequent step (chapter 4.3), I integrate the QCA findings with empirical evidence from other scientific studies and a stakeholder workshop with local policy makers and representatives from villages and NGOs to develop a participatory Bayesian network (BN). The BNs depicts migration decisions and illustrates two main and distinct – yet not mutually exclusive – pathways on which environmental degradation is influencing migration: (1) Soil degradation and rainfall variability reduce agricultural production and thus increase migration by increasing the need to migrate; (2) Unfavorable environmental conditions for agriculture increase the likelihood to search for non-farm activities, ultimately increasing migration abilities. I further use the BN to identify leverages for local policy makers to reduce migration needs. I highlight that addressing the existing barriers for the adoption of soil and water conservation measures (SWC) in the northern highlands are most promising to combat land degradation and reduce pressure on rural livelihoods in the northern highlands.

In chapter 5, I present empirical evidence from Ethiopia's southwestern rainforests – the migrant-receiving area. I describe a quantitative study, which integrates 224 surveys of local and migrant households, nine semi-structured key informant interviews and three group discussions in three different villages. I apply random forest regression techniques to understand under which conditions migration contributes to livelihood transition and deforestation. My results show that the engagement in forest activities depends mainly on a household's original livelihood. Thus, local households, which are traditionally highly dependent on forests, are more active in forest activities than migrant groups, which largely depend on intensive agriculture. However, forest activities – particularly the collection of non-timber forest products (NTFPs) – have substantially declined among the local population over the past two decades. I show that cropland in the study area expanded at the expense of the forest – partially due to the in-migration of smallholders from agriculture-based systems but also considerably due to the expansion of commercial agriculture for the production of cash crops, encouraged by Ethiopia's land tenure policy. I argue that the decline in forest area, but also limited opportunities to participate in local forest management groups, made it increasingly difficult for the local

forest-based people to pursue their traditional livelihoods. Rather, local people gradually adopted migrants' agricultural practices – a development fueled by Ethiopia's agricultural policy, which promoted land-intensive farming practices and the production of cash crops, further increasing forest degradation. Put together, I elucidate how governmental policies, commercial agriculture, land tenure and forest access mediate migration-degradation linkages.

Finally, in chapter 6, I synthesize the key findings from chapter 4 and 5 and propose avenues for future research. In sum, my thesis reveals key enabling and amplifying factors that mediate the linkages between environmental change and migration. I show that environmental change in the northern Ethiopian highlands impacts migration in farming household mainly via agricultural channels and that it can both trigger and inhibit migration. Yet, social and economic factors at the household scale are key to enable migration (rather than push factors), and as a result, migration as a strategy to deal with environmental change cannot be adopted equally among households. Supporting livelihood diversification to increase migration abilities and addressing the existing barriers to combat land degradation and reduce migration needs are key leverages for local decision makers in the northern highlands. Furthermore, my work demonstrates that agricultural policies, land tenure insecurity, and restricted forest access amplify the impact of in-migration on rural livelihoods and on the natural resource base in the southwestern rainforests. I argue that if decision makers do not address these amplifiers there is a risk of a feedback loop with further degradation, growing tensions between local and migrant groups and forced migration or immobility.

ZUSAMMENFASSUNG

Der Zusammenhang zwischen menschlicher Migration und Umweltwandel wird angesichts der prognostizierten Umweltveränderungen und der zunehmenden Zahl der betroffenen Menschen immer bedeutsamer. Veränderte Niederschlagsmuster und Landdegradation werden den Druck auf die Lebensgrundlagen vieler Bevölkerungsgruppen erhöhen, wobei die von natürlichen Ressourcen abhängigen Menschen im globalen Süden besonders gefährdet sind. In den letzten Jahren wurden große wissenschaftliche Fortschritte erzielt, um die Wissensbasis und unser konzeptionelles Verständnis der Zusammenhänge zwischen Umweltveränderungen und Migration zu verbessern. Es hat sich gezeigt, dass die Beziehung äußerst komplex, multikausal und kontextspezifisch ist. Dennoch gibt es nach wie vor erhebliche Wissenslücken darüber, wie Umweltwandel und Migration miteinander verknüpft sind und in den öffentlichen und wissenschaftlichen Debatten werden nach wie vor deterministische Ansichten vertreten.

Am Beispiel des ländlichen Äthiopiens untersuche ich zwei verschiedene Regionen ein: Zum Einen das nördliche Hochland Äthiopiens – ein Brennpunkt für Abwanderung, häufige Dürren, Ernährungsunsicherheit, schwere Landdegradation und veränderte Niederschlagsmuster. Zum Anderen die südwestlichen Regenwälder – ein Hotspot der Einwanderung, der für seinen Reichtum an Wäldern, Artenvielfalt und Ethnien bekannt ist – wo in den letzten Jahren rapide Veränderungen der ländlichen Lebensgrundlagen und ein Rückgang der Waldfläche zu beobachten waren. Ich stütze mich auf zahlreiche empirische Belege, die ich in beiden Untersuchungsgebieten gesammelt habe und wende qualitative und quantitative Methoden an, um zu einem besseren Verständnis der Zusammenhänge zwischen Umweltwandel und Migration beizutragen. In dieser Arbeit untersuche ich die folgenden übergreifenden Fragen: (i) Wie interagieren umweltbezogene und nicht umweltbezogene Faktoren bei der Gestaltung umweltbezogener Migration in landwirtschaftlichen Haushalten? (ii) Über welche Wirkungspfade entsteht umweltbedingte Migration und welche Hebel gibt es, um die Notwendigkeit zur Migration zu verringern? (iii) Wie beeinflusst Einwanderung zusammen mit nicht-demografischen Faktoren die Veränderung von Lebensgrundlagen und die Umweltdegradation?

In Kapitel 1 beschreibe ich den Forschungstand zum Einfluss von Umweltwandel auf Abwanderung und den Einfluss von Einwanderung auf die Umwelt. Ich skizziere die aktuellen Debatten und hebe insbesondere die Faktoren hervor, die diese Beziehung möglicherweise beeinflussen. Darüber hinaus arbeite ich die Forschungslücken heraus, die ich in dieser Arbeit adressiere und gebe einen Überblick über die Ziele und den Aufbau der Arbeit. In Kapitel 2 stelle ich meine Untersuchungsgebiete vor und veranschauliche ihre unterschiedlichen Merkmale in Bezug auf die ländlichen

Lebensgrundlagen und ihre sozialen, wirtschaftlichen, institutionellen und natürlichen Kontexte. Kapitel 3 gibt einen kurzen Überblick über die verschiedenen – teilweise neuartigen – Methoden, die ich zur Analyse meiner umfangreichen empirischen Daten verwendet habe.

In Kapitel 4 präsentiere ich empirische Belege aus dem nördlichen Hochland – dem Abwanderungsgebiet. In einem ersten Schritt (Kapitel 4.2) beschreibe ich eine qualitative, standortübergreifende Studie, die 42 Interviews in bäuerlichen Haushalten, 18 Fokusgruppendiskussionen und 20 Interviews mit Migrant*innen in sechs verschiedenen Dörfern integriert, um die Wechselwirkungen der Faktoren zu erfassen, die die Migration in bäuerlichen Haushalten antreiben. Mit Hilfe der *Qualitative Comparative Analysis* (QCA) zeige ich, dass zwei kausale Faktorinteraktionen für die Migration von Mitgliedern landwirtschaftlicher Haushalte entscheidend sind: Die Migrationserfahrung innerhalb des Haushaltes in Kombination mit der Nutzung der stabileren Sommerregenzeit (Kiremt) oder der Diversifizierung außerhalb der Landwirtschaft. Ich argumentiere, dass günstige Niederschlagsbedingungen und zusätzliche Einkommensquellen außerhalb der Landwirtschaft die wirtschaftlichen Ressourcen der Haushalte erhöhen und zusammen mit Migrationsnetzwerken die Migrationsfähigkeit steigern. Folglich sind es nicht die am stärksten gefährdeten Haushalte, die Migration nutzen können.

In einem weiteren Schritt (Kapitel 4.3) integriere ich die QCA-Ergebnisse mit empirischen Erkenntnissen aus anderen wissenschaftlichen Studien und einem Stakeholder-Workshop mit lokalen Entscheidungsträger*innen und Vertreter*innen von Dörfern und NROs, um ein partizipatives *Bayes'sches Netzwerk* (BN) zu entwickeln. Das BN stellt Migrationsentscheidungen dar und veranschaulicht zwei wesentliche und unterschiedliche – sich jedoch nicht gegenseitig ausschließende – Wirkungspfade, auf denen die Umweltdegradation die Migration beeinflusst: (1) Bodendegradation und variabler Niederschlag verringern die landwirtschaftliche Produktion und erhöhen somit die Migration, indem sie die Notwendigkeit zur Abwanderung verstärken; (2) Ungünstige Umweltbedingungen für die Landwirtschaft erhöhen die Wahrscheinlichkeit nach außerlandwirtschaftlichen Tätigkeiten zu suchen, was letztlich die Migrationsfähigkeit erhöht. Darüber hinaus nutze ich das BN, um Hebel für lokale politische Entscheidungsträger*innen zu identifizieren, welche die Notwendigkeit zur Migration verringern können. Ich mache deutlich, dass die Beseitigung der bestehenden Hindernisse für die Einführung von Boden- und Wasserschutzmaßnahmen im nördlichen Hochland am vielversprechendsten ist, um die Landdegradation zu bekämpfen und den Druck auf die ländlichen Lebensgrundlagen im nördlichen Hochland zu verringern.

In Kapitel 5 präsentiere ich empirische Erkenntnisse aus den südwestlichen Regenwäldern Äthiopiens – dem Einwanderungsgebiet. Ich beschreibe eine quantitative Studie, welche 224 Erhebungen unter einheimischen und eingewanderten Haushalten, neun halbstrukturierte Interviews mit Schlüsselinformant*innen und drei Gruppendiskussionen in drei verschiedenen Dörfern integriert. Ich verwende eine *Random Forest Regressionsanalysen*, um zu verstehen, unter welchen Bedingungen die Migration zu Veränderungen der ländlichen Lebensgrundlagen und zur Entwaldung beiträgt. Die Ergebnisse zeigen, dass der Grad des Engagements in Waldaktivitäten hauptsächlich von der ursprünglichen Lebensgrundlage eines Haushalts abhängt. So nutzen die die einheimischen, traditionell stark Wald-abhängigen Haushalte den Wald mehr als die eingewanderten Bevölkerungsgruppen, welche größtenteils von intensiver Landwirtschaft leben. Jedoch wurden die Waldaktivitäten – insbesondere das Sammeln von Nichtholzprodukten (*non-timber forest products*, NTFPs) – der einheimischen Bevölkerung in den letzten zwei Dekaden stark zurückgedrängt. Ich zeige, dass sich die Anbauflächen im Untersuchungsgebiet auf Kosten des Waldes ausgedehnt haben – teilweise aufgrund der Einwanderung von Kleinbäuer*innen aus landwirtschaftlich geprägten Systemen, aber auch in erheblichem Maße aufgrund der Ausweitung der kommerziellen Landwirtschaft für die Produktion von Cash Crops, die durch die äthiopische Landbesitzpolitik gefördert wurde. Ich behaupte, dass der Rückgang der Waldfläche, aber auch eingeschränkte Partizipationsmöglichkeiten in den lokalen Waldmanagementgruppen es der einheimischen Wald-abhängigen Bevölkerung zunehmend erschwerte, ihre traditionellen Lebensgrundlagen fortzuführen. Stattdessen übernahmen die Einheimischen nach und nach die landwirtschaftlichen Praktiken der Einwanderer – eine Entwicklung, die durch die äthiopische Agrarpolitik gefördert wurde, die landintensive Anbaumethoden und die Erzeugung von Cash Crops förderte und damit die Walddegradation weiter vorantrieb. Zusammenfassend beleuchte ich, wie Regierungspolitik, kommerzielle Landwirtschaft, Landbesitz und Zugang zum Wald die Zusammenhänge zwischen Migration und Umweltdegradation vermitteln.

Abschließend fasse ich in Kapitel 6 die wichtigsten Erkenntnisse aus Kapitel 4 und 5 zusammen und schlage Wege für künftige Forschungsarbeiten vor. Zusammenfassend lässt sich sagen, dass meine Arbeit wichtige begünstigende und verstärkende Faktoren aufzeigt, die die Zusammenhänge zwischen Umweltveränderungen und Migration vermitteln. Ich stelle heraus, dass Umweltveränderungen im nördlichen Hochland Äthiopiens die Migration in bäuerlichen Haushalten hauptsächlich über landwirtschaftliche Kanäle beeinflussen und dass sie Migration sowohl verstärken als auch hemmen können. Allerdings sind soziale und wirtschaftliche Faktoren auf Haushaltsebene ausschlaggebend für die Migration (und nicht Push-Faktoren), so dass die Migration als Strategie zur Bewältigung des Umweltwandels nicht von allen

Haushalten gleichermaßen genutzt werden kann. Die Unterstützung der Diversifizierung der ländlichen Lebensgrundlagen zur Steigerung der Migrationsfähigkeit und die Beseitigung bestehender Hindernisse zur Bekämpfung der Landdegradation und zur Verringerung der Migrationsnotwendigkeit sind wichtige Hebel für lokale Entscheidungsträger im nördlichen Hochland. Meine Arbeit verdeutlicht, dass die Agrarpolitik, unsichere Landbesitzverhältnisse und der eingeschränkte Zugang zum Wald die Auswirkungen der Einwanderung auf ländlichen Lebensgrundlagen und die natürlichen Ressourcen in den südwestlichen Regenwäldern verstärken. Ich argumentiere, dass eine Rückkopplungsschleife mit weiterer Degradation, wachsenden Spannungen zwischen einheimischen und zugewanderten Bevölkerungsgruppen und erzwungener Migration oder Immobilität droht, wenn Entscheidungsträger nicht gegen diese Verstärker vorgehen.

TABLE OF CONTENTS

LIST OF PUBLICATIONS AND AUTHOR CONTRIBUTIONS[1]

The dissertation contains content of two peer-reviewed articles, which have been published before submission of the thesis. The publications are cited in chapters and subchapters, wherever content of the articles was used.

Groth, J., T. Ide, P. Sakdapolrak, E. Kassa, and K. Hermans. 2020. Deciphering interwoven drivers of environment-related migration – A multisite case study from the Ethiopian highlands. *Global Environmental Change* 63(102094):102094.

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- Charlotte Wiederkehr: Writing - review & editing, Investigation
- Endeshaw Kassa: Investigation
- Jule Thober: Conceptualization, Writing - review & editing, Methodology, Investigation, Formal analysis

[1] Based on CRediT (Contributor Roles Taxonomy): https://www.elsevier.com/authors/policies-and-guidelines/credit-author-statement

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1. INTRODUCTION

Global environmental change increases livelihood pressure for millions of people worldwide, and natural resource-dependent people in the Global South are particularly vulnerable. Environmental changes can influence migration patterns, and in turn, migration has an influence on the environment in sending, transit and receiving areas (Hunter et al. 2015, Radel et al. 2019, Cattaneo et al. 2019). In the public and political discourses, deterministic and monocausal narratives on the environment-migration nexus persist and resulted in an increasing climate of fear, securitization of migration, and criminalization of migrants (Boas et al. 2019, McLeman 2019). Although much scientific progress has been made, scholars are still debating under what conditions environmental change increases or inhibits migration and whether migration necessarily leads to environmental degradation (IPCC 2014a, Olsson et al. 2019). With this dissertation, I aim to decipher the complex linkages between migration and environmental change using the example of rural Ethiopia – a country with high internal migration flows and whose natural resource-dependent population is highly affected and stressed by environmental change (CSA 2007, Piontek et al. 2014, Hermans-Neumann et al. 2017).

1.1. The influence of environmental change on migration

Environmental change, encompassing disturbances related to climate change and/or human activities, such as floods, shifting rainfall patterns and land degradation, and the numbers of people exposed to such changes will increase in the coming decades (IPCC 2018, Rigaud et al. 2018, Olsson et al. 2019). A longstanding human strategy to respond to adverse changes in the earth's environment is migration. There is no standard definition of environment-related migration (also referred to simply as mobility or migration in this thesis) and the term generally refers to the movement of people as a direct or indirect response to environmental change. Hereby, migration can relate to a range of durations and distances covered, as well as a whole spectrum from forced to voluntary decisions (IOM 2007). Globally, most existing and projected migration flows occur internally (i.e., within the border of a country) or within world regions, with highest numbers predicted for Africa (Rigaud et al. 2018, Cundill et al. 2021).

Fast-onset environmental changes, such as extreme weather events, tend to trigger involuntary migration (often called displacement) and short-distance types of migration responses, with people often returning after a short period (McLeman and Gemenne 2018). Such events usually have a very direct impact on migration as they suddenly disrupt people's livelihood, e.g. by damaging places of residence or causing economic disruptions, or are even life threatening. In contrast, slow-onset environmental changes, such as changing rainfall patterns or land degradation, tend to have less direct and sudden impacts on migration and are more likely to amplify existing drivers. Yet, there are many exceptions to these patterns, as the relationship between environmental change and migration is influenced by a myriad of contextual socioeconomic, demographic, environmental, and political factors (Black et al. 2011, Cattaneo et al. 2019, Cundill et al. 2021).

Environmental change can affect people livelihoods, e.g. by causing crop failures and reducing agricultural productivity, and as such can increase migration (Kubik and Maurel 2016, Falco et al. 2019). This is particularly relevant for people depending on natural resources as they are more vulnerable towards environmental changes, especially in regions with low adaptive capacities, such as many rural areas in the Global South (van der Land and Hummel 2013, IPCC 2014a, Serdeczny et al. 2017). However, many studies show that environmental change can also decrease migration, by undermining social and economic resources (e.g., agricultural production) necessary to migrate (van der Land and Hummel 2013, Cattaneo and Massetti 2015, Cattaneo and Peri 2016, Suckall et al. 2017). Consequently, environmental change can both increase the pressure on people and thus their need to migrate and limit people's ability to migrate[2]. This causes concern that those most at risk can become trapped and unable to move away from vulnerable environments, amplifying their vulnerability and leading to growing social disparities (Foresight 2011, Black et al. 2013). Economic status and education are central factors mediating environment-migration linkages. Both can increase the capacities to move, e.g., as migration can be costly, but also the options to adapt in-situ (Borderon et al. 2019). In addition, existing studies suggest that motivations to use migration vary widely and depend on wealth, as well. These studies indicate that better-off household tend to use migration as asset accumulation strategy to anticipate shocks, while poorer households are more likely to use it as a last-resort survival strategy (e.g., Asfaw et al. 2010, Kleemans 2015). Furthermore, a few studies also show that beneficial environmental conditions and social networks are not only pull factors for migration, but that natural capital and kinship ties also facilitate migration (Van der Geest et al. 2010, Doevenspeck 2011, Hunter et al. 2017). In addition, social norms or political framing conditions are also known to influence migration abilities, e.g. by marginalizing women under environmental stress and reducing their options for adaptation, including migration (Gray and Mueller 2012b, Mersha and Van Laerhoven 2016, Ayeb-Karlsson 2020) or by posing legal restrictions of international migration (McLeman 2019). Yet, even under extreme environmental stress and with the sufficient

[2] Migration need refers to the pressure to move resulting from vulnerability and migration ability encompasses the capacity to move (based on Black and Collyer, 2014; Carling, 2002; Carling and Schewel, 2018)

means to migrate, not all people are willing to leave. There is increasing evidence that people's perception of their environment, including associated risks, and their attachment to places are crucial for migration decisions (Wiederkehr et al. 2019).

Based on the above it becomes evident that migration is a multicausal and complex phenomenon, which can unfold on different pathways and with a variety of interacting multi-scale factors involved, largely depending on the local context. While it is clear that environmental change has an impact on migration, the 'how' and 'why' remain inconclusive and a major research gap (Cundill et al. 2021), also because it is methodologically challenging to unravel the causal complexity inherent to migration decisions. Yet, it is crucial to grasp the underlying mechanisms in order to support decision-making, e.g. to reduce underlying vulnerabilities. This calls for place-based research and the use of novel and participatory tools, which provide in-depth case knowledge, which are able to deal with causal complexity and to communicate complex mechanisms to local decision makers.

1.2. The influence of in-migration on environmental change

The reasons why people migrate can be manifold – the same applies to the places they choose as destinations. Rural-rural migration is a crucial aspect of population-environment linkages but has been little studied in migration research (Carr 2009, Radel et al. 2019). Favorable environmental conditions constitute an important pull factor for smallholders to move out of degrading or stressed environments and into other rural areas with more stable rainfall, higher soil fertility and abundant resources (Henry et al. 2003). These destination areas may experience significant population growth related to in-migration, which potentially increases pressure on natural resources and may ultimately lead to resource degradation. Such conclusions have been drawn especially in the context of deforestation in the humid tropics (e.g., Carr 2009, López-Carr and Burgdorfer 2013, Hermans-Neumann et al. 2016) or resource degradation in semiarid areas (e.g., Obioha 2008). Large-scale data-driven analyses often support such conclusions (e.g., Bai et al. 2008). However, it is acknowledged that there is, similar to the influence of environmental change on out-migration, no simple causal relation between in-migration and degradation (IPCC 2014a). Instead, a variety of direct and indirect demographic, political, economic, social and institutional factors at various scales mediate the influence in-migration has on the natural resource base. Even though studies on larger scales acknowledge the multicausality of environmental degradation, they often lack to provide an in-depth understanding under which conditions in-migration contributes to environmental degradation.

Existing more detailed case studies focus mainly on migrants' resource use and show that low educational attainment and impoverishment hinder migrants from using natural resources sustainably, for example, as they degrade their environment to fulfil immediate consumption needs (Zommers and MacDonald 2012, Codjoe and Bilsborrow 2012, Etongo et al. 2015). Others show that the impact of migrant and local practices does not differ and emphasize that the policy environment, market access, and land tenure are often neglected causes of land degradation (Van der Geest et al. 2015). There is growing evidence that insecure land tenure contributes to unsustainable land use by migrants and that secured tenure slows down deforestation (Codjoe 2006, Robinson et al. 2014, Holland et al. 2017), yet, only under land abundance (Unruh et al. 2005). This highlights the complexities and importance of the local context. Participatory forest management, for example, seems to have positive impacts on social livelihoods and forest conditions in destination areas (Tadesse et al. 2016, 2017, Hermans-Neumann et al. 2016). In addition, good integration of migrants into local (host) communities and knowledge of local conditions likely contribute to a stronger sense of belonging and responsibility, leading to more long-term, sustainable decisions and resource use by migrants (Cassels et al. 2005, Brondizio and Moran 2008, Codjoe and Bilsborrow 2012). Besides such local scale dynamics, macroeconomic forces can have strong impacts on the local level, as well. For instance, growing global market demands for agricultural commodities and the resulting expansion of large-scale agricultural projects at forest frontiers are the fastest growing drivers for tropical deforestation, and also affect rural livelihoods and land use decisions of smallholders (Rudel et al. 2009, Magliocca et al. 2020, Zaehringer et al. 2021).

Based on this varied evidence, it can be summarized that in-migration can contribute to various changes, including environmental changes, in destination areas. However, how and whether this leads to environmental degradation depends heavily on the local context and a variety of multi-scale factors. Moreover, only few local studies address the impact of migration on the resource use of local (host) population so far. Consequently, a better understanding of the factors that determine the impact of migration on the environment and the livelihoods of both migrants and local residents in receiving areas is needed to strengthen the knowledge base, which – in contrast to the influence of environmental change on out-migration – is lagging behind (Cundill et al. 2021). In addition, this can improve policies to curb resource degradation and counteract false attribution and migrant blaming.

1.3. Objectives and structure of this thesis

Despite significant scientific progress and an ever-growing number of studies on the influence of environmental change on out-migration, the complex interactions between environmental and non-environmental factors, as well as the multiple pathways through which environment-related migration emerges, continue to pose significant knowledge gaps and a methodological challenge in the research field. In addition, there is a limited understanding of whether and under which conditions in-migration contributes to environmental degradation in destination areas. In this dissertation, I address these gaps by drawing on rich, diverse and local empirical data, which I collected in two case study areas in rural Ethiopia – a sending area in the northern highlands and a receiving area in the southwestern rainforests (Figure 1). I use a multi-method approach that includes systematic qualitative, participatory, and quantitative statistical methods to analyze these data and to answer three different research questions concerning the causal linkages between migration and environmental change.

In **chapter 2**, I introduce the two Ethiopian case study areas by describing their environmental, demographic, socioeconomic, and institutional context, as well as the livelihoods of the rural population under study.

In **chapter 3**, I provide an overview of the three different methods I used to analyze the empirical data collected in the two case study areas, each tailored to answer a specific research question.

Chapter 4 addresses the influence of environmental change on out-migration (sending area) using the example of farming household in the northern Ethiopian highlands. The chapter aims to improve our understanding of the causal relationship between environmental change, socioeconomic factors and migration. Further, it addresses the methodological challenge of exploring this causal complexity inherent to migration decision by employing methods, which are novel and underutilized in the research field thus far. In a first study (**chapter 4.2**), I aim to shed light on the mechanisms shaping environment-related migration by asking:

(i) How do environmental and non-environmental factors interact in shaping environment-related migration in farming households?

In order to address this question, I utilize a multi-site approach and qualitative comparative analysis (QCA), which is a powerful tool to unravel complex causal linkages, to analyze qualitative household data. Moreover, I complement the findings with valuable insights from group discussions and interviews with migrants and local experts. In a second study (**chapter 4.3**), I investigate the various pathways on which direct and indirect factors interact to influence migration by posing the following question:

(ii) What are the pathways through which environment-related migration emerges and what leverages exist to reduce migration needs?

To shed light on this question, I integrated the findings from chapter 4.2, academic literature and a stakeholder workshop to develop a participatory Bayesian network (BN) depicting migration decisions of subsistence farmers. Based on this, I discuss entry points and existing barriers for local policy measures to reduce migration needs.

Chapter 5 contributes to closing the gap of research on the influence of in-migration on environmental change using the example of smallholder in-migration to Ethiopia's southwestern forest frontier (receiving area). In particular, with this chapter I aim to provide a detailed understanding of the role in-migration plays in livelihood transitions of rural households and environmental change, as well as the mediators of these linkages by asking:

(iii) How does in-migration, together with non-migration related factors, influence livelihood transitions and environmental degradation?

To answer this question, I analyze comprehensive household surveys, conducted in migrant and local households, using descriptive and analytical statistics and contextualize the results with qualitative data from group discussions and interviews.

Lastly, in **chapter 6**, I synthesize the empirical findings from chapter 4 and 5. For this purpose, I summarize the main findings from the two Ethiopian case studies and emphasize the contribution of the thesis to the research field. Based on this, I highlight the mediators of the linkages between migration and environmental change and discuss the potential of a self-enforcing feedback loop, which turns the migrants' destination area in southwestern Ethiopia into an out-migration area due to environmental degradation. Finally, I suggest avenues for future research based on conceptual reflections and the main findings of this thesis, and draw conclusions.

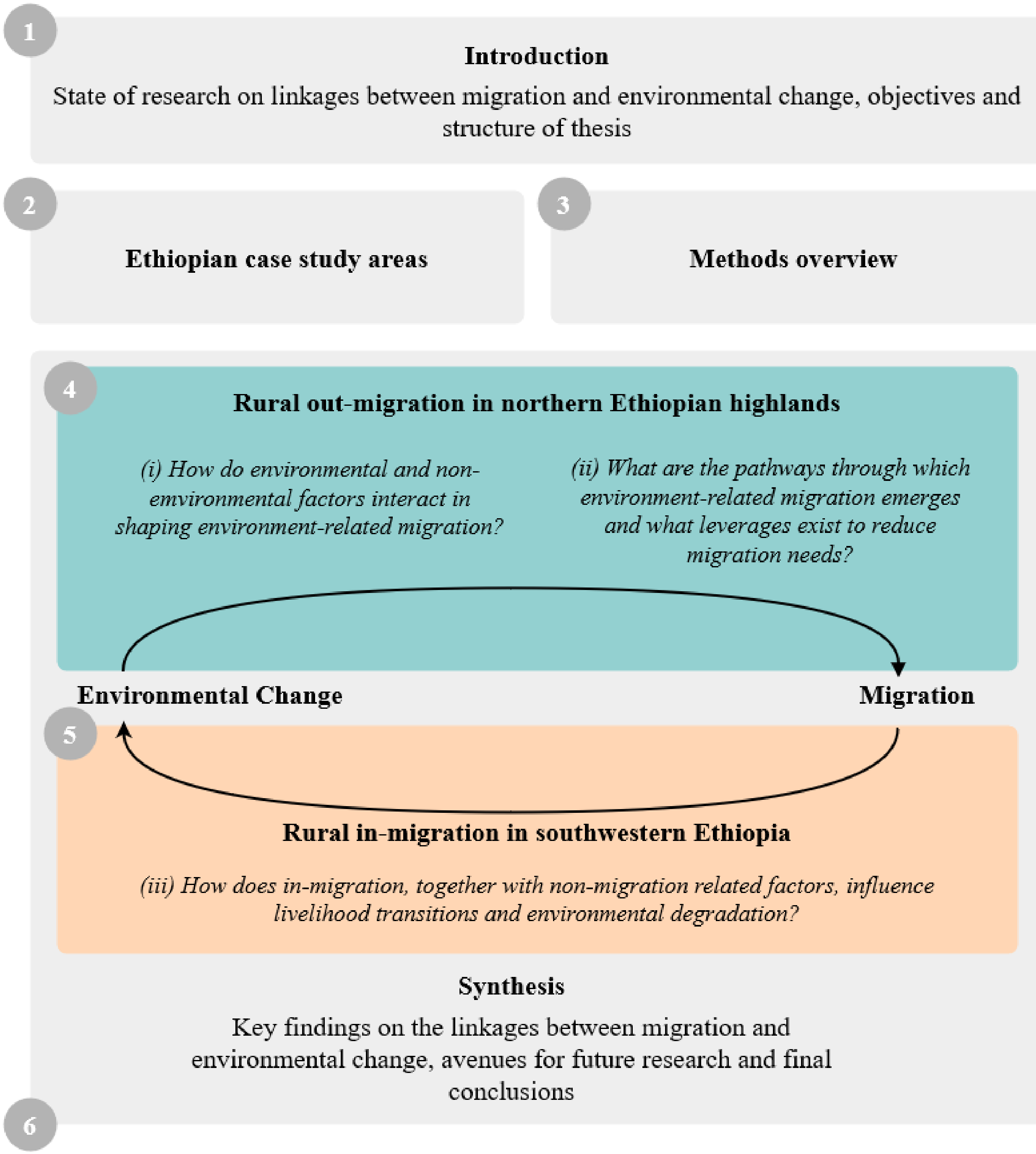

Figure 1: Overview of the structure of the thesis

2. ENVIRONMENTAL CHANGE AND MIGRATION IN TWO ETHIOPIAN CASE STUDY REGIONS

2.1. Environment-related migration in the northern highlands – The case of South Wollo[3]

Sub-Saharan Africa is considered a global hotspot of vulnerability to climatic and environmental stress because of its low adaptive capacity and the population's high reliance on rain-fed agriculture (Serdeczny et al. 2017). Within the region, the northern Ethiopian highlands are especially exposed due to the high levels of variability in precipitation and land degradation (Piontek et al. 2014). Moreover, the northern highlands belong to one of the most food insecure regions in Ethiopia and are a current, as well as a potential future, hotspot for out-migration (Little et al. 2006, Hermans-Neumann et al. 2017, Rigaud et al. 2018). This case study therefore focuses on a 'critical case' according to the definition of Flyvberg (2006, p. 230).

Although the highlands of Ethiopia are well represented in the literature on environment-related migration, the evidence on migration drivers, their interactions and their directional influences is inconsistent and remains context-specific. Studies that have explicitly focused on climatic changes, and especially drought-related studies, have generally concluded that climate shocks increase migration propensity, but highlight that other factors including gender, economic household resources and community vulnerability also strongly mediate and even have the potential to inhibit migration (Ezra 2001, Gray and Mueller 2012b, Mersha and Van Laerhoven 2016, Hermans and Garbe 2019). For example, Hermans and Garbe (2019) found that drought increased short-term migration, whereas it hampered long-distance migration due to the curtailed household resources. Furthermore, Gray and Mueller (2012b) as well as Mersha and van Laerhoven (Mersha and Van Laerhoven 2016) revealed that drought increased the labor-related mobility of men, whereas the marriage-related mobility of women declined due to the limited abilities of households to cover wedding expenses. In contrast, Tegegne and Penker (2016), for instance, showed that favorable agro-ecological conditions, sufficient agricultural production and improved access to markets increased short-term

[3] In a modified version, this subchapter is published in Groth, J., T. Ide, P. Sakdapolrak, E. Kassa, and K. Hermans. 2020. Deciphering interwoven drivers of environment-related migration – A multisite case study from the Ethiopian highlands. *Global Environmental Change* 63(102094):102094 and in Groth, J., K. Hermans, C. Wiederkehr, E. Kassa, and J. Thober. 2021. Investigating environment-related migration processes in Ethiopia – A participatory Bayesian network. *Ecosystems and People* 17(1):128–147.

migration. The authors emphasized that such mesoscale migration drivers are crucial for understanding environment-related migration in the region. Other scholars who have studied migration drivers without specifically focusing on environmental stressors such as drought have further identified land holding size, lack of in-situ non-farm activities, intravillage conflict, the absence of relief aid, livestock ownership, social networks and information flows as strong drivers for migration (Asfaw et al. 2010, Wondimagegnhu and Zeleke 2017). To date, no consensus on the complex set of factors shaping migration decisions in the region has emerged.

Together, these results suggest that to understand environmental migration in the northern highlands, one must account for household factors at the microscale in combination with mesoscale factors such as agro-ecological characteristics. However, the available evidence in this regard is inconsistent, not at least because mesoscale migration drivers are thus far underrepresented in the literature (Borderon et al. 2019). In addition, and similar to empirical studies in other regions of the world, the approaches either stick to qualitative migration narratives or do not have sufficient in-depth case-specific knowledge to explain how all the different influencing factors actually interact and how their interactions may enable or hamper migration. For the northern Ethiopian highlands, this is particularly unfortunate, as the region has an enormous relevance for current and potential future environment-related migration processes.

The case of South Wollo

I chose the South Wollo Zone of the Amhara Regional State in the northern Ethiopian highlands as a case study (Figure 2). Here, a significant depletion of natural resources and increasing climate variability have been observed, especially shifts in rainy season durations and water shortages due to declining rainfall amounts (Bewket 2009, Rosell 2011, Hermans-Neumann et al. 2017).

The rainfall in South Wollo has a bimodal pattern: precipitation falls during the Belg season between January and May and primarily during the Kiremt season between June and September, with annual precipitation sums significantly varying between years (Figure 3). In my study region, the changing rainfall pattern has been mainly illustrated by a tentatively delayed – and increasingly variable – onset of Belg. The onset of Kiremt has been less variable, yet it has been occurring tentatively earlier than it occurred in the past (Figure 3) and has been increasingly characterized by torrential rainfalls (Rosell 2011). Periodic droughts have become common in South Wollo.

In addition to rainfall failures, severe land degradation due to both climate change and the mismanagement of land is widespread (Nyssen et al. 2004, Morrissey 2013, Meshesha et al. 2014). Although land rehabilitation efforts have a long history, the northern highlands have been severely affected by topsoil losses, gully formation and declining soil fertility (Meshesha et al. 2014, Adimassu et al. 2017, Mekuriaw et al. 2018).

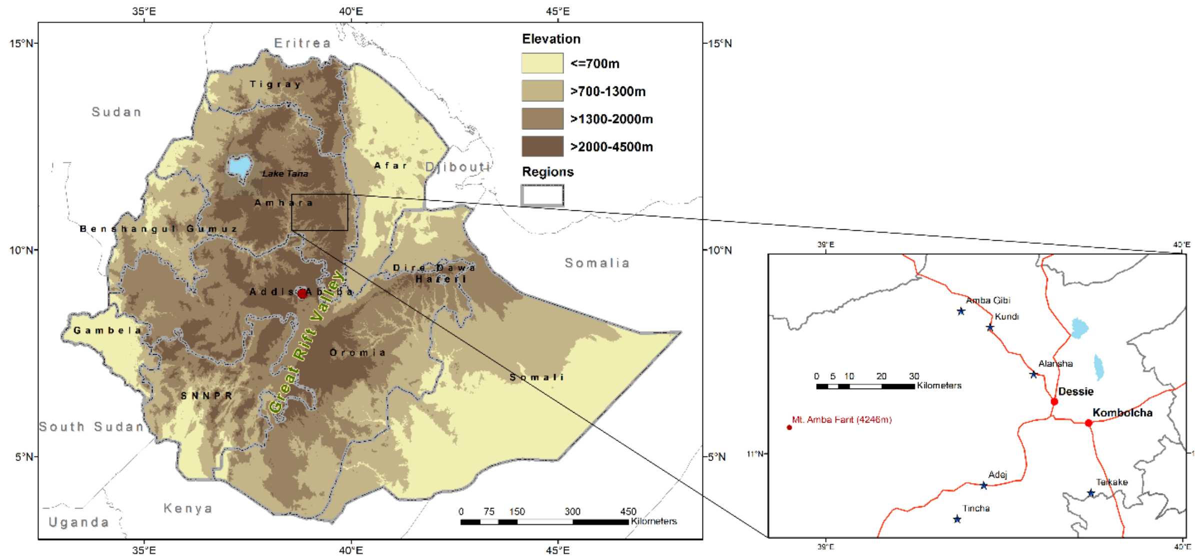

Figure 2: Left: Map showing Ethiopia's administrative regions and the location of the case study area (black rectangle) based on elevation data obtained from the Shuttle Radar Topography Mission (SRTM) at 250m resolution (Farr et al. 2007). Right: Map showing the study area, the South Wollo Zone, with the locations of the six studied kebeles (smallest administrative unit in Ethiopia) (blue stars), the two major cities of Dessie and Kombolcha and the main roads (red).

The livelihoods of the farmers in South Wollo depend mainly on mixed subsistence, rain-fed and low input agriculture; they keep livestock and grow mainly barley, wheat, teff, maize, pulses and sorghum. Overall, the altitude-dependent low temperatures combined with high precipitation intensity – partly in the form of hail, which potentially destroys the harvest – causes the farmers in the higher elevation regions to refrain from cropping during the Kiremt season. Those Belg-dependent farmers are considered the most vulnerable to the indicated changes in rainfall due to its increasing unpredictability (Rosell and Holmer 2007).

In densely populated South Wollo (148 persons/km^2 in 2007 (CSA, 2007)), the land has been almost completely distributed and is often only accessible via inheritance; hence, farmers suffer severe land scarcity (CSA 2007, Bezu and Holden 2014, Ege 2017). Land scarcity is expected to increase, given the growing population (annual population growth rate in 2018 was 2.6% (World Bank 2019)). In addition, severe land degradation significantly reduces crop yields and forces farmers to farm marginal lands, which also curtails livelihood security (Hurni et al. 2007). The northern highlands are one of the most food insecure regions in the country and have been dependent on relief aid for many years, even in seasons with adequate rainfall and harvests. South Wollo was one of the most affected zones during the famines in the 1970s, 1980s, 1990s, and most recently in 2015/16 (Little et al. 2006, Joint Government and Humanitarian Partners 2016). Governance structures are weak, and employment opportunities, especially in the rural areas of the highlands, remain rare (Ayenew 2002, World Bank 2005, Little et al. 2006).

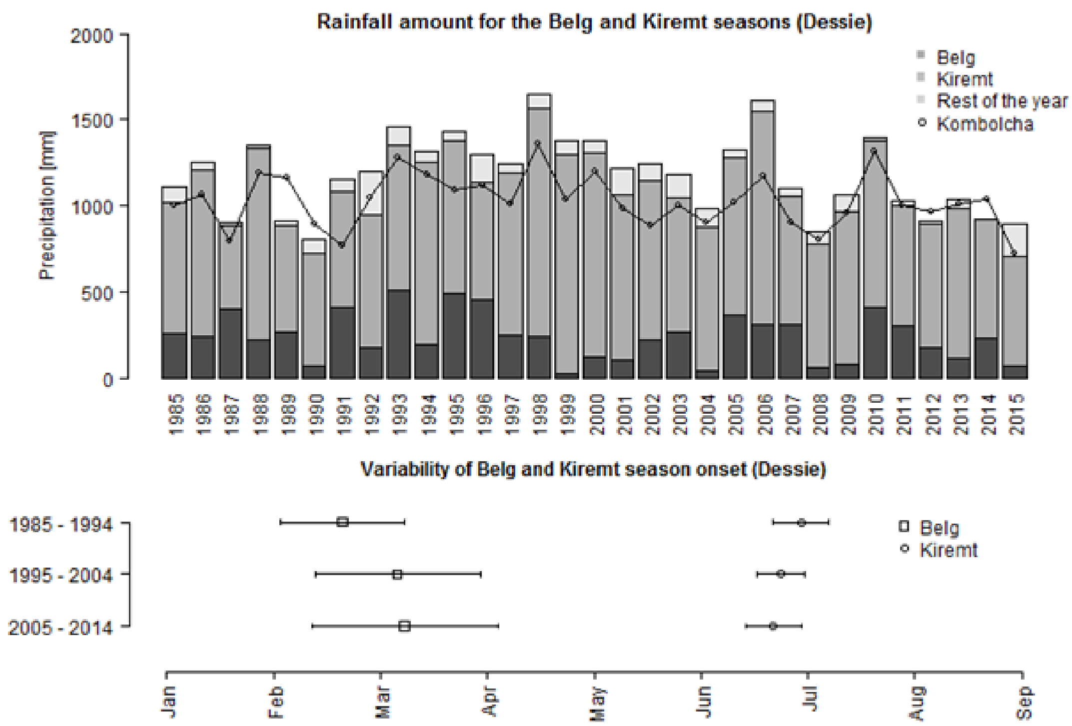

Figure 3: Upper panel: Annual precipitation for the Belg and Kiremt seasons between 1985 and 2015 for Dessie (2470 masl) and the total annual precipitation for Kombolcha (1842 masl) between 1985 and 2015. Lower panel: Mean onset and variability of onset (expressed in standard deviation) of Belg and Kiremt season for the decades 1985-1994, 1995-2004, and 2005-2014 in Dessie. Daily precipitation data were aggregated across three subsequent days. If more than 15 mm fell within three subsequent days, the onset of Belg or Kiremt was identified. Data were provided by the Meteorological Agency in South Wollo.

Consequently, farmers living in the northern highlands are some of the most vulnerable in the country, and the changing rainfall patterns, increasing land degradation and land scarcity further undermine their natural resource-dependent livelihoods. To address these adverse developments, farmers in the northern highlands apply various strategies, such as livestock and crop management, soil and water management, migration and income diversification (Meze-Hausken 2000a, Gilligan et al. 2009, Gebrehiwot and van der Veen 2013, Adimassu et al. 2017). Migration, as one of these strategies, occurs across various times and scales (Asfaw et al. 2010, Gray and Mueller 2012b, Weldegebriel and Prowse 2017, Hermans and Garbe 2019).

Figure 4: Upper panel: Rural landscape in South Wollo (left) and gully erosion (right). Lower panel: Farmer with livestock (left) and traditional and new housing (right). Photos: J. Groth

2.2. Migration to the southwestern rainforests – The case of Guraferda

I chose Ethiopia´s southwest rainforests, in particular the Guraferda district in the Bench Maji Zone of the Southern Nations, Nationalities, and Peoples' Region (SNNPR) (Figure 5), as a case study area, which is known for its richness in forests, biodiversity and ethnicities. The area is one of the last high forest areas in Ethiopia where wild coffee still grows (Wood et al. 2019). Favorable climate conditions and unoccupied lands in this region were the major reasons for various in-flows of smallholders from the drought-prone, degraded and densely populated parts of the country throughout Ethiopian history (Hammond 2008). In-migration in the more recent past is associated with a transition of forest-based to agriculture-based livelihoods and related increasing deforestation and forest degradation (Kassa et al. 2017, Getahun et al. 2017). However, the conditions under which these in-migration flows actually contributed to livelihood transitions and environmental degradation remain unclear.

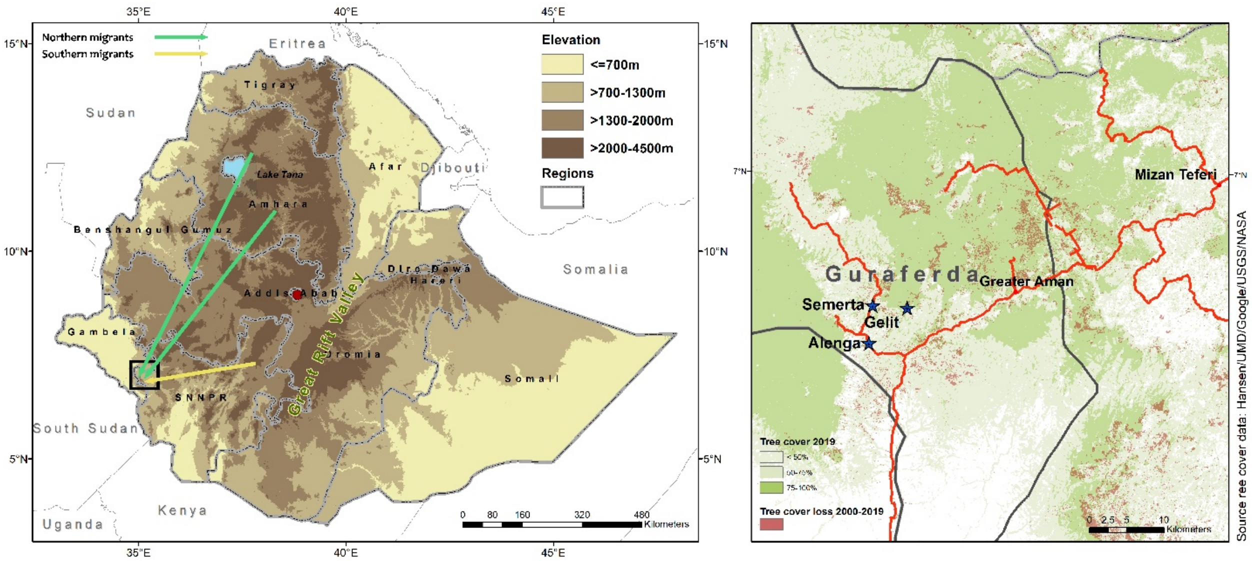

Figure 5: Left: Map showing Ethiopia's administrative regions and the location of the case study area (black rectangle) based on elevation data obtained from the Shuttle Radar Topography Mission (SRTM) at 250 m resolution (Farr et al. 2007). The three arrows showing the area of origin of the northern migrants (green) and southern migrants (yellow). Right: Map showing the study area, the Guraferda district, with the locations of the three kebeles (blue stars) studied during the empirical fieldwork, the two major cities of Mizan Teferi and Greater Aman and the main roads (red). In green, the tree cover in 2019 and in red, the tree cover loss between 2000 and 2019 is illustrated based on data obtained from a time-series analysis of Landsat images at a 30 m resolution (Hansen et al. 2013).

Guraferda has experienced rapid social-ecological changes over the past 20 years, including rapid population growth, expansion of cropland and agricultural livelihoods, forest loss, and changes in forest management and land tenure policies. In the following, I will explain these changes in more detail:

Between 2002 and 2018, the population of Guraferda grew from approximately 30,000 to 50,000 people, mainly through in-migration from the degraded and densely populated Ethiopian highlands (CSA 2007, Hammond 2008; Guraferda Land Administration, 2019). Beginning in 2001, an unknown number of 'northern migrants' from the northern Ethiopian highlands (mainly Amhara but also Tigrayans and Oromo) came without any government or institutional support to Guraferda. In addition, at least 8,000 'southern migrants' (mainly Welayta, Sidama and Kambaata) from the southern highlands resettled to Guraferda as part of a large intraregional resettlement program beginning in 2003 (Lemenih et al. 2014; Guraferda Land Administration, 2019).

Officially, land is state-owned in Ethiopia, and upon arrival, the planned southern migrants received 2.1 ha of land from local state authorities for their own disposal (Belay

2004), which equals a total of approximately 16,000 ha. In contrast, northern migrants did not receive formalized, state-recognized land use rights. Instead, they obtained land by making their own arrangements with locals, as large parts of Guraferda were under the traditional forest tenure – the so-called *kobbo* system (see Appendix C) – which is still recognized by the local communities (Kassa et al. 2017). To this end, kobbo owners transferred portions of their forestland to the newly arrived migrants from the north in exchange for rent or a share of the harvest (ibid.). However, these land transfers were not state-recognized (Debonne 2015). In other cases, northern migrants cleared or simply used unclaimed land, which was possible because of the land abundancy in 2003 and the absence of formalized rules on forest use, which were perceived as de facto open access (Stellmacher and Eguavoen 2011, Debonne 2015, Kassa et al. 2017).

The arrival of diverse settlers has greatly increased the cultural, linguistic, and ethnic diversity of the Guraferda population, including the livelihood systems. At arrival, both migrant groups were based on sedentary farming and plantation systems with cultivating cash crops such as coffee and pepper (FEWS NET 2006). In contrast, the local groups – the Dizi, Sheko and Menit – practiced shifting cultivation of mainly maize and relied heavily on non-timber forest products (NTFPs) (ibid). Unlike to the locals, migrants used the forest mainly as a source for timber and fuelwood (Figure 6). In the last two decades, Guraferda lost approximately 26,000 ha of forest (Guraferda Land Administration, 2019) and transitioned from a forest-based to an agricultural system (FEWS NET 2006, Kassa et al. 2017) (Figure 6). Kassa et al. (2017) have shown that locals engage less in forest activities and instead increasingly focus on agriculture, a shift that is inter alia influenced by in-migration, albeit details of this link remain unclear.

In the same period, large-scale commercial agricultural projects expanded and an additional area of 22,000 ha was allotted to private investors (Bench Maji Zonal Statistics, 2019). Furthermore, there have been policy and institutional changes in Guraferda. In 2010, a land reform secured land for migrants and limited the maximum land size to 2.1 ha for all migrant households (Debonne 2015; Guraferda Land Administration, 2019). This overruled the agreement that northern migrants had with local people (and therewith the traditional kobbo system) and officially allocated the land claimed by northern migrants to them, thereby reducing the land held by locals and resulting in a pluralism of tenure arrangements. In addition, in 2005 the state released a land proclamation that allowed the state to confiscate land or transfer it to private investors for public benefits (Proclamation No. 455/2005 and No. 456/2005).

Participatory forest management (PFM) schemes were introduced in the area to protect the remaining forest starting around 2010 (SWFLG 2014). Under PFM, forest use rights and responsibility for sustainable management of the forest were transferred to communities – now made up of a mix of migrants and local people – to so-called forest user groups (FUGs) (ibid). Restrictions on the use of forest products (e.g., permission required for collecting NTFPs) were introduced for forest under the FUG domain but also for all remaining trees and forests on the farmers' land (for details see Appendix C). However, this contradicts the customary user rights of the locals under the kobbo system (Kassa et al. 2017).

Figure 6: Transition of livelihoods and use of forest products from ~2003 (upper figure, launch of major resettlement program) to ~2018 (lower figure, year before data collection) of southern migrants (left, yellow), northern migrants (middle, green) and local households (rights, red). The southern and northern migrants focus on intensive farming and use the forest mainly as a source for timber and fuelwood, both in 2003 and 2018. In contrast, the livelihoods of the locals changed considerably from shifting cultivation with hand tools and a focus on collection of NTFPs to sedentary, intensive agriculture. The forest cover considerable declined between 2003 and 2018.

Figure 7: Upper panel: Rural homestead in the Guraferda district (left) and smallholder coffee field (right). Lower panel: Freshly cleared forest plot (left) and pile of harvested hot pepper (right). Photos: J. Groth

3. OVERVIEW DATA ANALYSIS METHODS

3.1. Qualitative comparative analysis (QCA)[4]

In **chapter 4.2**, I apply QCA to **decipher interwoven influence factors of environment-related migration** based on qualitative data collected in six different kebeles (see Figure 2 for the locations of the six kebeles and chapter 4.2.1 for details on the data collection). QCA is a set-theoretic approach that aims to detect causal relationships within data (Schneider and Wagemann 2012). The causal relationships between the potential influence factors and each phenomenon can be described as being either necessary[5], sufficient[6] or non-existent. In particular, QCA identifies whether (combinations of) various causal conditions (~ independent variables) are necessary and/or sufficient for an outcome of interest (~dependent variable), which in my case was out-migration. If a relationship between these influence factors and migration is detected, I use the notion of causal factors or causal relationships.

QCA is a powerful tool for depicting complex causal patterns characterized by conjunctural causation (conditions only have an impact if other conditions are present or absent) and equifinality (several different combinations of conditions can result in the same outcome) (Ragin 1987, Schneider and Wagemann 2012). Research has long highlighted that migration decisions can be explained by plentiful – and equally valid – pathways of intertwined direct and indirect migration drivers (equifinality). Migration decisions, including northern Ethiopia (e.g., Hermans and Garbe 2019), typically can only be explained by the interaction of several factors (conjunctural causation) (de Haas 2010, Foresight 2011). Consequently, QCA is especially appropriate in the context of chapter 4.2. Furthermore, QCA allows the integration of qualitative and quantitative data in the context of medium- and large-N research designs. Hence, it combines the advantages of large-N statistical analyses (generalizability beyond a few cases and high replicability) and in-depth case studies (deep knowledge of the respective context and the data used) (Schneider and Wagemann 2012). Despite its large potential to improve our understanding of migration driver interactions, QCA is an underutilized method in

[4] This subchapter contains content published in Groth, J., T. Ide, P. Sakdapolrak, E. Kassa, and K. Hermans. 2020. Deciphering interwoven drivers of environment-related migration – A multisite case study from the Ethiopian highlands. *Global Environmental Change* 63(102094):102094.

[5] The outcome is a subset of the condition. Whenever the outcome is present, the condition is present. The outcome cannot be achieved without the condition.

[6] The condition is a subset of the outcome. When the condition is present, the outcome is present.

migration studies thus far, yet, it is applied widely in other research fields such as environmental security (Ide 2015, Kirchherr et al. 2016).

3.2. Bayesian networks (BNs)[7]

In **chapter 4.3**, I aim to shed light on the **pathways through which environment-related migration emerges and to discuss the leverages to reduce migration needs with local stakeholders.** I use a BN depicting migration decisions, which I developed based on the QCA results from chapter 4.2, additional empirical findings from scientific literature and a stakeholder workshop conducted with local policy makers and representatives from both villages and NGOs in South Wollo (for details on the used approach see chapter 4.3.1).

BNs are probabilistic models representing a set of variables (in this case factors that influence migration) and their conditional dependencies on one another (aka interlinkages). BNs consist of (a) a directed acyclic graph of nodes (i.e., influential factors) connected by edges (i.e., statistical relationships between two influential factors) and (b) conditional probabilities for each variable given its parents in the graph (Aguilera et al. 2011). Each influential factor has a set of mutually exclusive states. BNs enable modelling complex and multicausal systems of many variables in an efficient and illustrative way, and are therefore a valuable tool for analyzing migration drivers. Recently, participatory research efforts developed expert-based BNs using interviews, questionnaires and workshops for a range of sustainability aspects, including food insecurity (Kleemann et al. 2017) and land use change (Celio and Grêt-Regamey 2016). In particular, their straightforward visualization makes BNs a useful communication and learning tool. I used the software Netica version 6.04 (Norsys Software Corp. 2019) to set up and analyze the BN and to demonstrate it during the workshop. While a QCA identifies combination of conditions that explain migration, the added value of a BN is that it allows to identify chains of influencing factors that lead to migration, including their directional influence and relative importance.

3.3. Random forest regression techniques

In **chapter 5**, I use quantitative data from a household survey to apply random forest regression techniques to identify the **drivers of forest activities in local and migrant households** in both 2003 (launch of a major resettlement program) and 2018 (year before data collection) and analyze the changes between both years. I contextualize the results with qualitative data from interviews and group discussions to understand what

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[7] This subchapter contains content published in in Groth, J., K. Hermans, C. Wiederkehr, E. Kassa, and J. Thober. 2021. Investigating environment-related migration processes in Ethiopia – A participatory Bayesian network. *Ecosystems and People* 17(1):128–147.

role migration, together with non-migration related factors, plays in livelihood transitions (i.e. changes forest activities) and deforestation (for details see chapter 5.1).

Using regression trees has the advantage that no assumptions on the distribution of the data have to be made, as regression trees split the data into multiple subsets. On each subset, a prediction model is fit, and thus, each split creates a ‘node’ that indicates the value of the response variable, the value of the predictor variables and the number of observations used in each split. Now, with a random forest regression, multiple regression trees are combined (rather than relying on an individual tree), which increases the predictive power of the model and reduces overfitting compared to a single regression tree (Prasad et al. 2006). Therefore, random forest regression employs a bootstrap procedure (random sampling with replacement) to grow a forest of regression trees (Breiman et al. 2001). Random forests are particularly strong in addressing multiple correlated drivers (Breiman et al. 2001) and thus are well suited to understanding multicausal, non-linear phenomena in social-ecological systems (Archibald et al. 2009, Hermans-Neumann et al. 2016).

4. EVIDENCE FROM SENDING AREAS: MIGRATION IN THE NORTHERN ETHIOPIAN HIGHLANDS

4.1. Analytical lens taken in the case study[8]

There exists a plurality of migration theories, which can be assigned to the individual, household, community or macroscale and as such, using different lenses to understand migration causes (Hagen-Zanker 2008). Theories, such as push and pull models (Lee 1966) or neoclassical micro migration theory (Sjaastad 1962) mainly focus on individual desires and aspirations, with improving one's well-being as the central migration cause. Theories, such as the dual labor market theory (Rodriguez and Piore 1981), considers macro-level trends (i.e. labor demands) as determinants for migration. In contrast, the New economics of labor migration (NELM) theory and livelihood approaches choose the household as the level of analysis and views migration as a household strategy to diversify risks and cooperation (Stark and Bloom 1985, de Haan 2000, Etzold and Sakdapolrak 2016). In the context of environment-related migration, household-scale approaches are often applied. Migration is identified as a risk diversification strategy for households (e.g. Findley 1987, Dillon et al. 2011, Hunter et al. 2014) or climatic stress is considered as a constraint for the household to engage in migration, since its curtailing household resources (e.g. van der Geest 2011, Gray and Bilsborrow 2013, Nawrotzki and Bakhtsiyarava 2017). Based on this, I have chosen a household perspective to understand migration, acknowledging the high potential of individual and community-scale research to complement my findings. In view of the interactions between migration drivers at the household scale that I aim to shed light on, my research is inspired by a framework proposed by Black et al. (2011). The framework provides a comprehensive conceptualization of the multiple spatial and temporal dimensions of the direct and indirect drivers (including environmental aspects) of migration. The framework conceptualizes migration as the result of multiple interwoven environmental and non-environmental factors at various scales, which makes it very suitable in the context of this chapter.

In the remainder of the chapter, I use the notions of environmental or non-environmental influence factors for migration when referring to direct or indirect migration drivers according to Black et al. (2011). Furthermore, I specify the directional influence of these

[8] This subchapter contains content published in Groth, J., T. Ide, P. Sakdapolrak, E. Kassa, and K. Hermans. 2020. Deciphering interwoven drivers of environment-related migration – A multisite case study from the Ethiopian highlands. *Global Environmental Change* 63(102094):102094.

factors and use the notion of enabling factors, if these influence factors increase the migration ability of a household (e.g., Carling and Schewel 2018). This may include intervening facilitators for migration, such as social networks or legal frameworks (Black et al. 2011), and personal and household characteristics, such as financial resources (e.g., Zickgraf 2018).

4.2. Deciphering interwoven drivers of environment-related migration[9]

The changes in the natural environment of the Earth are increasingly being recognized as threats to people, especially for those dependent on natural resources. Rapid or slow-onset hazards, such as tropical storms, shifting rainfall patterns and land degradation, can have an impact on migration patterns (Foresight 2011). These environment-related migrations can take various forms across scales and times and are likely to become even more urgent in the view of the projected climatic changes and the increasing numbers of people affected (IPCC 2014b, 2018).

Scientifically, major progress has been made in providing empirical evidence and in conceptualizing the relationship between the environment and migration (McLeman 2013, Neumann and Hilderink 2015, Hunter et al. 2015). In recent years, the community has moved beyond the monocausal understanding of environment-related migration (e.g., Myers 2002) towards a more complex and multicausal conceptualization (Bardsley and Hugo 2010, Castles et al. 2015, Cattaneo et al. 2019). The vast number of empirical studies describe migration as a risk diversification strategy that is heavily shaped by social, economic, political, demographic and environmental factors (Nawrotzki et al. 2013, Morrissey 2013, Warner and Afifi 2014). These factors can enable or inhibit migration, are often interrelated, and operate at different scales (de Haas 2010, Foresight 2011, Call et al. 2017). Consequently, environmental changes influence migration outcomes through a '*complex web of causal links*' (Mastrorillo et al. 2016 p. 155). This complexity – which is inherent to environment-related migration – makes it challenging to draw coherent conclusions on the influence of the interactions between environmental and non-environmental factors on migration (Kniveton et al. 2008, Renaud et al. 2011, Fussell et al. 2014). Despite this complexity, deciphering these causal interlinkages between environmental change and migration is crucial, for example, for the development of strategies to reduce forced migration and to build local resilience, but

[9] In a modified version, this subchapter is published as Groth, J., T. Ide, P. Sakdapolrak, E. Kassa, and K. Hermans. 2020. Deciphering interwoven drivers of environment-related migration – A multisite case study from the Ethiopian highlands. *Global Environmental Change* 63(102094):102094.

also to counter an inept securitization of environment-related migration (Methmann and Oels 2015 p. 51-68).

One main reason for the difficulty of grasping the complex interactions is the methods that are commonly utilized in empirical studies of environment-migration linkages: mostly, either quantitative large-N or qualitative small-N approaches are applied. Qualitative research designs potentially allow for high explanatory power for factor interactions because they are based on sound knowledge of the local context and thus enable the analyses to tackle complex migration narratives (Borderon et al. 2019). However, they tend to be criticized for lacking replicability and generalizability (e.g., Bilsborrow and Henry 2012). Quantitative approaches, on the other hand, are promising for obtaining results on the magnitude and direction of migration drivers on larger scales. Nevertheless, quantitative approaches have a restrained ability to deduce causalities from complex realities since case-specific knowledge is typically limited.

Several scholars made attempts to overcome these methodological shortcomings, for instance by integrating survey or census data with Bayesian belief networks (Drees and Liehr 2015) or agent-based models (e.g. Kniveton et al. 2011, Hassani-Mahmooei and Parris 2012) to achieve an increased understanding of complex migration linkages. Further, recent participatory techniques such as mobility mapping were employed to overcome the lack of scaling options in ethnographic studies (e.g. Safra de Campos et al. 2017) or to capture short-term migration patterns for large areas by using mobile network data (Lu et al. 2016). Another possible, yet so far under-utilized strategy (but see Haeffner et al. 2018) to integrate the benefits of qualitative and quantitative approaches is qualitative comparative analysis (QCA), which allows complex causal links to be traced by using a systematic set-theoretic approach (see chapter 3.1). QCA is especially powerful for detecting the influence of combinations of several factors on a certain phenomenon (Schneider and Wagemann 2012). Further, it has shown to be a promising tool for deciphering interwoven influencing factors, for instance in the field of environmental security (Ide 2015, Kirchherr et al. 2016). QCA holds the potential to improve our understanding of the interactions between migration drivers, which remains as a significant knowledge gap in the field of environment-related migration.

This subchapter addresses this gap. Here, I aim to decipher the circumstances under which rural households in the northern highlands of Ethiopia engage in migration. I employed a qualitative, multisite approach by integrating data from six kebeles (smallest administrative unit in Ethiopia) and utilized QCA – a novel method in the research field – for data analysis. As such, my approach considers the complex interactions of micro- and mesoscale migration drivers without sacrificing in-depth, case-specific knowledge.

4.2.1. Data collection and implementation of qualitative comparative analysis

Selection of the research sites

This chapter is based on a qualitative case study design and used a purposive sampling approach. During a preparatory visit in April/May 2017, I interviewed officials in 19 kebeles belonging to the four woredas (districts) of Legambo, Dese Zuria, Kutaber and Kalu in the South Wollo district. I did so to systematically increase heterogeneity regarding the composition of livelihoods, the major risks for these livelihoods (including the role and extent of land degradation and rainfall variability), and the main coping and adaptation strategies (including migration).

Based on the information provided, I purposively selected six out of the 19 kebeles for further study with the aim of increasing heterogeneity in the relevant socioeconomic and ecological variables for which I assumed that they would influence migration. These kebeles are distributed along an agro-ecological gradient ranging from Kola (1200-1600 masl), to Weyna Dega (1600-2600 masl) and Dega (2600-3600 masl), according to two different specifications of land degradation (high and low severity) and two different specifications of remoteness (own market and asphalt road). The six sites are further specified based on the rainy seasons used by the farmers (Table 1). While not drawing a random sample, this approach increases the confidence that my results are not driven by the characteristics of specific sites, but are broadly representative of South Wollo.

Table 1: Details of the six studied kebeles as described by the local officials. Agro-ecological zones are defined according to Hurni (1998). I defined land degradation as the reduced capacity of the soil and land to provide goods and services for human well-being mainly driven by soil erosion, i.e. gully erosion or the loss of topsoil and nutrients. The level of land degradation was determined by the local officials.

Kebele	Agro-ecological zone	Belg	Kiremt	Own market	Asphalt road	Land degradation
Adej	Dega	x				High
Alansha	Dega	x	x		x	Low
Amba Gibi	Weyna Dega		x			High
Tincha	Weyna Dega		x	x		Low
Kundi	Kola		x	x	x	High
Teikake	Kola	x	x			Low

Collection of qualitative data

Between November 2017 and February 2018, I conducted in-depth fieldwork by spending eight to nine days in each kebele. The data collection was conducted in Amharic (the local language) with the aid of a local assistant who received training prior to the fieldwork. The identification of appropriate respondents was supported by local extension workers and, similar to the selection of the six research sites followed, a purposive sampling approach. To assure the ability to recall the last decade, respondents had to be at least 30 years old.

I started the data collection with three mixed-sex focus group sessions (each with five to seven participants) in each kebele; the first was held with kebele officials (e.g., kebele administrations head, local extension workers, and religious leaders), the second with heads of migrant households or their spouses, and the third with heads of non-migrant households or their spouses. In each focus group session, I adopted methods used for community participation, such as wealth ranking, historical timelines, daily activity calendars, livelihood risk assessments, strategy ranking and mobility maps (modified after Kumar 2002, Kienberger 2009, Rademacher-Schulz et al. 2012). The focus groups were crucial for obtaining an overview of the specifics of local livelihoods and to build trust among the communities.

Complementing the focus groups, I conducted six to eight semi-structured household interviews per kebele. Hereby, I covered migrating and non-migrating households equally. The households were selected with the aim to maximize heterogeneity regarding household wealth, and thus, represented at least one household from the low, middle and upper wealth spectrum of the kebele in each migration category (migrating/non-migrating household). During the household interviews, first, I gathered features of the economic and social composition of the household, including the main activities, land and crop management and personal characteristics of the household members. Second, questions addressed the perceived changes in land degradation and rainfall, how such changes had affected the respondent's daily lives, and household strategies for addressing those environmental changes. Third, details of migration experiences such as time span, destination, reason for leaving and returning and financial or material transfers for all current and former household members were gathered (see Appendix A). In addition, I conducted follow-up interviews with returnees who were members of the already interviewed migrant households to gather in-depth knowledge of the socioeconomic, personal, political and environmental factors driving out-migration. An overview of the socioeconomic household characteristics can be found in Appendix A.

Finally, the information from the focus groups and interviews were contextualized through expert talks, i.e., key informants from non-governmental organizations and local government operating in the region. Overall, the qualitative approach and the intensive collaboration with a well-established local NGO enabled a trustworthy relationship with the communities and thus deepened the insights into the local lives and challenges of the people. In total, I conducted 18 focus groups (three in each kebele), 42 household interviews (seven to eight in each kebele), 20 interviews with returnees (among the 20 migrating households) and five expert talks. In the remainder of the analysis, I used the 42 households as the unit of analysis.

Figure 8: Left: Focus group discussion with community members and facilitator (Photo: J. Groth). Right: Interview situation with researcher, local translator and household head (Photo: K. Hermans)

Qualitative comparative analysis

To integrate the different kinds of data and to decipher migration driver interactions, I applied a QCA (see chapter 3.1. for further details). For the QCA algorithm that identifies necessary and sufficient (combinations of) conditions, I needed to employ a calibration procedure. In other words, I translated the (largely qualitative) empirical information from the interviews into numerical formats. As my outcome was binary (migration/non-migration), I employed the crisp-set, binary version of QCA (Schneider and Wagemann 2012). Hence, I defined whether each household was a member in the set of cases where a certain condition was present (1) or not (0). In line with good practices in QCA (Schneider and Wagemann 2012, Schneider and Rohlfing 2013), I developed causal conditions and calibration thresholds in an iterative process of consulting the relevant literature (as outlined in the description of the conditions in the following section) as well as utilizing my in-depth knowledge of the study. Subchapter 2.1 and Appendix A provide further information on this. Following established standards, I limited the analysis to a maximum of five conditions to reduce the number of logical remainders (combinations without empirical evidence) and to avoid the problem of ‘too many variables, too few cases’, which reduce confidence in the results (Marx and Dusa 2011, Ide 2018).

Theoretical assumptions and calibration

For my outcome of interest, a household[10] was categorized as migrating (positive case) if one of the household members left the kebele for at least one month within the last five years, excluding migration for purely marital or educational purposes. This definition was based on information gathered during the household and migrant interviews, given that the shortest migration duration reported was one month, and that migration for exclusively educational or marital purposes was present in two households only[11] (all others had rather mixed motives).

In this section, I present the causal conditions and their directional expectations, which were used to calibrate the original interview data as absent or present for the 42 cases.

i. **Belg-dependent only** *(belgonly)***:** Households that were fully dependent on Belg rain are considered to be more vulnerable to rainfall variability than others, as Belg rainfall amounts are smaller than those in Kiremt, and Belg seasons have become shorter and increasingly variable within the study area (see Figure 2 in chapter 2.1; Rosell 2011). Households that exclusively used Belg rainfall for farming were calibrated as part of this set. Among these households, I expected limited abilities to engage in migration (Gray and Mueller 2012b) since rainfall changes threaten the economic basis of farming livelihoods, especially in areas with limited irrigation infrastructure. However, this tendency could be countered by the strategy of migrating to overcome increasing risks, such as season failures or food shortages (Hermans and Garbe 2019).
ii. **Perceived land size was too small** *(landscarc)*: The household perceived its cultivated land as too small to fulfill the food needs of the household. This condition combined land productivity and land size in relation to the number of household members who depended on the same land resources and does not differentiate between own land and sharecropped land. Hence, all households that described their cultivated land as 'too small' or 'not enough' during the interviews were members of this set. Land scarcity is a well-known driver of out-migration in the Ethiopian highlands (Gray and Mueller 2012b, Morrissey 2013) and it was one of the major reasons to migrate as mentioned in the semi-structured interviews with household heads and returning migrants.
iii. **Migration experience** *(migratexper)*: The influence of kinship ties on migration decisions has long been recognized among scholars (e.g., Brown and Tilly 1967,

[10] A household includes all absent or present members who depend substantially on the same food and income.

[11] The two households with exclusively marital or educational migration motives blur the main solution term when calibrated as a migrating household as shown in robustness test #13 (Appendix A.5).

Choldin 1973, Asfaw et al. 2010). The respondents often mentioned migrated siblings (or other household members) as a strong incentive for leaving. I therefore assumed that existing migrants increased the likelihood that members of the same household would also decide to migrate. A household was part of this set if at least two subsequent migration events (for migrating households) occurred or if the most recent migration event had taken place before 2013[12] (for non-migrating households).

iv. **Non-farm (in-situ) diversification** *(non-farm)*: In regions where people depend strongly on natural resources, they become potentially vulnerable to environmental change and stressors. Many of my interview partners responded that agricultural activities had become increasingly insecure (in particular due to increasing rainfall uncertainty and land degradation), and they had therefore been seeking jobs outside agriculture. I expected that increasing environmental stress and insufficient options for livelihood activities outside agriculture (as is the case for South Wollo) would increase the motivation to migrate to places where these options exist to diversify livelihoods and increase the household income (Stark and Bloom 1985, Asfaw et al. 2010). Consequently, for households having access to non-farm in-situ activities, the need to migrate would decrease. I calibrated households as part of this set if they were involved in at least one of the following activities; daily labor, cultivating eucalyptus trees, or running a small enterprise (which, compared to agriculture activities, play a minor role for the household income).

v. **Kebele has own market and/or asphalt road connection** *(marketroad)*: Having a market close by and/or access to distant markets through paved roads facilitates small business activities and livelihood diversification. Households in remote localities were not part of this set, and I expected that household members in these locations would tend to be more motivated to migrate and to diversify their livelihoods elsewhere to reduce the risks associated with increasing environmental stress (Kniveton et al. 2008, Tegegne and Penker 2016).

The complete dataset that resulted from the calibration process together with a truth table can be found in Appendix A. Once the data were calibrated, I used the fsQCA 2.5 software (Ragin et al. 2014) to test which of the five conditions were necessary or sufficient for explaining the occurrence of migration. If not otherwise stated, I reported the parsimonious solution as it is considered most robust (for more details see Baumgartner and Thiem 2020).

Testing the robustness of the QCA results was crucial for confirming the validity of the results (Skaaning 2011). To do so, I followed the schema developed by Ide (2015), which

[12] Given that a non-migrating household was defined as a household in which no member had migrated within the last 5 years (before the data collection in 2017).

comprises a large number of different tests generally considered adequate in the QCA literature. Specifically, I checked whether the solution was robust to (1) changing consistency thresholds, (2) different inclusion thresholds for the number of cases populating a given truth table row, (3) adding or dropping causal conditions, (4) changing calibration decisions and (5) excluding a group of cases, i.e., potential outliers (see Appendix A for further information). Robustness was indicated if the resulting solution terms reproduced the main solution or showed a sub- or superset relationship.

4.2.2. Conditions determining environment-related migration

First, I detected the potential necessary conditions for migration. Following the established standards, I used the common consistency threshold of 0.9 for assuring necessity. This implies that the respective condition needs to be present in at least 90% of the migration cases (Schneider and Wagemann 2012). The consistencies were measured for the absences and presences of all five conditions and only the absence of *belgonly* passed the respective threshold since 18 out of 20 migrating households (90%) used Kiremt for farming. For the 14 subsequent robustness tests, the absence of *belgonly* exceeded the 0.9 threshold in six tests and remained well above 0.8 in the remaining eight tests (Appendix A). I therefore conclude that the availability of another rainy season for cropping besides the Belg season (hence, the Kiremt season) was a quasi-necessary condition for the migration of household members.

The QCA yielded two sufficient causal pathways for migration (Table 2); first, the combination of migration experience and the absence of full Belg dependency explained migration for 15 out of the 20 migrating households. The second pathway, which had almost equally strong empirical evidence, showed that the combination of migration experience and the availability of non-farm in-situ diversification explained migration for 14 out of the 20 migrating households. The main solution term covered 17 out of the 20 migrating households (85%), implying that overall, it explained 39 out of the 42 cases under study. This coverage indicates a high empirical relevance of my results.

The robustness tests demonstrated the robustness of the main solution terms (*migratexper*(~belgonly+non-farm) → migration*), which were exactly reproduced by 10 out of 15 tests. For the remaining five tests, the solutions showed a sub- or superset relationship to the main solution, meaning that either the robustness test solutions were contained in the main solution term (main solution was a superset of the test solution) or the main solution was contained in the test solutions (main solution was a subset of the test solution). No robustness test provided any results that contradict the main solution. In addition, for all performed tests, the causal pathway containing the main solution had the highest raw coverage, with at least 0.69. All tests performed, including the detailed explanations and respective parameters, can be found in Appendix A.[13]

Table 2: Parsimonious solution term for sufficiency

Solution term	migratexper * (~belgonly + non-farm) → migration	
Solution coverage[14]	0.85 (17 out of 20 cases)	
Solution consistency[15]	1.00	
Causal pathway	migratexper * ~belgonly	migratexper * non-farm
Raw coverage[16]	0.75 (15 out of 20 cases)	0.70 (14 out of 20 cases)
Unique coverage[17]	0.15 (3 out of 20 cases)	0.10 (2 out of 20 cases)
Cases covered	15 out of 20	14 out of 20

* = and + = or ~ = absence of → = sufficient for

4.2.3. Interpretation and consequences of interwoven migration drivers

Land degradation and precipitation variability in the northern Ethiopian highlands curtail the livelihoods of the populations dependent on agriculture and can also be important drivers of migration (e.g., Morrissey 2013). Previous studies in the region have identified that migration is mainly a strategy for diversifying household income sources and reducing the risks of environmental stressors; however, this is very much context dependent (Gray and Mueller 2012b, Morrissey 2013, Wondimagegnhu and Zeleke 2017, Hermans and Garbe 2019). Indeed, the young rural populations in particular articulated strong aspirations in the interviews to live and work elsewhere, given the increasingly harsh environmental conditions for agriculture, the growing scarcity of land, and the few job opportunities in the rural areas. Nonetheless, the circumstances under which some households actually decide to migrate remain unclear. I identified three intertwined contextual factors within the migrating households: the use of Kiremt rainfall

[13] Data that support the findings of this study are openly available on https://osf.io/5tm92/ (DOI 10.17605/OSF.IO/5TM92)

[14] Expresses the degree to which the outcome is explained by the solution term. It is the share of cases that are explained by the solution term.

[15] Expresses the degree to which empirical evidence supports the claim that a set-theoretic relationship [sufficiency] exists. A solution consistency of 1.00 implies that there were no contradictory truth table rows included in the logical minimization process.

[16] Expresses the degree to which the outcome is covered by a certain causal pathway. It is the share of cases that are explained by a certain causal pathway.

[17] Expresses the degree to which a single causal pathway solely explains the outcome. It is the share of cases that are explained by certain causal pathway solely.

(~*belgonly)*, non-farm in-situ income activities (*non-farm)* and migration experience (*migratexper)*. All three conditions are so-called INUS conditions for migration, implying that they are by themselves insufficient to cause migration but in combination become sufficient conditions under which households adopt migration (for more details see Schneider and Wagemann 2012).

The use of Kiremt rain (~*belgonly*) was identified, in addition to being an INUS condition, as the only quasi-necessary condition. From this, I infer that the more favorable environmental conditions in the regions where the Kiremt season is used increase the likelihood of migration. This might be because the Kiremt rain, compared to the Belg rain, is often more favorable for agriculture given its higher and less variable rainfall amounts (Figure 3). In addition, advantageous temperatures during the Kiremt season facilitate crop growth and the implementation of soil and water conservation measures such as tree and grass planting (expert interview, Hurni et al., 2007). Consequently, the Kiremt farmers have a higher agricultural diversity[18] and yield compared to the Belg-dependent farmers. I argue that Kiremt households can derive more stable incomes from their agricultural activities, allowing them to be more likely to accumulate at least small amounts of savings or assets. As a result, their economic resources and their adaptive capacities increases, and thus, their ability to migrate. This is in line with findings from Hermans and Garbe (2019), who revealed that households using the Kiremt rains have significantly more coping strategies available for responding to drought conditions compared to Belg farmers. These findings highlight the importance of mesoscale, agro-ecological features for shaping migration, which have thus far been studied less than household or individual influence factors (but see Tegegne and Penker, 2016).

In contrast to my expectations, the QCA identified the presence of a non-farm in-situ activity as another INUS condition for migration. Furthermore, the second causal pathway revealed that *non-farm* substituted the use of Kiremt (and vice versa) as it could equally cause migration (if *migratexper* was simultaneously present) given the low unique coverage of both pathways. Within the interviewed households, activities such as daily labor (e.g., construction work), small businesses (e.g., tailoring work, running a cafeteria) or the cultivation of eucalyptus trees were reported as supplementary income sources. I infer, that similar to ~*belgonly*, *non-farm* enables the accumulation of income and assets and thus increases the adaptive capacities of the households to deal with (environmental) stressors and thus allow additional flexibility for actions, including migration. However, one may argue that the described causal effect can also be reversed,

[18] Belg farmers focus on a few crops and vegetables types, which are primarily barley, potatoes and cabbage, whereas Kiremt farmers can cultivate wheat, maize, sorghum, pulses, teff and several vegetables.

i.e., migration made it possible to carry out a non-farm activity. This may apply to activities that require seed capital (e.g., small businesses) but apply less to activities such as daily labor or the cultivation of eucalyptus trees (where usually no or very little financial investment is required). Furthermore, the results of the robustness test, in which I excluded small business activities and used only the cultivation of eucalyptus tress*,* showed no significant change to the main solution term, suggesting that my interpretation of the effect direction is more likely (see Appendix A, test #6).

Collectively, the two identified INUS conditions, *~belgonly* and *non-farm*, highlight the relevance of favorable environmental conditions and in-situ livelihood diversification since both can increase the economic resources of a household, which could be used for migration. This implies that migration as adaptation is constrained for those lacking the respective resources – which are predominately the most vulnerable ones – such as the Belg-dependent farmers, or for farmers that have limited access to non-farm activities for reasons such as the remoteness of the kebele or gender or age. The importance of economic resources for environment-related migration has long been recognized, but mainly in the context of long-term and international (costly) migration (e.g., Gray and Mueller 2012a). At the research sites, various migration types in terms of distance and duration occurred, and my identified causal pathways encompassed all of them, implying that the economic resources can enable several types of migration and are not limited as facilitators for long-term or -distance migration. It is still possible, however, that follow-up studies reveal important differences between short- and long-distance/-term migrations not covered by my study.

In addition to the conditions discussed above, my results highlight the central role of migrant networks for migration. *Migratexper* is the only causal condition that is part of both sufficiency pathways, hence indicating its high importance. This aligns with research that has long been emphasizing the importance of social networks for better understanding migration processes (Brown and Tilly 1967, Choldin 1973, Massey and España 1987). Often, scholars have argued that migrant networks reduce the risks and costs of migration (e.g., McLeman and Smit 2006, Doevenspeck 2011). Indeed, when asked about the reasons for choosing a specific destination, the respondents often reported that other family members or close friends already live there and supported them in finding jobs and housing. In addition, several focus group discussions revealed that young people see their migrated siblings or friends with better clothes and mobile phones, and therefore, their own desire to migrate is strengthened. Interestingly, the latter statements exposed another strand of how migrant networks can influence migration: migration depends strongly on the perceptions and the stories that the returnees convey. I thus conclude that migrant networks not only shape the abilities to migrate but also the migration aspirations (cf. Carling and Schewel 2018).

Contrasting earlier studies in the region (e.g., Gray and Mueller 2012b, Morrissey 2013), I identified neither land scarcity nor the lack of job opportunities as migration drivers. While both aspects were mentioned during the interviews with the returnees as motivations to migrate, they were, interestingly, not detected as causal conditions in my analysis. However, the identified main solution highlights the inevitable interconnection between the economic resources of households and the migration networks. Thus, I can infer that migration, from a household's perspective, depends more on the enabling factors than on, e.g., the push factors and is shaped by the presence, perception and experience of other migrants. This is further supported given that the perceived impact of rainfall variability and education level within the household played only a minor role in the robustness tests (see Appendix A).

Despite the rich information and the interesting implications that I derived from the analysis, one should also be aware of its limitations. One of them is that QCA as a method is geared towards explaining outcomes, and is indeed unable to estimate substantive effects or thresholds other than by identifying the prominence in the solution formula. Another one is that I have been unable to gain satisfactory insights into the current state of and recent changes in land degradation and its impact on the livelihoods of the farmers. I believe that the vast majority of the interviewees had biased answers with regard to land degradation because there was little coherence in their responses to yield change, soil erosion and the success of the many soil and water conservation measures in South Wollo. One possible reason for these biases could be the general mistrust of the local authorities by the farmers and their dependence on the support of the local authorities (Rahmato 2009). Another reason for inconsistent responses, which is also relevant for rainfall variability, may have been a mismatch between the measured and perceived environmental changes (Murtinho et al. 2013, e.g., Reyes-García et al. 2016). This may be because of aspects of vulnerability or cultural backgrounds influence local perceptions (for Ethiopian studies, see Meze-Hausken 2004, Rettberg 2010, Adimassu et al. 2014). But while perceptions might differ from measured changes, it is the former on which farmers base their decision and behavior (Hansen et al. 2004, Thomas et al. 2007, Silvestri et al. 2012). Furthermore, my proposed main solution – although the solution coverage was quite high – left three cases of migrating households unexplained (cases 3, 4 and 26). These three cases had in common that the migrants within the household were solely female, whereas in all other households, only men or both men and women migrated. Studies from the northern highlands showed that there are gender-specific barriers for climate adaptation, including migration, associated with differences in roles, responsibilities and access to resources (Gray and Mueller 2012b, Mersha and Van Laerhoven 2016). Although my study did not explicitly aim to analyze the influence of gender on migration, the three unexplained cases suggest that migration evolves differently for women than for men.

Finally, my analysis did not capture migration for less than one month. Although such short-term migrations were not reported during the household or migrant interviews, they still might occur. They are however more difficult to recall, especially for other household members, compared to longer migration and as such could have escaped my analysis.

4.2.4. Implications for on-going scientific debates

This chapter sought to disentangle the drivers of environment-related migration at the household scale by studying a region particularly vulnerable to environmental change: the northern highlands of Ethiopia. I combined the comprehensive data collected during extensive field research via QCA, a novel method in the research field that is well suited to the unraveling complex causal patterns that are inherent to environment-related migration.

In contrast to other studies, I identified neither land scarcity nor the lack of non-farm activities as drivers of migration. Overall, the two causal pathways suggest that migrant networks in interaction with economic resources – either gained through favorable environmental conditions or non-farm in-situ income diversification – are drivers of migration at the household scale. This is so because they can reduce the costs and risks of migration, but also because they influence migration aspirations. Moreover, my results demonstrate that only the interaction of migration networks and either mesoscale environmental factors or household economic factors can sufficiently explain why migration occurred in the migrating households (and why it did not occur in the non-migrating households). From this, I conclude that migration at the household scale is strongly mediated by the ability of a household to migrate (and is not dominated by push factors such as land scarcity or lack of non-farm activities). This contradicts push factor-centered and largely determinist narratives about environmental change and migration (cf. Boas et al. 2019).

Furthermore, my findings offer important conclusions about the most vulnerable households in the areas where only Belg rain can be used for farming. In these areas, households would need to engage in non-farm in-situ diversification activities to be able to migrate. In other words, the absence of an alternative in-situ livelihood diversification option and the unfavorable environmental conditions undermine the pivotal resources necessary for migration. This indicates that limited livelihood options and unfavorable environmental conditions can force people to stay put. The Foresight report (2011) highlighted the issue of 'trapped populations' and stressed that people who are unable to leave are mostly those with the fewest capital assets and staying put contributes to their impoverishment and increases vulnerability.

However, one have to avoid overemphasizing migration as a decision solely dependent on the lack or presence of economic household resources, and one have to be careful in concluding that the absence of these resources necessarily means that people are trapped. My analysis revealed that the perception and experience of other migrants shaped migration decisions as well, and the motives for persistence illustrated that there were several reasons for non-migration, such as strong ties to the place of residence and social dependencies. Thus, a separate analysis of non-migration accounting for factors related to risk and migration perceptions, place attachment and place identity may generate further insights regarding (non-) migration (for more details Adams 2016, Adams and Kay 2019). Nevertheless, from my findings I conclude that migration is an important adaptation strategy in the northern highlands, which, however, cannot be adopted equally among households since it is more contingent on factors shaping migration abilities than on push factors for migration. Thus, I want to stress that more attention should be paid to migration-enabling mechanisms to better understand how to strengthen rural livelihoods and their abilities to choose migration (in the case that they want to) and reduce the risk of trapping people in vulnerable environments.

My multisite approach also enabled me to move beyond household-centered influence factors and to consider mesoscale factors like agro-ecology. Thus, I generated new insights into the influence of the rainy season (and the related agro-ecological features) on the adaptive capacities of households and thus on migration. These findings stress the need to put more effort into incorporating mesoscale migration drivers in future studies to avoid missing important interactions between migration drivers and to enhance our understanding of migration processes.

Finally, I want to encourage scholars in the field of environment-related migration to utilize QCA or other novel methods more frequently to overcome methodological challenges and to fill the still-existing knowledge gaps. The often used qualitative and quantitative approaches for analyzing environment-related migration are limited either in moving beyond extensive case descriptions or in dealing with the multicausal and complex nature of migration processes (Kniveton et al. 2008, Piguet 2010, Neumann and Hilderink 2015). In my study, using QCA allowed me to compare and abstract my in-depth findings from the households to unravel the various ways in which households engage in migration. However, given the binary type of QCA I employed, some of the details were lost in the analysis. The return to my rich interview data, however, provided the content I needed to actually understand how the complex interactions of the three identified conditions enabled households to participate in migration. Thus, in combining QCA with in-depth interviews, multiple causal conditions for migration and the relevance of social and economic (non-) environmental factor interlinkages for the ability of people to migrate were demonstrated. As such, this chapter has illustrated how the gap between qualitative and quantitative research can be bridged to address complex causalities that are necessary for a better understanding of migration processes.

4.3. Investigating environment-related migration processes[19]

Against the background of significant uncertainties, limited data and persisting monocausal narratives regarding the environment-migration nexus in both academic studies and public discourses (Bettini 2013, Hermans and Ide 2019), participatory and interdisciplinary approaches have gained momentum. Recently, approaches such as mobility mapping (Lu et al. 2016, Safra de Campos et al. 2017) and Bayesian networks (BNs) (Drees and Liehr 2015, Andriatsitohaina et al. 2020, Dufhues et al. 2021) have been used to shed light on the complex interactions of migration drivers by also involving the people concerned. This potentially allows mutual learning processes between scientists from different disciplines, practitioners and people affected, and thus, helps to reduce vulnerabilities, support bottom-up decision making and counter monocausal migration narratives.

In this chapter, I build on such approaches by integrating the findings of in-depth qualitative fieldwork and literature-based evidence to develop a BN that depicts subsistence farmers' migration decisions in the context of environmental change in the northern highlands of Ethiopia. BNs allow tackling the complexity and multicausality of environment-related migration in a very illustrative and straightforward way, and hence can serve as a communication tool and can facilitate stakeholder involvement in research processes (Sun and Müller 2013). I used the BN during a stakeholder workshop to discuss my findings and pressing issues of environment-related migration, to study the relative importance of direct and indirect drivers of environment-related migration and to improve our understanding thereof in the northern highlands. Subsequent to this stakeholder workshop, I used the plurality of gained insights to discuss barriers for adopting local policy measures, more explicitly soil and water conservation (SWC) measures that aim to reduce soil degradation – a pressing environmental issue in the region that fuels migration needs of local subsistence farmers. Overall, this chapter contributes to a better understanding of environment-related migration processes, discusses leverage points for reducing migration needs and presents specific methodological recommendations to complement the existing toolkit in the research field.

4.3.1. Development and implementation of a participatory Bayesian network

I performed a participatory approach to derive an increased understanding of the interplay and direction of influential factors that drive environment-related migration.

[19] In a modified version, this subchapter is published as Groth, J., K. Hermans, C. Wiederkehr, E. Kassa, and J. Thober. 2021. Investigating environment-related migration processes in Ethiopia – A participatory Bayesian network. *Ecosystems and People* 17(1):128–147.

My approach integrates knowledge derived from in-depth qualitative fieldwork, academic literature and a stakeholder workshop to develop a BN (for further details see chapter 3.2) displaying migration decisions of subsistence farmers in South Wollo (Figure 9). My analysis focuses on the perception of farmers and stakeholders on the potential influential factors for migration (e.g., perceived level of soil degradation), as studies form the northern Ethiopian highlands showed that perceptions are crucial to understand migration behavior (e.g., Meze-Hausken, 2004; Adimassu et al., 2013; Mekonnen et al., 2018).

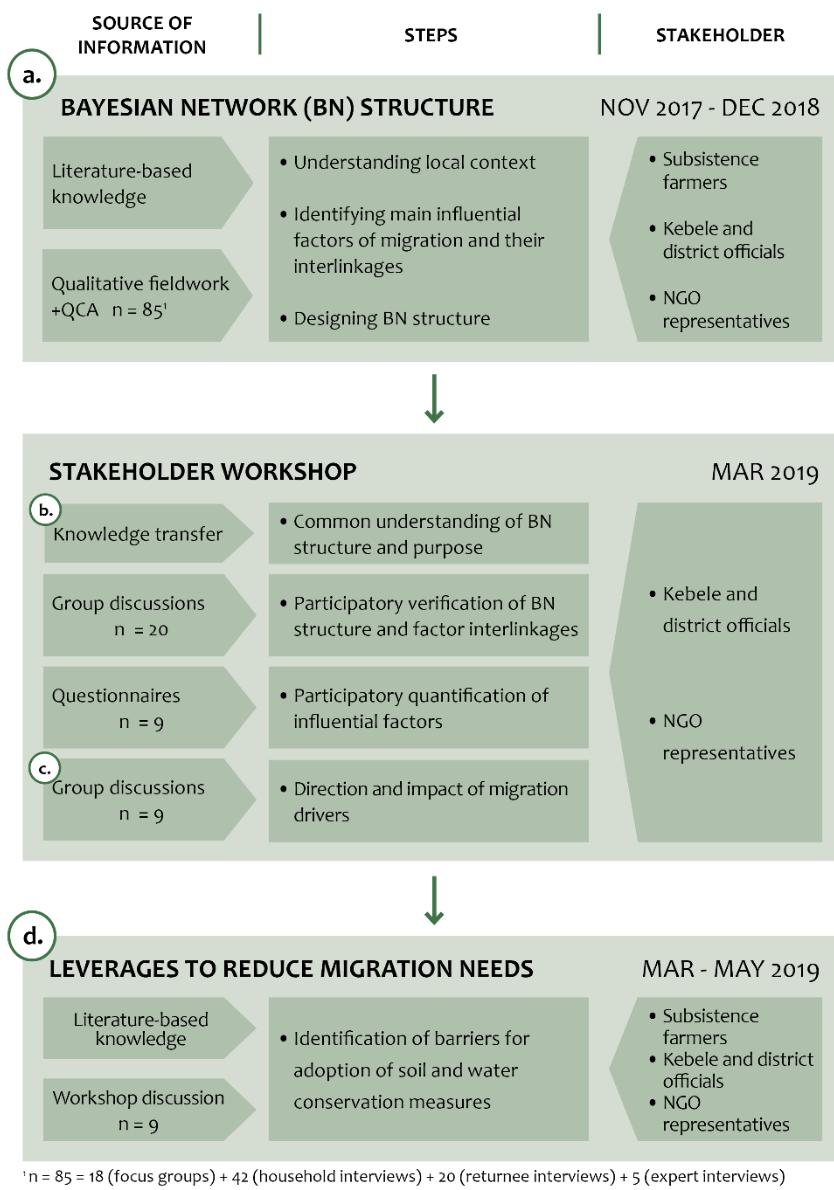


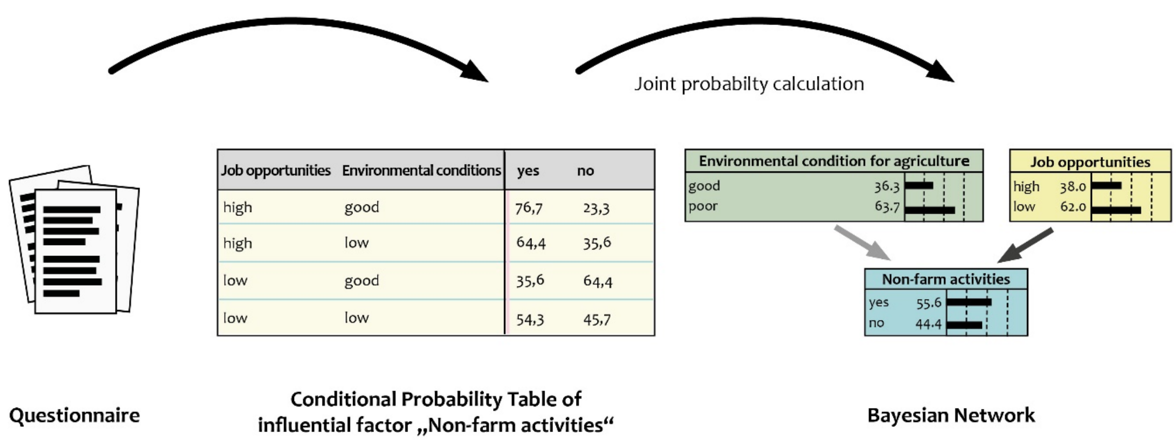
Figure 9: Time horizon, stakeholder participations, information sources and steps of the three phases of my approach. The n represents the number of individuals contributing to the respective step.

Bayesian network structure

To develop the BN structure I first identified potential influential factor for migration based on the results of chapter 4.2 comprising 42 semi-structured household interviews, 18 focus group discussions, five expert interviews and 20 migrant interviews in six kebeles in South Wollo (Figure 2). I combined the influential factors – namely non-farm activities, migration experience in the social network and agricultural production – identified in chapter 4.2, with additional literature-based knowledge from the Ethiopian highlands to develop the BN structure. The BN structure displays which influential factors interact and directly or indirectly influence migration decisions of rural subsistence farmers in South Wollo. Here, I focused on household push and enabling factors of migration for employment or sustenance motives in the context of environmental changes. Push factors for migration are factors increasing migration need, whereas enabling factors increase people's migration ability (e.g., Black et al., 2011; Carling and Schewel, 2018).

Participatory quantification of Bayesian network

In March 2019, our research group conducted a two-day workshop in South Wollo, Amhara, with kebele and district officials (the same individuals who were engaged chapter 4.2) and NGO representatives. During this workshop, I introduced the BN method to the workshop participants to generate a sound understanding of the BN structure and its purpose. At the beginning of the workshop, the BN did not contain any information on the factors' direction or magnitude, neither on the magnitude of the linkages between the factors nor consequently on how they influence migration. Within BNs, the magnitude of linkages between factors is expressed with so-called *conditional probability tables* (CPTs). I used *questionnaires* to determine the CPTs during the workshop (Figure 10). Therefore, each workshop participant received a questionnaire where they had to answer two different types of questions for each influential factor (see questionnaire in Appendix B). The first question for each factor concerned in what state a factor was more likely, dependent on the state of its parent influential factors. For instance, participants were asked if they thought that under good environmental conditions for agriculture and ample (high) availability of job opportunities a household was more likely to be engaged in non-farm activities or more likely not to be engaged in non-farm activities. The second question aimed to quantify the probability for the situation described in the first question by asking how many households out of 10 would be in the situation described in the first question. For instance, if a participant answered that under good environmental conditions and with ample job opportunities 8 out 10 households would engage in non-farm activities, I derived an 80% probability for the described linkage between the three factors. In that way, for each influential factor, each respondent provided a probability for a certain situation to happen. I averaged the responses (probabilities) across all participants for each influential factor and populated the CPTs with this information. In this case, households were engaged in non-farm activities with an average probability of 76.7% if job opportunities were ample (high) and environmental conditions for agriculture were good (and with 23.3% they did not engage in non-farm activities under the same conditions) (Figure 10). As a result, each influential factor has its own CPT based on the participant's responses. I determined the number of questions according to Cain et al. (2001). To avoid biasing participants' opinions, I had the participants fill in the questionnaires on their own. However, this can result in contradictions within one filled-out questionnaires meaning that the participants' answers were not logically related (Cain 2001). I dropped illogical answers and used the average of all remaining answers to quantify the BN. On average, 79% of the answers per question were logical and I hence used them for calculating the conditional probabilities. As a last step, the BN software uses the information of the CPTs to calculate the joint probabilities (Jensen and Nielsen 2007) (Figure 10). The resulting quantified BN indicates the probability distribution of all influential factors depending on their parent influential factors. I neither populated the BN with external data nor validated the BN with subsets of my own data as it is typically done for making predictions (Marcot et al. 2006). In this study, the aim was to use a BN as a communication and learning tool to understand the stakeholders' perspectives. As such, the conditional probabilities displayed in the final BN are fully based on the questionnaires conducted during the workshop.



Job opportunities	Environmental conditions	yes	no
high	good	76,7	23,3
high	low	64,4	35,6
low	good	35,6	64,4
low	low	54,3	45,7

Figure 10: The Bayesian Network's participatory quantification. I used questionnaires to determine the probabilities specified in the Conditional Probability Tables (CPTs). CPTs express the magnitude of the linkages between influential factors. Each row in a CPT determines the probability that a factor (e.g., non-farm activities) is in a certain state (e.g., yes) depending on the state of its influential factors (e.g., if job opportunities are ample (high) and environmental conditions are good, then 76.7% of the households are engaged in non-farm activities). The joint probabilities were calculated based on the CPTs by using Netica (Norsys Software Corp. 2019).

Direction and impact of migration drivers

The resulting quantified BN illustrates the directional influence and the relative importance of the migration drivers as perceived by the workshop participants. Finally, I used the quantified BN in the workshop as a communication facilitator to visualize and discuss the impacts of the changes in influential factors on migration. To complement this, I ran *sensitivity analyses* of the quantified BN to assess the extent to which the factors influence each other. In particular, I used the sensitivity measure entropy reduction as provided by Netica (Norsys Software Corp. 2019). The higher the entropy reduction of factor B due to information of factor A, the higher is the influence of factor A on factor B. In other words, the more sensitive is factor B toward factor A. I differentiated between three levels of influence, given that my BN is limited to a maximum of three influential factors per variable. The most influential factor is the one that caused the highest entropy reduction and the least influential factor is the one that caused the lowest entropy reduction (see Figure 12).

Leverages to reduce migration needs

I used the insights from the stakeholder workshop as a basis to discuss entry points and barriers for local policy measures to address pressing environmental issues and reduce migration needs in South Wollo. I focused on soil degradation because the BN had identified it as one of the most important factors influencing migration. In this chapter, I discuss the barriers for subsistence farmers to adopt SWC measures – one of the most important local policy measure to address soil degradation in South Wollo – and conclude with recommendations for action based on the plurality of stakeholder perceptions.

Figure 11: Break-out groups during the stakeholder workshop. Photos: J. Thober

4.3.2. Interpretation of the quantified Bayesian network on environment-related migration processes

Interlinkages of migration drivers

In this chapter, migration was defined as the decision to leave one's household for more than one month, excluding migration for purely educational or marital purposes. The direct and indirect influential factors I included in the BN can be categorized into four different groups: environmental, livelihood, household opportunities and social factors (

Table 3 and Figure 12). Being aware of the multicausal nature and complexity of migration decisions, I had to limit the number of possible influential factors and their states to allow for meaningful discussions during the stakeholder workshop. In the following section, I describe the assumed interlinkages between the migration drivers for the BN structure and their potential directions. For selected interactions, on which the literature-based evidence lacks consensus, I describe two possible directional influences. I use the BN quantification from the workshop to understand the mixed evidence on the directional influence of migration drivers rather than specifying the directional influence in the BN prior to the workshop (see section 4.3.1).

Figure 12 shows the developed BN on migration drivers. Starting from the center of the network, agricultural production is a direct influential factor for migration given its central role for the livelihoods of subsistence farmers in South Wollo. Agricultural production covers cropping and keeping livestock at the household scale. I assumed that whether the agricultural production is sufficient to fulfill the household's subsistence needs affects migration decisions, as earlier studies confirmed (e.g., Tegegne and Penker 2016). However, the influence's direction on migration can be contrasting. On the one hand, if a household cannot fulfill its food demand by agricultural production, household members might choose to migrate to diversify their income activities elsewhere to fulfill the household's needs. On the other hand, insufficient agricultural production can reduce the households' economic resources and as such can also inhibit migration (e.g., Gray and Mueller, 2012).

Agricultural production itself is influenced by several factors, including the availability of agricultural technologies and loans (Asfaw et al. 2010). In addition, I accounted for the severe and increasing land scarcity, which hampers the agricultural production of farmers in South Wollo (Meshesha et al. 2014) by including land availability as another influential factor of the agricultural production. Land availability is measured as the ratio of land size (including owned, rented and sharecropped land) and household members. The third influential factor of agricultural production is the condition of the environment, which accounts for a combination of soil degradation, precipitation variability and the type of rainy season used for cropping. First, soil degradation, which is mainly driven by soil erosion due to mismanagement and/or natural hazard, results in the soil's reduced capacity to provide goods and services for human well-being, including food and fodder. Second, precipitation variability, which comprises the fluctuation of rainfall patterns from year to year, including fluctuating season duration, start and end dates and rainfall intensities or amount of rainfall, adversely affects agricultural production. The third environmental condition is the rainy season and I distinguished between Kiremt and Belg season, given their different levels of variability and influence on agricultural production. In principle, a household that uses the Kiremt season for cropping can rely on more stable and higher rainfall amounts than a household that solely depends on the Belg season. As such, households using the Kiremt rains usually have more options for crop diversification and are more likely to produce more food and fodder as compared to a household that exclusively uses the Belg season.

Besides agricultural production, non-farm activities are central for the livelihoods in rural South Wollo and directly influence migration (chapter 4.2). I argue that if a household's agricultural production is restricted by adverse environmental conditions, the household will look for non-farm activities such as wage and daily labor to fulfill its needs. This may increase a household's financial resources and thereby motivate a (costly) migration decision (chapter 4.2). Engaging in non-farm activities is itself influenced by employment opportunities in the place of residence and differs among localities due to distance to roads, markets and cities.

The final group of migration drivers in the BN accounts for social factors influencing migration decisions. Whether one opts for or against migration is related to one's personal attitude, including norms and opinions regarding migration (De Jong 2000). Here, I considered two factors as identified from the literature and my fieldwork that mainly drive this attitude: migration experience within one's social network and social norms within the village communities. Migrating family members can be strong incentives for migration, since they tend to reduce migration risks and costs and enhance migration desires (McLeman and Smit 2006; chapter 4.2). Nevertheless, whether migration as an accepted strategy within a community strongly mediates migration decisions (e.g., Martin et al. 2014). For instance, if the community views migration as a chance to 'improve life' and a person has a family member living outside their own community, migrating to this region may be considered preferable.

During the stakeholder workshop, I used break-out groups to let the participants discuss the BN structure and to add or delete influential factors respectively. In general, the participants strongly agreed with my proposed BN structure (see Appendix B).

Table 3: Definition and states of BN influential factors (for more details see Appendix B)

Factor	**Definition**	**States**
Soil degradation	Reduced capacity of the soil to provide goods and services for human well-being mainly driven by soil erosion, i.e., the loss of topsoil and nutrients. Soil erosion can be caused by natural hazards such as intensive rainfall and/or by land mismanagement.	Low / High
Precipitation variability	This factor covers one or more of the following aspects: fluctuating season duration, start and end dates of rainy seasons, rainfall intensities or amount of rainfall.	Low / High
Rainy season	Rainy season used for cropping activities.	Belg / Kiremt / Both
Environmental condition for agriculture	A measure of agricultural suitability, it comprises soil degradation, precipitation variability and which rainy season(s) are/is used for cropping.	Poor / Good
Availability of technologies	Availability of technologies such as SWC measures (e.g., terracing, composting, check dams, shrubs), agricultural inputs (e.g., fertilizer) and loans.	Yes / No
Land availability	The ratio of land size (including owned, rented and sharecropped land, and cultivated land) to the number of household members.	Low / High
Job opportunities	The chances for household members to find work besides cropping and keeping livestock. This is determined by the remoteness of the place of residence, i.e., distance to the next street or market, as well as the access to and the labor market demand, i.e., distance to the next big city.	Low / High
Agricultural production	Amount of agricultural products produced by the household. This includes cropping and livestock farming, but not forest products.	Not-sufficient / Sufficient
Non-farm activities	The household activities that are beyond cropping and keeping livestock such as wage and daily labor (e.g., construction work), running a cafeteria and growing/selling eucalyptus trees.	Yes / No

Personal attitude toward migration	The opinion and beliefs of a person regarding migration. This depicts whether the person thinks of migration as something desirable or something to avoid.	Positive / Negative
Social norm	The village community's informal understanding of migration. This depicts whether the members of the village community see migration as something desirable or something to avoid.	Positive / Negative
Migration experience in social network	The access to the migration experience of family members, neighbors or friends.	Available / Not available
Migration	This comprises out-migration from rural South Wollo to rural or urban destinations. It includes short-term/-distance (e.g., seasonal migration to nearby towns) and long-term/-distance migration (e.g., to Saudi Arabia) of a household member (for at least one month, excluding migration for *purely* marital and educational attainment).	Yes / No

The state and impact of migration drivers

Based on the questionnaires, I first quantified the current state of soil degradation, precipitation variability, use of rainy season, land availability, availability of technologies, job opportunities, social norm and migration experience in South Wollo. Second, I quantified the conditional probabilities, i.e., the probability of an influential factor being in a certain state given the states of their parent influential factors (e.g., the probability of having good environmental conditions for agriculture under the condition that soil degradation is high, precipitation variability is low and the Belg season is used for cropping).

The BN shows that the environmental conditions for agriculture are currently in a poor state. Soil degradation and precipitation variability are both high for the majority of households in South Wollo, with more than 20% of households exclusively relying on the small Belg rainy season. I also see limited livelihood opportunities for households given low land availability and few job opportunities for the majority of households. Technologies such as SWC measures and agricultural inputs are available to about 50% of households in South Wollo. Furthermore, I found that nearly three out of four households have access to migration experiences via their social network and that migration is seen as desirable by 60% of the village communities.

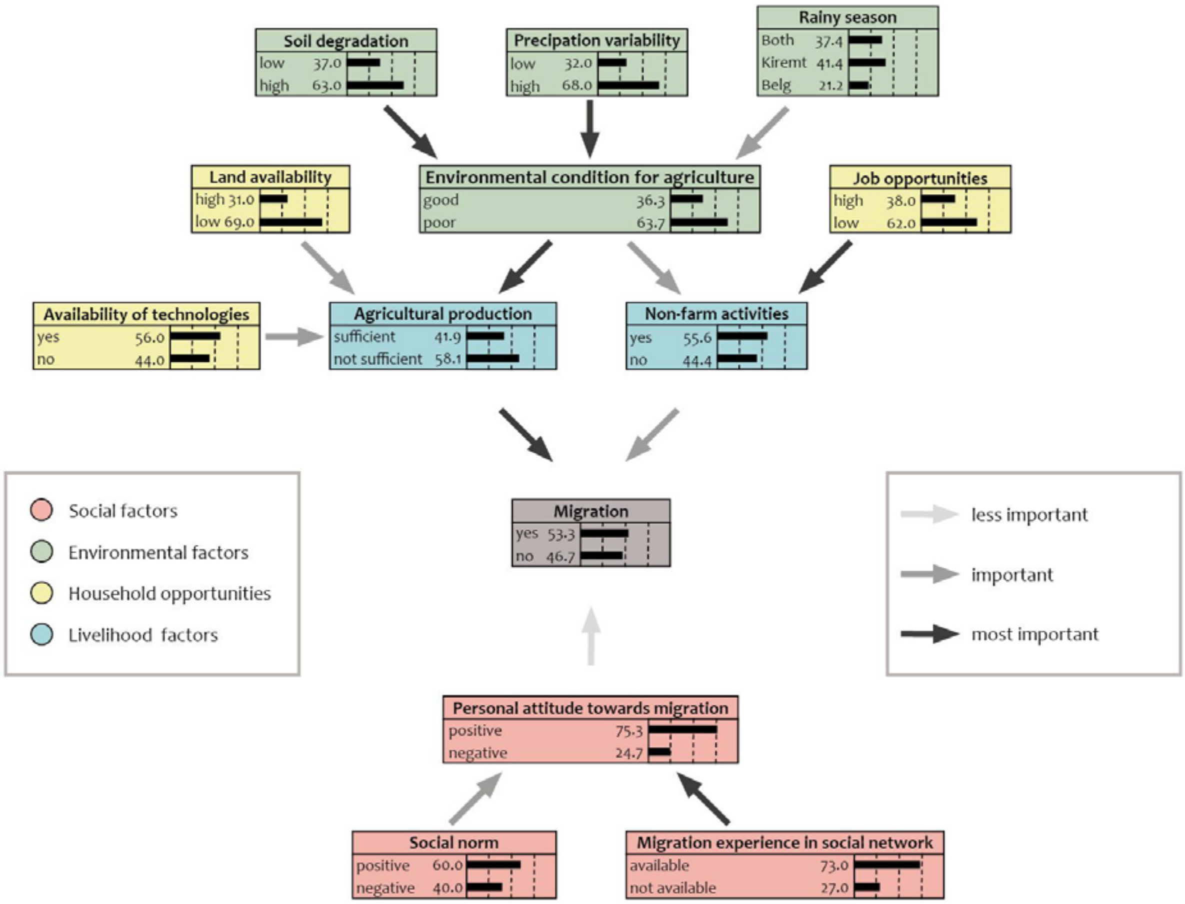


Figure 12: The Bayesian network of the current state of environment-related migration of subsistence farmers in South Wollo. The numbers beside the states represents the percentage of households that are in the respective state. The horizontal bars visualize these percentages. The color of the arrows indicate the relative importance of one influential factor (parent node) on another influential factor (child node) based on the sensitivity analysis.

The quantified BN shows in which direction factors influence migration, their relative importance and their interlinkages (Figure 12 and Table 4). The sensitivity analysis with Netica – which is used to study the influential factors' relative importance on migration – showed that the sufficiency of agricultural production most strongly influenced migration. Presumably, low agricultural production increases migration because migration pressure is high with low availability of food and income from agriculture. Agricultural production in turn is highly influenced by the environmental condition, which is adversely impacted by high precipitation variability and high soil degradation. This is highlighting the agricultural channel via which climatic changes often influence migration (Falco et al. 2019). Compared to soil degradation and rainfall variability, the stakeholders ranked lower the rainy season's impact on the environmental condition. This might have been caused by the fact that numerous participants considered this to be part of the rainfall variability factor, given that seasons are determined by their variability and amount of precipitation. Furthermore, the impact of the availability of technologies on agricultural production was low. This is likely caused by households' lack of adopting technology, by inappropriate design or application of these technologies or by the overriding impact of the environment's condition, e.g., terracing cannot compensate for an extremely deteriorated environmental state. Moreover, the state of land availability only minimally influences agricultural production. This somehow contrasts other studies that indicate land scarcity is often a strong migration driver in the northern highlands (Asfaw et al. 2010, Gray and Mueller 2012b, Morrissey 2013). However, in those studies, land scarcity was often described as direct motivation to migrate especially for landless young people in the rural areas. Yet, in my BN, land availability is an indirect influential factor that impacts migration via agricultural production (Falco et al. 2019). This missing direct link to the migration decision is likely to cause the lower than expected influence. Furthermore, land availability's impact is overridden by the current poor state of the environmental condition, i.e., the land holding size under deteriorated environmental conditions does not matter substantially.

Moreover, migration decisions are – although to a lower extent – driven by household members' engagement in non-farm activities, which in turn is strongly dependent on the availability of job opportunities. According to the BN, adverse environmental changes increases non-farm activities possibly because the higher need for additional income sources given the poor environmental conditions and hence the insufficient agricultural production. The results suggest that non-farm activities lead to an increase in migration. This contradicts Meze-Hausken's (2000b) findings, who mentioned that non-farm activities could also alleviate the migration pressure and showed that households 'with more survival strategies tend to resist distress migration longer than those having only few survival strategies' (Meze-Hausken 2000b). According to my results, migration is caused by either the increased migration ability due to more economic resources and/or by the higher migration pressure caused by insufficient agricultural production.

Finally, the results show that under sufficient agricultural production, an increase in non-farm activities reduces migration. I argue this is due to the overall low migration need and because people might have little aspirations to migrate when they have a job. That way, non-farm activities are not an enabling factor as under insufficient agricultural production, but rather become a 'bonding factor'. However, if non-farm activities are reduced, the especially younger household members start to search for job opportunities elsewhere, despite the sufficient agricultural production, and consequently, migration increases. This assumption is based on the interviews conducted during the empirical field work showing that younger people in rural South Wollo have strong aspirations to work elsewhere. It is also in line with Bezu and Holden's

(2014) findings, who showed that the Ethiopian youth have minimal interest in a rural livelihood and thus, rural-urban migration is very common among them.

Overall, the BN revealed no clear-cut relationship between environmental factors and their influence on migration, which illustrates their complex dynamic. Nevertheless, I can conclude that environmental changes – in particular increasing soil degradation and precipitation variability – increases migration, either through high migration needs due to low agricultural production and/or through increased non-farm activities that enable migration through financial means. This supports findings that migration can be both a risk-coping strategy for poor households and an asset-accumulation strategy for better-off households (e.g., Asfaw, Tolossa and Zeleke, 2010).

Compared to the sufficiency of agricultural production and the engagement in non-farm activities, the personal attitude has little influence on migration. Hence, the importance of social factors highlighted in the literature (e.g., Brown and Tilly, 1967; de Haas, 2010) was not reproduced with my BN, most likely due to uncertainties regarding the definition of migration. The workshop revealed the challenge to generalize migration connotations as this strongly depends on the type of migration (i.e., internal, external, legal, illegal). This explains stakeholders' vague and diverging answers, and consequently, the impact of the personal attitude on migration is little in the BN. Another reason for this low impact could be that households sent family members away to reduce livelihood risks. The greater the pressure on a household, the less it matters whether an individual family member perceives migration as an opportunity or a risk. Nevertheless, my results show that the individual perception of migration is positively influenced by the migration experience available in the household's social network. This is in line with findings that examined the positive influence of network effects and information flows on migration, arguing that migrant networks reduce migration's risks and costs (e.g., Asfaw, Tolossa and Zeleke, 2010; Bylander, 2015; Wondimagegnhu and Zeleke, 2017). Finally, the impact of the village community's informal understanding of migration on a person's migration perception is rather small in the BN. Again, this is partly caused as the migration experience's impact overrides the village communities' understanding, i.e., if there is a migration experience in the social network, the village community's opinion influences the individual perception less strongly than without a migration experience available.

Table 4: Impact of influential factors on migration in the quantified Bayesian network as based on the participants' answers.

Influential factor	Impact on migration	Likely explanation
Insufficient agricultural production	Increase	If the household cannot fulfill its needs by agricultural production, household members might migrate to earn additional income to fulfill the household's needs.
Household members engaged in non-farm activities	Increase	Performing activities beyond cropping and keeping livestock, such as selling eucalyptus, might affect a household's financial resources and thereby enable migration.
Positive personal attitude toward migration	Increase	The personal attitude directly influences migration decisions.
Factor interactions		
Under the condition of sufficient agricultural production, an increase in non-farm activities leads to less migration	Decrease	If the household has a sufficient agricultural production and is engaged in non-farm activities, the migration need is low and household members are tied in South Wollo and thus, have fewer incentives to migrate. If engagement in non-farm activities decreases, people might start to search for job opportunities elsewhere and consequently migration increases.
High soil degradation	Increase	High soil degradation leads to poor environmental conditions for agriculture. Poor environmental conditions a) lowers the agricultural production and b) increases non-farm activities. The latter occurs mainly because of higher needs for additional income sources to compensate low agricultural production rates. Together, a high soil degradation increases migration needs.
Ample job opportunities in South Wollo	Increase	Increases non-farm activities, which enables migration

4.3.3. Leverages to reduce migration needs in South Wollo: Soil and water conservation (SWC) measures

I used the BN to discuss major migration pathways with the participants during the workshop and the possibilities for local policy measures to reduce livelihood risks in South Wollo. Results of my sensitivity analysis show that agricultural production is the major driver of migration, which in turn is mainly driven by precipitation variability and soil degradation (see Figure 12). The workshop discussions confirmed that declining agricultural production rates are posing increasing risks for farmers and, combined with limited job opportunities in rural South Wollo, increasing subsistence farmers' migration needs. Stakeholders agreed that local measures to circumvent or adapt to the increasing fluctuations in precipitation are limited, whereas possibilities for combating soil degradation are considered more promising. SWC is a common approach of locally implemented measures – including biological measures such as tree planting or grass strips and physical measures such as check dams – to rehabilitate degraded soils, foster sustainable land management and improve agricultural yields in Ethiopia by involving the entire community in implementing the respective measures (Bewket 2007, World Bank 2014, Haregeweyn et al. 2015). Institutionalized SWC efforts were introduced in the early 1970s in Ethiopia and since then large programs, such as the Food-For-Work (1973–2002) and the National Sustainable Land Management Project (SLMP) (2008–2018) were initiated with various donors' support (Haregeweyn et al. 2015). However, despite these enormous efforts, several barriers that hamper farmers' adoption of SWC measures exist. Here, I draw on the plurality of the workshop participants to discuss adoption barriers, which need to be addressed to secure livelihoods and reduce migration pressure for subsistence farmers in South Wollo.

The workshop participants highlighted the *lack of information and awareness* regarding soil degradation and related SWC efforts as one of the major barriers for SWC adoption. They emphasized that awareness-raising has to be the core objective to enhance SWC, e.g., with establishing demonstration sites within the communities. Wordofa et al. (2020) recommend to focus SWC efforts on the better experienced farmers and use those with larger plots as model farmers to demonstrate SWC measures. These demonstration sites can help to scale up SWC and therewith, increase adoption rates of the less-experienced farmers, step by step.

As a further hurdle, the workshop participants mentioned the *lack of resources*, especially financial ones, to afford materials, e.g., to build terraces and check dams. Non-farm activities and loans for subsistence farmers, e.g., to start small-businesses, could increase the financial means of subsistence farmers and thus, constructing SWC structures. However, my BN revealed that for 62% of the households in South Wollo, job opportunities are rare (see Figure 12). Moreover, the lack of jobs and income is not only a hurdle to build SWC measures, but also they increase migration needs as they hinder the diversification of income sources to compensate for deficits in agricultural production. In addition, limited financial means in principle reduce people's capabilities to engage in costly migration, which in turn increases the risk of becoming trapped in vulnerable environments (cf. chapter 4.2). Consequently, creating income sources is critical to a) reduce migration needs, b) enable investments in (durable) SWC measures and c) increase agency in migration processes.

Further, a *lack of institutional support* from extension agents reportedly hampers implementing SWC measures, which confirms earlier findings (Tefera and Sterk 2010, Adimassu et al. 2013). Extension agents are overwhelmed with the workload that comes along with the participatory and integrated watershed development approach. Improved financial and human resources, as well as practical and communication skills, are therefore needed to enable extension agents to effectively support rural communities in implementing SWC measures (Belay and Abebaw 2004).

Land tenure insecurity was another factor identified as favoring soil degradation as it arguably reduces smallholders' incentives to increase efforts to conserve soils. This is in line with Gebremedhin and Swinton (2003) and Bewket (2007) who observed its negative influence on adoption, given that insecure and short-term use rights are less likely to motivate durable but more costly measures compared to long-term use rights. This suggests that securing tenure for farmers, e.g., increasing land transferability, enhances sustainable land management (e.g., Ali, Dercon and Gautam, 2011).

A similar issue was raised regarding the *inappropriateness of SWC measures* to the local conditions. The stakeholders mentioned that promoted activities such as compost or grazing restrictions are often not feasible for farmers, given the lack of materials (plant residues, cow dung) and the knowhow to produce compost or alternative grazing land for their livestock. In a region where rural livelihoods are under constant pressure, through e.g., food insecurity and population pressure, grazing restrictions should be used very carefully. If restrictions are enforced, they need to be complemented with options for livelihood diversification, for instance with cut and carry systems where farmers have access to the closed areas for collecting fodder. Bewket (2007) also mentioned SWC measures' inappropriateness and found that the design of some measures was too narrow and hindered the ploughing activities, or that measures were simply too land- and labor-consuming. My results show that 69% of the households in South Wollo face land scarcity (Figure 12), making well-designed and less land-consuming measures even more relevant.

Another major barrier, though not discussed during the workshop, is the *lack of labor* to implement and maintain SWC schemes. Several scholars showed that farmers are less inclined to build and maintain labor-intensive schemes – especially in insecure tenure systems – when these measures' benefits emerge in the long term (Adimassu et al. 2013, Nigussie et al. 2018). In addition, the participants raised the issue of farmers *lacking trust* toward the government, given the government's *top-down approach* to promote SWC. The top-down implementation is also widely criticized in the literature (Haregeweyn et al. 2015, Nigussie et al. 2018). Insufficiently integrating local and place-specific knowledge greatly hinders accepting SWC, which in combination with other barriers ultimately hampers sustainable implementation and adoption of SWC measures.

Lastly, there is a fundamental *contradiction between the measures to combat soil degradation and the government's agricultural input packages,* which promotes intensifying agriculture, for example through frequent ploughing, and applying artificial fertilizers and pesticides. Workshop participants mentioned that these practices often succeed to increase farmers' yields in the short term, but also have a high potential to increase soil degradation in the long run, which Taddese (2001) confirmed. My results show these unsustainable practices increase long-term migration needs as well. Thus, first and foremost, the contradictions in government programs must be urgently resolved to achieve sustainable and integrative land management.

4.3.4. Methodological reflections

The stakeholder workshop benefited from the combination of different workshop formats, such as presentations, group discussions, questionnaires and plenary discussions to encourage all participants' active involvement. Furthermore, through an intensive and continuous collaborative place-based research in the study area throughout recent years, we established a trustful relationship between workshop participants and our research team, which is essential for a successful workshop.

Overall, the participants' understanding of and agreement with the BN were high. Likely reasons for this were (a) the careful design process of the BN based on insights from extensive fieldwork in the region embedded in scientific literature and (b) the well thought-through knowledge transfer of the BN method and the research insights in the frame of the stakeholder workshop in which participants were encouraged to provide feedback. Yet, despite the open and interactive workshop atmosphere, there was limited criticism on the methods and findings, which was likely the result of cultural norms and the new method introduced. A possible strategy to counteract this in the future is to provide options for anonymous feedback.

Quantifying the BN's conditional probabilities, i.e., how a change in one influential factor is affecting another influential factor, was hampered by diverging answers across stakeholders and by ontological uncertainty. This includes mainly stakeholders' difficulties in estimating the impact of factors on other factors, resulting in vague answers with equal probabilities for all states of the influential factor (cf., Salliou et al. 2017). Other scholars encountered similar challenges during participative developments of BNs, for example, the high variance in expert judgements (Kleemann et al. 2017) and the tendency for giving answers around the mean attributed to 'insufficiently detailed or simply a general problem in questionnaire-based surveys' (Celio and Grêt-Regamey 2016). In this case, the workshop discussions revealed varying notions of the migration term. Most important, the locals' perception of migration largely depends on whether participants had international, internal or both migration forms in mind. International migration was connoted rather negatively and internal migration rather neutrally, depending on whether it was perceived as a common livelihood strategy, as a 'last resort' or as an illegal and risky activity for farmers. Together, this challenged being able to quantify the social influential factors, resulting in a low impact of the influential factors personal attitude and social norm on migration. Such challenges can be minimized by expanding the workshop and thereby supporting (a) a common understanding of terms and concepts in an interactive way and (b) active engagement of all participants to handle diverging answers. Hurdles for participants may further be reduced through one-on-one interviews, such as Kleeman et al.'s (2017) implementation, rather than group discussions, although they are potentially prone to biases and are time-intensive.

Overall, the BN method was a valuable communication tool for visualizing the complex interplay of migration drivers. The BN facilitated group discussions and thereby enabled me to derive an improved understanding of environment-related migration in South Wollo. By comprising various levels of factors, BNs allow delineating the indirect influence of various environmental change factors and assessing their relative strength as crucial migration drivers. For future endeavors, the presented BN could be further developed, e.g. by involving a larger number of participants and applying model testing and validation to use it as a tool for local decision-making in South Wollo (Marcot et al. 2006).

4.3.5. Implications of the findings and approach

My analysis shows how slow-onset environmental changes in South Wollo influence livelihoods and migration dynamics mainly through agricultural production. In particular, perceived increases in precipitation variability and soil degradation enhance migration, either through increased non-farm activities, which enable migration through economic resources, or through insufficient agricultural production, which increase migration needs. Based on my quantified BN and the discussions with the stakeholders, I found that a major leverage to reduce livelihood and migration pressure is to improve the adoption of SWC measures. I found that a couple of factors – including the top-down approach of implementing SWC measures; the non-integrative implementation of inappropriate, labor-demanding and foremost physical SWC measures; the lack of resources at the responsible institutions combined with contradicting governmental programs – hinder sustainable land management in South Wollo, which in turn increases migration need. I conclude that to be effective, the design and implementation of SWC measures require active engagement of local extension services, farmers and rural communities. Without considering farmers' perspectives and knowledge, SWC measures most likely fail, potentially fueling migration. However, to increase farmers' acceptance and trust requires improving the socioeconomic boundary conditions: My results suggest that securing long-term land use rights, reducing the overall pressure on land resources (e.g., through diversification of livelihoods, integrated SWC measures) and aligning and maximizing synergies between government strategies and programs, are essential to achieve sustainable and integrative land management.

The presented approach illustrates that participatory BNs are suitable to engage stakeholders in research processes and to derive recommendations for actions, which should account for these stakeholders' needs in the end. In addition, BNs have the potential to be used as supportive tools in decision-making processes, for example by advising local decision-makers on how to foster livable futures for their communities. I conclude that participatory approaches and stakeholder involvement requires a) a well-anchored host in the respective region, b) a trustful relationship between the research team and the participants, c) interactive workshop formats to facilitate discussions and feedback, d) a sufficient timeframe to discuss and develop a common understanding of the central terms or to conduct a follow-up workshop to discuss diverging answers and open questions and e) in-depth information on the topic and the region gained either through intensive literature reviews or empirical research. In its entirety, my approach allowed for integrating a wide and heterogeneous knowledge spectrum to tackle a societally relevant and demanding issue.

5. EVIDENCE FROM RECEIVING AREAS: MIGRATION TO THE SOUTHWESTERN ETHIOPIAN RAINFORESTS

Every year, approximately 13 million ha of forests is lost worldwide, with the highest forest loss rates in the tropical regions of Latin America, Southeast Asia and Africa (FAO 2020). Such forest decline and degradation pose a risk to those who depend on forest resources. In the tropics, the rural poor heavily rely on forest resources such as wood, medicine or food to meet their subsistence needs (Angelsen et al. 2014, Wunder et al. 2014). Migration-induced population growth is often considered an important underlying cause of tropical deforestation and degradation, primarily because a growing population increases the demand for fuelwood, timber and agricultural land (e.g., López-Carr and Burgdorfer 2013).

Research on in-migration-environment linkages is mainly concerned with the question of whether migrants are 'agricultural colonists' or under what circumstances migrants become 'exceptional resource degraders' (e.g., Codjoe 2006, Codjoe and Bilsborrow 2012). An increasing number of studies show that the impacts of in-migration on the environment are highly context-dependent and thus, cannot confirm simplified explanations about the linkages between migration and environmental degradation (Zommers and MacDonald 2012, Jones et al. 2018). Non-demographic factors at various spatial scales, such as socioeconomic household characteristics or institutional settings (e.g., resource access mechanisms or land tenure security), are supposed to be crucial in mediating the influence of in-migration on natural resources (e.g., Unruh et al. 2005, Caviglia-Harris et al. 2013, Tadesse et al. 2016, Hermans-Neumann et al. 2016). Further, there is evidence that the level of migrant integration, the migrants knowledge of the local contexts and interaction with the local (host) communities influence their use of natural resources (Cassels et al. 2005, Codjoe and Bilsborrow 2012, Hartter et al. 2015). Yet, detailed empirical insights into the influence of migration on traditional livelihood practices of local communities at tropical forest frontiers and the interaction between locals and migrants, e.g., the exchange of livelihood practices and local knowledge, are lacking. Besides population dynamics, macroeconomic forces such as large-scale land acquisition (LSLA), considered as major non-demographic drivers for deforestation (e.g., Rudel et al. 2009, Magliocca et al. 2020) and can add substantial pressure on the local natural resource base and consequently on natural resource-dependent livelihoods at forest frontiers (Cotula 2012). Moreover, it has been shown that LSLA affect the land use of surrounding smallholders and thus indirectly contribute to environmental degradation, for which migrants are often blamed (Zaehringer et al. 2021).

Consequently, this chapter aims broadening the current scope of migration-degradation analysis by assessing the linkages between in-migration, resource use and the livelihoods of local communities. I focus on rural in-migration of land-seeking smallholders to tropical forest frontiers, as this migration type increases the demands for agricultural land potentially at the expense of forest and thus likely influences forest-dependent livelihoods. Therewith, I acknowledge smallholder in-migration as contributing factor to livelihood and related resource use transitions in receiving areas; yet, I aim to challenge the assumption that it alone and necessarily leads to environmental degradation.

In this chapter, I aim to understand how in-migration, together with non-migration related factors, influences livelihood transitions and deforestation in the southwestern rainforests, in particular the Guraferda district (details on the study area are provided in chapter 2.2). Against what I delineated in chapter 2.2, I hypothesize that in-migration in Guraferda has contributed to the reduction of the forest-based livelihoods of local people through two main pathways. First, I hypothesize that migration contributed to forest loss through increased demand for cropland and increased clearing activities by migrants and that the resulting reduced forest availability hampered traditional forest activities. Second, upon arrival, migrants continued and spread their 'new agricultural practices' from their origin – Ethiopia's open highland landscapes. As a result, cropland expansion and increased agricultural activities gradually replaced forest activities. Third, I hypothesize that the two former pathways between in-migration, reduced forest activities and forest cover loss are influenced by changes in governmental policies related to forest access and land tenure.

5.1. Data collection and quantitative analysis

Selection of research sites

During a preparatory visit in February 2018, district and kebele officials were interviewed to gather information on land use change and in-migration for several districts and kebeles in the Bench Maji zone. Based on this information, I selected three kebeles in Guraferda district for in-depth research to increase my sample variation regarding in-migration and resulting population composition, remoteness, institutional settings and forest availability and loss (Table 5).

Data collection

Between January and March 2019, I conducted in-depth fieldwork, supported by five local enumerators who received training prior to the fieldwork. The data collection was mainly conducted in Amharic, but a few interviews required additional translation to the local languages. In each kebele, the data collection started with one group discussion with local officials and leaders to obtain an overview of the specifics of rural livelihoods, kebele infrastructure, population dynamics, land cover, forest product use and forest institutions. In addition, the discussions were crucial to build trust and gain access to the communities under study.

Table 5: Characteristics of the three research sites in 2018. Data obtained during focus group discussions and from statistical records of the kebeles and Guraferda land administration office.

Kebele	Total population	Locals	Northern	Southern	Year-round road	Distance to local market	PFM	Loss of forest area † 2003 – 2018	Forest area† in 2018
Alenga	4695	5%	70%	25%	Yes	7 km	Since 2017	1191 ha (68.4%)	549 ha
Semerta	2444	7%	25%	68%	None	17 km	Since 2011	425 ha (22.5%)	1468 ha
Gelit	1522	25%	50%	25%	None	20 km	None	1316 ha (100%)	0 ha

† forest which is accessible for kebele community (excludes forest transferred to private investors and where access is restricted for kebele community)

After the group discussions, I conducted household surveys – which were adjusted during a pretest phase prior to the survey campaign – in all three kebeles (Appendix C). I selected the respondents (household heads or their spouses) based on a random stratified sample. The household survey equally comprises all three population groups (locals, southern migrants and northern migrants) with the respondents within these groups being selected randomly. I collected mainly quantitative data on socioeconomic household characteristics (including assets and savings, education level, ethnic group, involvement in conflicts), the share of forest and other livelihood activities, household land use and holdings, use and availability of forest products, knowledge and enforcement of the rule on forest products and participation in local forest user groups. I employed a partially retrospective survey by not only collecting information about the household in the recent year (2018) but also about the situation of the household before the start of the resettlement program (2003). Hence, households that were formed or arrived after 2003 were excluded from the survey.

To complement the household surveys and group discussions, I conducted semi-structured expert interviews at the zonal level and key informant interviews at the kebele scale. For the latter, I interviewed one key informant from the local, northern migrant and southern migrant groups in each kebele. In sum, I conducted three group discussions at the kebele scale, 230 surveys at the household scale, nine semi-structured key informant interviews at the kebele scale and three semi-structured expert interviews with representatives from local NGOs and the zonal government (Appendix C).

Figure 13: Left: Group discussion with kebele officials and leaders. Right: Household survey conducted by local enumerator. Photos: J. Groth

Data analysis

Initially, I used the household survey data to investigate how the engagement in forest activities and the use of the four major forest products – honey, wild coffee, fuelwood and timber – changed from 2003 to 2018 for each of the three population groups. Subsequent, I used a set of variables related to household characteristics, forest availability, forest institutions, social capital, forest products, household assets and land use from my survey data (Table 6) and used a random forest regression tree procedure (see chapter 3.3) to explain what drives the share of forest activities in households in both 2003 and 2018. In addition, I used rank-sum test to explore group-specific impacts on forest clearing.

Related to my first hypothesis, that the increased demand for cropland resulted in increased clearing activities by migrants and that the resulting declining forest availability led to a reduced share of forest activities, I analyzed two aspects. First, I used the regression analysis to examine the influence of the variables available forest area and NTFP use, which is highly correlated with forest availability, as drivers for the share of forest activities. Second, I performed a Kruskal-Wallis rank-sum test (for non-normally distributed data) and a post hoc pairwise Wilcoxon rank-sum test to test whether there were differences between the two migrant groups and the local group regarding forest clearing activities – and therefore a migrant specific impact on forest availability – in 2003. To test my second hypothesis, whether the migration-induced spreading of cropland replaced forest activities, I used the regression analysis to examine the influence of the variables seasonal cropland and perennial cropland used by a household as drivers for the share of forest activities. For the statistical analysis, I used 224 out of the 230 surveys, as I had to exclude six surveys due to missing response variables (Appendix C). Finally, I used additional data from the key informant and expert interviews to contextualize the results from the statistical analysis and to address my third hypothesize, whether changes in forest access and land tenure mediated the influence migration had on engagement in forest activities and resource degradation in Guraferda.

For the random forest regression analysis, I first grew 500 regression trees using a random subset of twelve independent continuous and categorical variables at each split, using two-thirds of the total data (see Appendix C for details on data distribution). The remaining one third was used for testing. I build two random regression models, one with the data for 2003 and one for 2018, to explore the differences between the two periods. Furthermore, I used the mean-squared error (MSE) to evaluate the importance of each predictor for the model. The percentage of increase in the MSE (% IncMSE) indicates how much the predictive power of the model is reduced when a predictor is randomly permuted. Consequently, the higher % IncMSE is, the higher the importance of the predictor for the model. The random forest model results indicate the average over all 500 trees grown, and thus, the model does not allow the exploration of any split conditions.

Therefore, I employed a second step, where I grew two single regression trees – one for 2003 and one for 2018 – and pruned them where a split does not increase the model quality based on a complexity parameter. I further added the criterion that the final nodes have at least 10 observations to allow meaningful interpretation of the model results. As a result, I obtained two stable trees, each indicating a combination of predictors explaining low to high shares of forest activities within the observed households. The statistical analysis was implemented using R software and by applying the ‘randomForest’ package (Breiman et al. 2001) and the ‘rpart’ package (Therneau et al. 2015).[20]

In the following subchapter, I present the results of the descriptive and analytical statistics based on the household survey data and contextualize them with qualitative information from the interviews.

[20] Code and data that support the findings of this study are openly available on https://osf.io/9uwr4/ (DOI 10.17605/OSF.IO/9UWR4)

Table 6: Definitions, mean values, standard deviation, range of the response variables and all predictors for 2003 and 2018 included in the statistical analysis.

Variable name	**Definition**	**Mean (SD)**	**Min; Max**	**Mean (SD)**	**Min; Max**
		2003		**2018**	
		Response			
Forest activities [%]	Percentage of total household livelihood provided by forest activities; refers to time spent gathering the four main forest products consumed in all three kebeles: wild coffee, honey, fuelwood and harvesting timber	23(20)	0; 100	16 (11)	0; 50
		Predictors			
		Household characteristics			
Sex household head [female, male]	Sex of the household head	F = 22 M = 202		F = 22 M = 202	
Formal education of household head [completed years]	Completed years of formal education of the household head	2(3)	0; 10	2(3)	0; 10
Local [y,n]	Household is a member of the local population	Yes = 72 No = 152		Yes = 72 No = 152	
Northern [y,n]	Household is a member of the northern migrant population	Yes = 78 No = 146		Yes = 78 No = 146	

Southern [y,n]	Household is a member of the southern migrant population	Yes = 74 No = 150		Yes = 74 No = 150	
Alenga [y,n]	Household is located in Alenga	Yes = 73 No = 151		Yes = 73 No = 151	
Semerta [y,n]	Household is located in Semerta	Yes = 79 No = 145		Yes = 79 No = 145	
Gelit [y,n]	Household is located in Gelit	Yes = 72 No = 152		Yes = 72 No = 152	
Savings [ETB]	Amount of savings of household	549(8018)	0;120k	10k(40k)	0; 430k
		Forest availability			
Available forest†† [ha]	Area of state, community or own forest area which can be used by the household	293 (1705)	0; 25k	250 (540)	0; 3000
		Forest institutions			
Member in forest user group [y,n]	Household is member of the kebele forest user group (PFM)	FUGs did not exist in 2003		Yes = 80 No = 144	
Enforcement of timber permission [y,n]	Level to which the household respects the customary/governmental rules for timber harvest	no =161 yes = 46		no = 45 yes = 167	
Knowledge of rules on timber use [y,n]	Household knows about the customary /governmental rules for the use and harvest of timber	Yes =52 No = 167		Yes = 191 No = 23	
Knowledge of rules on	Household knows about the customary/governmental	No rules existed in 2003		Yes = 21 No = 202	

fuelwood use [y,n]	rules for the use of fuelwood				
Social capital					
Majority [y,n]	Household population group belongs to the majority in the kebele	Yes = 75 No = 149		Yes = 75 No = 149	
Conflicts [y,n]	Household was involved in a conflict (personal, over natural resources, over assets) with another household or group up to 4 years after arrival or in the last 4 years	Yes = 1 No = 223		Yes = 22 No = 202	
Walking distance to kebele center [min]	Walking minutes from the homestead to the kebele center	23 (17)	1; 120	23 (17)	1; 120
Forest products					
Forest product gross value [%]	Percentage of gross value generated by collecting and harvesting forest products contributing to all forest and agriculture products collected, produced or harvested	31(26)	0; 100	14 (11)	0; 57
Timber use† [pieces]	Pieces of timber from native tree species harvested by household	83(81)	0; 580	106 (106)	0; 700
Fuelwood use [loads]	Loads of fuelwood from native tree species collected by household	107 (54)	0; 364	123 (49)	0; 364
Honey and wild coffee use [kg]	Amount of honey and wild coffee collected by the household	46 (194)	0;2560	17 (61)	0; 750

		Household assets and land use			
Land owned† [ha]	Area of land (forest, seasonal and perennial cropland, others) owned by household	3 (3)	0; 25	3 (2)	0; 18
Shared land† [ha]	Area of own land the household shares with another household	0 (0)	0; 5	1 (1)	0; 6
Tin roof [y,n]	Household has a tin roof	Yes = 31 No = 193		Yes = 116 No = 108	
TLU	Tropical livestock unit owned by the household	2 (2)	0; 16	2 (2)	0; 7
Seasonal cropland† [ha]	Area of cropland used to cultivate seasonal crops owned by household	2 (2)	0; 12	2 (1)	0; 9
Perennial cropland† [ha]	Area of cropland which is used to cultivate perennial crops owned by household	0 (0)	0; 3	1 (1)	0; 3
		Others			
Eucalyptus used as timber [pieces]	Pieces of timber from eucalyptus trees harvested by household	0 (4)	0; 50	61 (255)	0; 3000
Eucalyptus used for fuelwood [load]	Loads of fuelwood from eucalyptus trees collected by household	0 (1)	0; 20	6 (20)	0; 156
Tree plant [y,n]	Household planted trees on own land within the last 4 years	Yes = 64 No = 160		Yes = 91 No = 133	
Forest clearing†† [ha]	Area of forest cleared by household	0 (1)	0; 5	0 (0)	0; 2

† medium data uncertainty †† high data uncertainty (available forest area 2003 and forest clearing 2018)

5.2. Changes and drivers of forest activities

Changes in forest activities and forest product use between 2003 and 2018

In both years 2003 and 2018, forest activities were more important for local households than for the two migrant groups (Figure 14). Yet, from 2003 to 2018, there was a sharp decline in forest activities from 37% to 24% in the local group, while in the other two migrant groups, forest activities declined from approximately 16% to approximately 12%. This declined importance of forest activities is also reflected in the maximum share of forest activities per household across all three groups. In 2003, the maximum share of forest activities reached 100% while it was halved in 2018, indicating that no single surveyed household depended solely on forest activities. Further, I find that there was little change in product use between 2003 and 2018 among migrants; however, among the local group, the use of honey and wild coffee decreased significantly, while the use of timber increased. Thus, I conclude that the decline in forest activities among local households is primarily due to a decline in the use of the main NTFPs – honey and wild coffee.

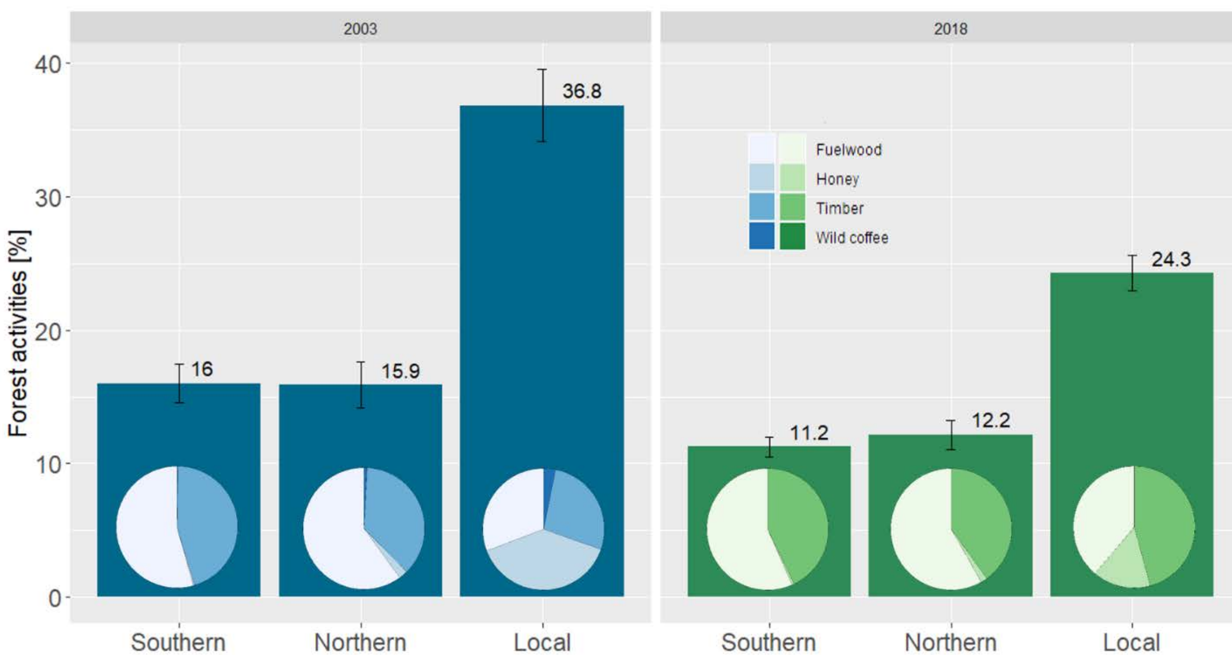


Figure 14: Shares of forest activities and forest products used by southern migrants, northern migrants and locals in both 2003 and 2018. Error bars indicate the standard deviations.

Key informants and survey respondents emphasized that decreasing forest cover and increasing forest degradation hindered NTFP collection, reporting population increases, expansion of smallholder and commercial cropland, and the use of herbicides as part of intensive farming practices as the main drivers. In fact, not only did smallholders increase land demand, but commercial agricultural projects also spread in Guraferda: between 2002 and 2018, an additional area of 22,000 hectare was allotted to private investors (Bench Maji Zonal Statistics, 2019). This rapid expansion can be explained by the enactment of the land proclamation in 2005 that privileged land transfers to private investors.

In addition, I found that in 2018, local households were rarely part of the local forest user groups, mainly due to reported language barriers. FUG meetings are held in Amharic, which is spoken fluently by most migrants but not necessarily by locals. Group-specific barriers to access the forest might have further contributed to the declining forest activities in local households between 2003 and 2018.

Changes in drivers of forest activities between 2003 and 2018

Changes of driver importance between 2003 and 2018

The random forest regression models explain 41% of the variance in the data in 2003 (Figure 15 left) and 39% in 2018 (Figure 16 left). The most important driver for forest activities in both years is the percentage of gross value produced by forest products, which increases the MSE by 31% in 2003 and 17% in 2018. In both years, this is followed by membership in the local group (13% increase in MSE in 2003 and 15% in 2018) and the use of NTFPs (10% increase in MSE in 2003 and 15% in 2018). In the 2003 model, the use of timber increases the MSE by 9%, followed by the membership in the southern migrant group and the forest area available for a household (both 8% increase in MSE). In contrast, in 2018 timber use and forest area available are less important (both below 5% increase in MSE), but southern group membership for 2018 is similar high (7% increase in MSE). The kebele Alenga is important in explaining the share of forest activity in a household in 2018 (8% increase in MSE), yet in 2003 it has a lower importance (below 5% increase in MSE).

Interestingly, seasonal or perennial cropland increases the MSE by less than 5% in 2003 and thus have a very low relative importance, whereas in 2018 the area of seasonal cropland used by a household is more important with a 10% increase in MSE. From descriptive statistics, I know that cropping activities increased from 2003 to 2018 (Appendix C). In addition, local and migrant key informants in all kebeles reported that mainly locals adopted ‘new farming practices’ from migrants. Conversely, few migrants reported that they adopted, for example, honey collection from locals.

Driver interactions that explain forest activities in 2003 and 2018

In the next step, I identified split conditions using single regression trees, which trees allows the identification of pathways that explain low to high shares of forest activity and the directional influence of predictors in 2003 (Figure 15 right) and in 2018 (Figure

16 right). Overall, both single trees have a somewhat lower predictive power compared to the random forest regression models, with an r^2=0.31 in 2003 and an r^2= 0.34 in 2018. The 2003 model's predictions are more confident for lower shares of forest activity, but stay the same for the 2018 model (see Appendix C for model uncertainties). Compared to 2003, the single regression tree for 2018 is rather small, which can be mainly attributed to the overall lower importance of forest activities in 2018 (cf. Figure 14).

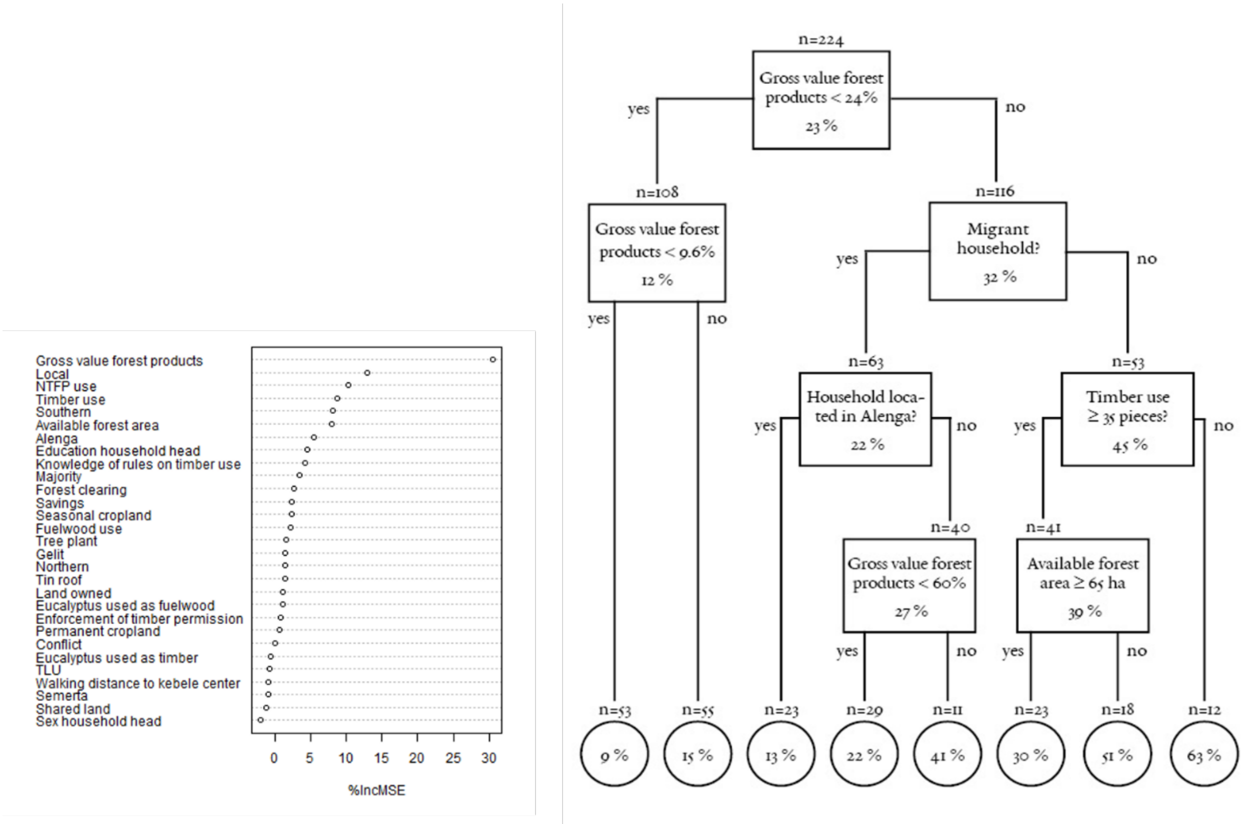


Figure 15: Left: Relative importance of the predictors for explaining the share of forest activities in households in 2003 expressed as an increase in mean squared error (% IncMSE). Right: Pruned regression tree for 2003. Each split indicates the split condition, the mean share of forest activities and the number of households (observations) used in each split. The final nodes indicate the mean share of forest activities and the number of households.

In 2003, the households with the lowest share of forest activities (below 15% for 108 of the 224 total households) are explained by a gross value of less than 24% produced by forest products. In other words, for almost half of the households, forest activities were a minor activity in 2003, and consequently, the gross value generated by these households through the collection or harvesting of forest products was small. For the other half of the sampled households, which spent approximately 32% of their total livelihood activities with forest-related activities, the most important split condition was their population group membership. While migrant households have an average share of 22% in forest activities, local households devoted twice as much of their livelihood activities to forests (45%).

For migrant households in 2003, those located in Alenga have a lower share of forest activities (13%) than the other two kebeles (at least 22%). Another branch of the regression tree divides the local households into 41 households harvesting more than 35 pieces of timber per year and showing a mean share of 39% in forest activities, and 12 households harvesting less than 35 pieces of timber per year but showing the highest share of forest activities in the sample (63%). These local households with the highest share of forest activities engage only little in timber harvesting (the average number of collected timber pieces collected in the entire sample in 2003 is 83 pieces) and instead spend a great deal of time on time-intensive collection of foremost non-timber forest products. Local households, which collect more than 35 pieces of timber per year, are further subdivided into two groups. Those with more than 65 ha of forestland available (including forestland exclusively used by a household and forest area that can be used by all village dwellers) have, on average, only a 30% share in forest activities, and households with less than 65 ha of forestland available have a comparatively high 51% share in forest activities.

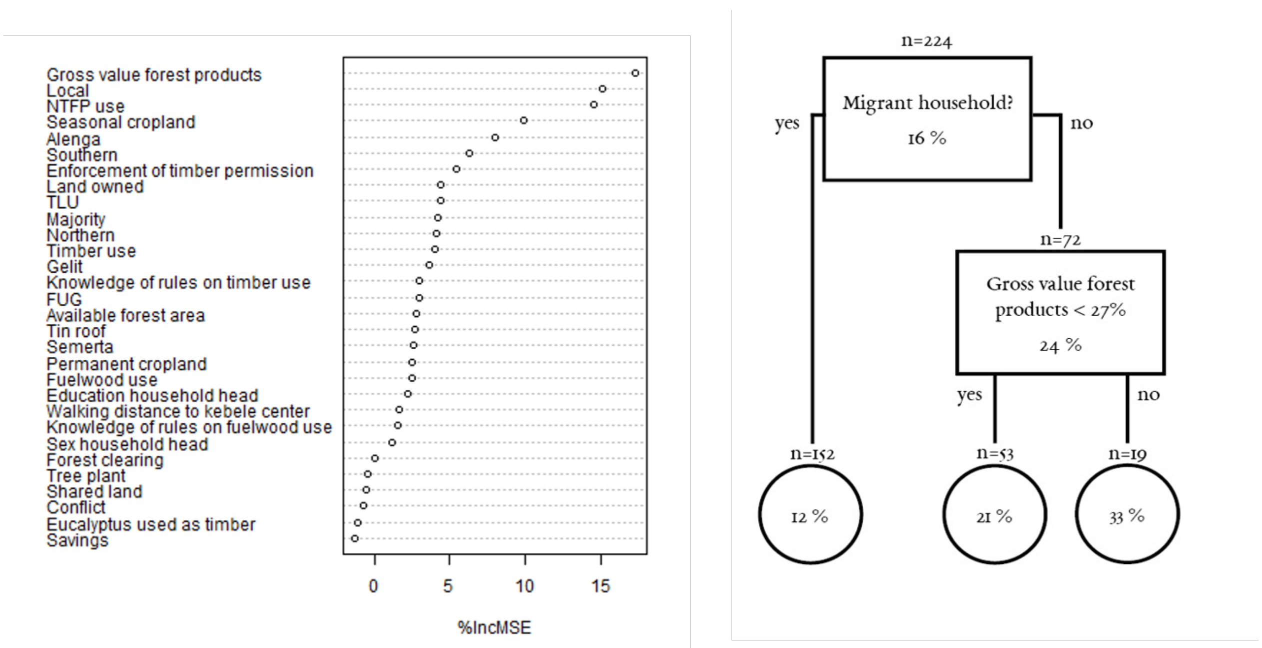


Figure 16: Left: Relative importance of the predictors for explaining the share of forest activities in households in 2018 expressed as an increase in mean squared error (% IncMSE). Right: Pruned regression tree for 2018. Each split indicates the split condition, the mean share of forest activities and the number of households (observations) used in each split. The final nodes indicate the mean share of forest activities and the number of households.

In 2018, the most important split condition is population group membership, similar to 2003. Migrant households have an average share of forest activities of 12%, while local households reach a twice as high average share of 24%, yet to a lower extent compared to 2003. Local households can be further divided into 53 households (the majority of local households) that achieve an average share of forest activities of 21% and only 19 local households that achieve the highest average share of forest activities of 33%.

Engagement in forest clearing

The Kruskal-Wallis test showed that the amount of forest clearing in 2003 differs significantly between population groups (p=0.04). The post hoc pairwise Wilcox test revealed a significant difference between the forest clearing activities of northern migrants and locals (p=0.04) (Appendix C). In 2003, the average area of forest cleared by local households was 0.14 ha, that cleared by southern households was 0.15 ha, and that cleared by northern households was 0.32 ha. Key informants reported that informal land transfers from the locals to northern migrants or clearing of unclaimed forest land by northern migrants was a common practice around 2003.

In contrast, for 2018 households reported almost no clearing activities, although the field team observed freshly cleared forest plots in the study area every now and then during the data collection in 2019. In addition, I observed that northern migrants are increasingly blamed for clearing activities, and in recent years, there have been reports on violent conflicts over land use rights between locals and northern migrants (Debonne, 2015; expert interviews).

5.3. Why smallholders stop engaging in forest activities – The role of in-migration in livelihood transitions and on deforestation

In-migration and expansion of commercial agriculture contributed to forest cover decline, hampering the collection of NTFPs for local communities

I examined NTFP use – which highly depends on access to large and ecologically intact forest areas – to investigate the influence of forest availability and used the qualitative data to identify the reasons for forest cover decline in Guraferda. As shown, NTFP use was among the most important drivers of forest activity in both years. Therefore, high forest dependence is associated with the high use of NTFPs. Reasons reported for the declining forest cover and increasing forest degradation – main obstacles for the collection of NTFPs – suggest that migration is not the only nor the main driver. Besides changes in farming practices, which fueled forest degradation and the expansion of smallholder cropland, commercial cropland increased tremendously in Guraferda by 22,000ha. Consequently, the expansion of large- and small-scale agriculture has contributed immensely to the decline of forest cover in Guraferda, with the in-migration of land-seeking smallholders being only one contributing factor. Overall, the shrinking forest area in Guraferda hindered forest activities, especially NTFP collection of local households. This is critical because NTFPs are vital to the livelihoods of forest-dependent people (Pandey et al. 2016, Rasmussen et al. 2017).

The results for 2003 show that a local household with comparably little available forest area has a higher share of forest activities than a local household with more forest available, therewith contradicting my interpretation above. However, this finding may also suggest that the relationship between forest activity and forest size is non-linear and that there is a minimum area threshold that enables people to collect NTFP. Yet, estimating the size of available forestland was difficult for respondents, especially in 2003 (see Table 6), because common land (such as forests) was not yet demarcated and was partially perceived as de facto open access. Thus, these specific results need to be treated with caution.

Changes in forest access mechanisms hindered engagement in forest activities

In addition to forest availability, forest management changed in Guraferda. With the introduction of PFM schemes and related FUGs at two of the research sites (Alenga and Semerta), the communities took over forest management, yet, NTFP use declined in all kebeles and it seems that the PFM had little influence on the revival of forest activities. A study by Wood et al. (2019) in the neighboring Sheko District shows that PFM has the potential to reduce forest loss and maintain biodiversity. However, the authors identified strong links between the forest and local communities as a crucial factor for PFM success. In the studied kebeles, locals became the minority after in-migration in the early 2000s, and are rarely part of the FUGs mainly due to language barriers (see section 3). I argue that the exclusion of locals from the newly established local forest management institutions further reduced their forest activities and presumably hinders the effectiveness of PFM schemes in Guraferda. My results suggest that in-migration has altered population composition and social structures and, in combination with institutional changes, may have changed resource access mechanisms (Ribot and Peluso 2009). However, an in-depth analysis of the influence of PFM on forest activities was beyond the scope of this chapter.

Lack of formal land use rights fueled forest clearing by migrants, reducing opportunities to engage in forest activities for locals

I revealed a significant difference between the clearing activities of northern and local households in 2003. The average area of forest cleared by northern households in 2003 was twice as large as the area cleared by local households and southern households. Unruh et al. (2005) showed for southern Zambia how clearing activities were used to consolidate land claims under insecure tenure in areas of abundant land availability (as in Guraferda in 2003). In Guraferda, northern migrants, unlike southern migrants, faced a lack of formal land use rights upon arrival in Guraferda. I argue that northern migrants in their comparatively volatile situation and given the de facto open forest access used forest clearing as an important strategy to claim land they needed for their agricultural livelihoods in the new settlement area. This accelerated reduction in forest cover, in turn, limited NTFP collection for locals in particular (see above).

Since 2014, forest clearing has been officially prohibited. This makes it a particularly sensitive issue and likely explains the mismatch of reported clearing activities for 2018 between the survey and the observations in the field. The recently observed land clearing activities and reported conflicts between local and northern migrants, might be a result of tenure pluralism, created by the land reform in 2010 (see chapter 2.2), and the shrinking land availability caused by population increase and the expansion of commercial agriculture (Unruh et al. 2005, Stellmacher and Eguavoen 2011, Robinson et al. 2014).

In-migration of cereal-based smallholders and agricultural policies fueled the uptake of seasonal cropping activities, substituting forest activities

Seasonal cropland shows a sharp increase of relative importance, from low in 2003 to the fourth most important variable in 2018, whereas perennial cropland remained of low importance from 2003 to 2018. These findings have two interesting implications. First, the cultivation of seasonal crops has mainly replaced forest activities. Seasonal cropping in Ethiopia is typically practiced in open, treeless fields that can be easily ploughed with an ox and is therefore rather incompatible with forest-dependent livelihoods. In comparison, perennial crops such as coffee – the main perennial crop in Guraferda – require shade trees that can still be used for honey production and thus do not completely prevent NTFP collection in these plots. Second, the exchange of knowledge and adoption of new livelihood activities between groups happened mainly in one direction – from migrants to locals. I argue that Ethiopia's agricultural policies played a key role in determining this direction of exchange, as they encouraged the production of cereal (cash) crops for growing national and international, mirroring Ethiopia’s economic strategy (Spielman et al. 2010, Abro et al. 2014). New farming practices, such as the use of improved seed varieties, frequent plowing, inorganic fertilizer, and pesticide use, have been introduced and advanced in Guraferda over the past two decades (Kassa et al. 2017). I conclude that these practices – which were already common in the open landscapes of the origin region of both migrant groups – fueled the uptake of the new farming practices by the locals. In addition, these new agricultural practices led to soil and forest degradation in the southwestern highlands (ibid), putting additional pressure on the forest-dependent livelihoods of the locals, who were already stressed due to shrinking forest cover and barriers to participation in local forest management institutions (as outlined above). Moreover, if not counteracted, further degradation could reduce yields and eventually stress agriculture-based livelihoods, holding the potential to trigger out-migration and risk a self-enforcing feedback loop between migration and resource degradation.

Further, migrant households in Alenga are significantly less active in the forest than households in Gelit or Semerta (Figure 15). Compared to the other two kebeles, Alenga was and is the closest to the local market and main road, which facilitates the sale of crops and could thus encourage engagement in seasonal cropping, reducing dependence on forest resources (Acheampong et al. 2018, Beyene et al. 2020). However, Alenga differs from the other two kebeles in terms of remoteness, population composition and forest size, loss and management. Hence, I cannot clearly determine the decisive factor(s). Nonetheless, my results suggest that mesoscale factors at the kebele scale mediate household livelihood outcomes and should therefore be considered in further studies, e.g., by using multiscale analyses accounting for spatial variations in migration-induced population growth, aspects of remoteness and forest loss rates.

5.4. Methodological reflections

The decision for a retrospective survey design – as every decision in research – is related to certain trade-offs. I aimed to grasp how and why livelihoods in my study area changed over time. Yet, there exists no longitudinal dataset for southwestern Ethiopia that would have allowed for a similar analysis. Thus, I opted for a retrospective design, with the limitation that the data for 2003 are less accurate than for 2018. I countered this effect by choosing 2003 as a particularly significant year in the recent history of Guraferda, as this was the year that the major resettlement program was launched and a significant number of people migrated. This not only changed the situation for the migrants – who started a new life in Guraferda – but also changed the daily life of the locals tremendously. Such life-changing and remarkable anchor points facilitate recalling other activities or conditions in the same period (Herting and Tanur 1993). Further, the random forest regression tree procedure proved very powerful in dealing with a wide range of potential drivers and complex mechanisms in social-ecological systems. Nonetheless, my qualitative data from the interviews were crucial to contextualize the statistical results. In sum, the insights provided with this chapter are novel for Ethiopia's insufficiently studied southwestern parts and provide a sound basis for further research.

5.5. Leverages to reduce adverse impacts on natural resources and rural livelihoods

Existing research on migration-degradation linkages identified in-migration as a strong driver for deforestation, forest degradation and livelihoods transition, including in southwest Ethiopia (e.g., Kassa et al. 2017). I expanded the scope of existing studies, by providing a local-scale analysis, which in particular investigated the factors mediating the impact in-migration has on rural livelihoods and on deforestation in southwest Ethiopia.

I conclude that the cultivated area in my study area of southwestern Ethiopia expanded at the expense of the forest – partially due to the in-migration of smallholders from agricultural-based systems but also considerably due to the expansion of commercial agriculture for the production of cash crops. As a result, forest activities, especially the collection of NTFPs for forest-based local communities, were limited. In addition, participatory forest management was introduced, and forest management was transferred to the local communities to protect the remaining forest patches. My findings show that the decline in forest area – likely together with restricted possibilities for participation in the newly established forest management groups – made it increasingly difficult for the local people to pursue their forest-based livelihoods. Rather, local people gradually adopted migrants' agricultural practices. In addition, Ethiopia's agricultural policy, which promoted land-intensive farming practices and the production of cash crops for national and international markets, further encouraged the uptake of agricultural activities and increased forest degradation. In sum, I showed, how governmental policies, commercial agriculture, tenure security and forest access mediate migration-degradation linkages. Based on this, I identified the following leverages to reduce the adverse impacts on natural resources and related challenges for locals and migrants in receiving areas:

1) Tenure security has a critical role in the extent of forest clearing by migrants. However, especially in areas with many competing interests in land resources – such as migrant receiving areas – developing **inclusive tenure policies** is not an easy undertaking. Yet, there is increasing evidence that secured tenure reduces tropical deforestation and unsustainable land use by frontier residents (Robinson et al. 2014, Holland et al. 2017), including migrants (Codjoe 2006). I suggest that tenure reforms should aim to **secure long-term land use rights for all frontier residents** (including planned and unplanned migrants) who rely on (forest-) land to support their livelihoods.

2) This includes that the **expansion of large agribusinesses** near kebeles and in intact, large and common forest areas used for NTFP collection has to be **restricted** by law.

3) Furthermore, formalizing land rights for migrants should **not have negative impacts on customary land use rights of local or indigenous groups**, as curtailment of indigenous or local land rights can lead to marginalization of these groups and could fuel tensions and conflicts (e.g., Dhiaulhaq and McCarthy 2020).

4) While the in-migration of land-seeking smallholders will increase the demand for cropland, the **densification of settlement sites could reduce the further sprawl of human settlement into intact forest areas** and thus reduce negative impacts on biodiversity (Rodrigues et al. 2021).

5) Furthermore, PFM schemes can be a way by which communities can simultaneously protect and benefit from forests, but **PFM schemes have to be carefully embedded in the local context and ensure equal participation**, especially in areas with groups of different cultural backgrounds.

6) Moreover, I have shown how intensive seasonal cropping – fueled by national policies that are not suitable for high forest ecosystems in Ethiopia – has gradually replaced forest activities and contributed to forest degradation. There is strong empirical evidence that agroforestry and trees on farms have multiple benefits for rural livelihoods, including increased well-being and incomes, improved diet and even the potential for enhanced agricultural yields (Reed et al. 2017, Rasmussen et al. 2020, Miller et al. 2020). Thus, **encouraging diversified livelihood activities consisting of a mix of agriculture and forest activities** by promoting the use and marketing of non-timber forest products and REDD+ schemes (partially already started in Guraferda) could reduce pressure on forests as well as on rural livelihoods.

This chapter shows that governmental policies, land tenure arrangements and local alterations in resource access are strong mediators of the impact in-migration had on livelihood transition and on natural resources in the study area. As such, this chapter underlines the complex, multicausal relationship between in-migration, livelihoods and resource degradation, countering simplified and deterministic narratives and an inept framing of in-migration and migrant as threats for traditional livelihoods and natural resources in receiving areas.

6. SYNTHESIS

6.1. Key findings and contributions of this thesis

The question of whether environmental change influences migration has been the subject of numerous studies, but less attention has been paid to the details of how and why exactly. Moreover, due to the multicausality inherent to migration processes, disentangling factor interactions shaping migration remains a methodological challenge. Furthermore, the impact of migration on the livelihoods and the environment in migrant receiving areas received comparatively less attention. In particular, there is a need to examine whether and under which conditions migration contributes to livelihood transitions and resource degradation in migrant destinations. These aspects have been recently underlined as crucial gaps within the research field, in particular for internal migration in Africa (Cundill et al. 2021). In this thesis, I addressed these gaps by applying a multi-method approach to analyze place-based empirical evidence from a rural sending area and a rural receiving area in Ethiopia.

Chapter 4 addressed the influence of environmental change on migration using the northern Ethiopian highlands – a rural out-migration hotspot within the country where changes in rainfall patterns and severe land degradation are evident – as a case study (see chapter 2.1). In **chapter 4.2**, I conducted an in-depth qualitative and multisite study of 42 farming households to understand under what conditions they engage in migration. I applied QCA – a novel method in the research field and powerful tool to decipher complex causal patterns – to disentangle interwoven factors shaping migration. The QCA revealed that migration experience within the household in combination with either the usage of the stronger and the less variable rainy season (Kiremt) or non-farm in-situ livelihood diversification are sufficient conditions to explain migration. Both favorable environmental conditions during the Kiremt season and non-farm income activities contribute to higher and more stable household economic resources, thereby also increasing migration ability. Yet, only if a household also had migration experience, i.e. access to migrant networks, it engaged in migration. These findings underlined that intertwined economic and social resources are crucial to enable migration. Moreover, this chapter was one of the first studies to propose QCA as an approach to overcome the major methodological challenges of detecting complex causalities in the research field. In **chapter 4.3**, I described an approach to develop a participatory BN that depicts migration decisions of subsistence farmers in the context of soil degradation and rainfall changes. Therefore, I integrated the QCA findings based on chapter 4.2 with literature-based evidence and insights from a stakeholder workshop. I quantified the BN by involving local policy makers and representatives from NGOs and villages during a stakeholder workshop in the northern Ethiopian highlands. Subsequently, I utilized the resulting BN to identify distinct migration pathways and barriers for the adoption of local policy measures to reduce migration needs. The BN revealed that migration induced by soil degradation and/or rainfall changes is mainly influenced via agricultural channels, yet I uncovered two distinct pathways: First, soil degradation and changes in rainfall reduce agricultural production and thus increases migration by increasing the need to migrate. Second, unfavorable environmental conditions for agriculture increase the likelihood that households will seek non-farm activities to secure their livelihoods, which increases migration by increasing household economic resources and therewith the ability to migrate. However, limited employment opportunities in the rural highlands, ultimately limits participation in non-farm income activities for farming households. Altogether, the BN reflects multiple – yet not dichotomous – rationales behind migration decisions: In some cases, migration is a survival strategy under increasing environmental stress and livelihood pressure. In other cases, it is a strategy to accumulate assets, which (further) enhances migration abilities. Lastly, the chapter underlines that combating soil degradation is the most important leverage that can be addressed locally to reduce pressure on farming livelihoods and thus migration needs. However, contradictions with other policies and a top-down implementation without taking into account local realities, such as the local land tenure situation and farmers capacities, largely hinder the adoption of local policy measures.

In sum, with chapter 4 I contribute to expanding the methodological toolkit of migration research by applying two underutilized methods, yet both well-suited to deal with the multicausality inherent to migration processes. Besides, the participatory BN provided an illustrative representation of complex migration processes and thus, a suitable communication tool to be used with stakeholders. My findings substantiate that slow-onset hazards are rarely direct causes for migration, but rather affect rural farming households in the Ethiopian highlands via agricultural channels and interact with the socioeconomic factors operating at different scales. Furthermore, the results show that while environmental change exacerbates migration needs by reducing agricultural production and increasing livelihood pressure, it can also undermine the resources necessary to migrate. In addition, differences in household's economic and social resources strongly determine whether household are able to engage in migration. That bears the risk that, contrary to common deterministic narratives, the most vulnerable households are not able to migrate but instead become trapped in vulnerable environments, amplifying existing inequalities. Lastly, it becomes apparent that approaches solely based on push-pull theory are not sufficient – likely even overrated – to explain environment-related migration as they ignore the underlying inequalities, which may also inhibit migration.

In **chapter 5**, I presented a study, which addressed the influence of smallholder in-migration, together with other non-demographic factors, on the livelihoods of local and migrant communities and forest degradation. I used the example of Ethiopia's southwestern forest frontier – a rural hotspot of in-migration and forest loss in Ethiopia – where smallholders experienced a rapid transition from forest-based to agriculture-based livelihoods (see chapter 2.2). In this chapter, I integrated 224 household surveys conducted in three different kebeles using a statistical approach to investigate how and why the engagement of local and migrant households in forest activities has changed since the launch of a major resettlement program in 2003. The findings were complemented by qualitative insights from group discussions and interviews to assess the role of in-migration in livelihood transitions and deforestation. The analysis showed that forest activities mainly declined in local households, the part of the population, which is – in contrast to the agriculture-based migrant groups – traditionally heavily dependent on forest resources (mainly NTFPs). My findings reveal that forest cover in Guraferda declined partially due to the in-migration of smallholders from agricultural-based systems but also considerably due to the expansion of commercial agriculture, fueled by the national land tenure policy. With the decline in forest, the forest-based local population gradually adopted migrants' agricultural practices, which was further encouraged by agricultural policies and barriers to participate in forest management for locals. The chapter challenges simplified assumptions in in-migration-degradation debates by showing that governmental policies, land tenure insecurity and barriers to forest access mediate the impact of smallholder in-migration on rural livelihoods and forest resources at Ethiopia's southwest rainforests. Based on this, I conclude that securing land tenure and equal access to natural resources for frontier residents, and promoting a mix of agricultural and forest livelihood activities can reduce the adverse impacts on natural resources and related challenges for locals and migrants in in-migration areas.

In sum, chapter 5, sheds lights on an understudied link in a largely overlooked region and thus, provides foundation for future research in the region and beyond. Chapter 5 complements existing studies on in-migration-degradation linkages by specifically investigating under which conditions in-migration contributes to adverse environmental impacts. The chapter revealed crucial mediators of this relationship, which elucidates that the influence of in-migration on environmental change is just as multifaceted and non-linear as the influence of environmental change on out-migration. In addition, the chapters provides a fine-grained perspective on the impact on forest-based local groups and thus, shows how their livelihoods changed considerably due to in-migration, but also through governmental policies, growing macroeconomic forces and alterations in forest management. Ultimately, if communicated well, such fine-grained findings can help to counteract false attributions of the causes for environmental degradation in migrant receiving areas and thus, support policymaking and reduce adverse impacts for frontier residents.

6.2. The mediators of the linkages between environmental change and migration in Ethiopia

The empirical evidence from Ethiopia shows that environmental change is neither inevitably the cause nor consequence of migration. Rather, this depends on various intertwined mediating factors at the micro-, meso- and macroscale, which determine whether households stressed by environmental change are able to migrate and which mediate the influence of migration on natural resources. I use the notions of *enablers*, i.e. mediators increasing the ability to migrate and *amplifiers*, i.e. mediators contributing to adverse environmental impacts of migration and attribute them to the macro- (i.e. regional to national), meso- (i.e. kebele or community) or microscale (i.e. household) (Figure 17).

In the upper part of Figure 17, I illustrate migration experience within a household as most important social enabling factor operating at the microscale as it facilitates migration by reducing costs and risks of migration and influences migration aspirations. Yet, only in combination with sufficient economic household resources, this constitutes a migration enabling mechanism. Households are more likely to have the necessary economic resource to engage in migration when they are located in environmental beneficial areas with more stable rainfall and lower land degradation rates compared to the larger region. These mesoscale factors have a major impact on household agricultural production, which is largely dependent on rainfall and is characterized by low inputs in the northern highlands. Yet, economic household resources for migration can also be gained, by engaging in non-farm income activities, which is determined by the availability of job opportunities at the macroscale, i.e. the larger region. In essence, this substantiates how migration enablers interact across and within scales.

On the lower part of Figure 17, I illustrate the key factors amplifying the adverse impacts of migration on the environment. On the microscale, insecure land use rights of parts of the migrant group lead to increased forest clearing activities by these households shortly after arrival. Further, changes in the forest management created barriers for local households to access the forest and pursue their traditional forest-based livelihoods. In addition, in-migration of smallholders introducing intensive farming practices fueled the adoption of these practices by locals and contributed to forest degradation. However, these various factors are influenced by other political and economic factors at larger scales. Land tenure insecurity is fueled primarily by the pluralism of land tenure at the mesoscale. It is the result of the introduction of formal land use rights for migrants, which contradicts the customary tenure system of local groups in kebeles where both locals and migrants settle. Further, national agricultural policies and changes in the states land tenure fuel the uptake of intensive farming practices and the expansion of large-scale commercial agriculture as response to growing national and international market demands and eventually amplify forest degradation in southwestern Ethiopia.

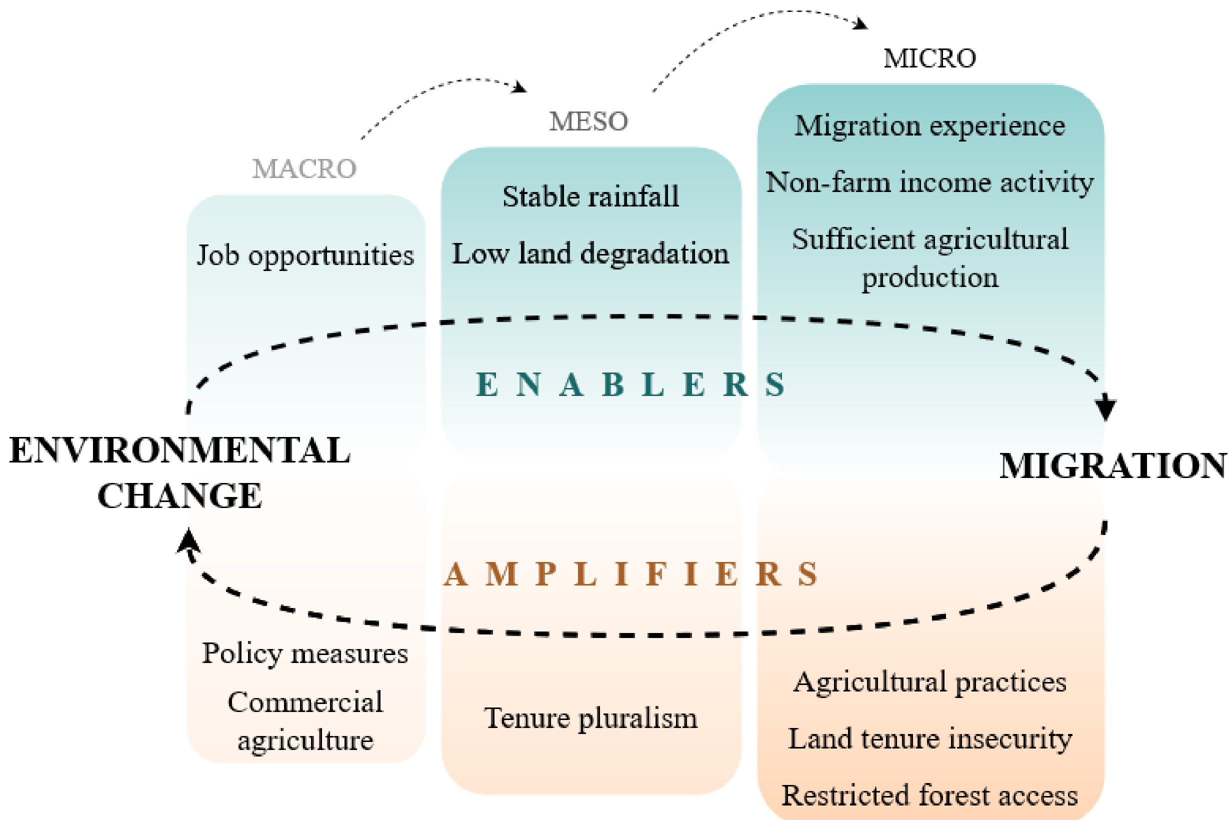


Figure 17: Main mediators on the micro-, meso- and macroscale of the linkages between migration and environmental change based on the empirical evidence from Ethiopia

6.3. A self-enforcing feedback loop?

Based on what is presented above and integrated in Figure 17, the following question arises: Under which conditions can a self-enforcing feedback loop between migration and environmental change emerge, which turns the receiving area into a sending area due to environmental degradation?

First, it is important to mention that migration patterns in Ethiopia have changed in recent years, as most of the migration flows are rural-urban nowadays (Bundervoet 2018). Even though migration from the northern and southern highlands to the southwestern forest frontiers is limited by ethnical federalism and legal restrictions nowadays, kinship migration from the northern and southern highlands to the southwestern frontiers were reported during the data collection for chapter 5 these barriers. In addition, the Ethiopian government still resettles people from densely populated zones in the southwest to the southwestern rainforests (Debonne 2015). Thus, even though migration rates to Ethiopia's southwestern forest frontiers have declined, forest degradation is continuing due to livelihood transitions and the expansion of smallholder and commercial cropland. Hence, the dynamics investigated in this thesis, and the question whether and under which conditions a self-enforcing feedback loop can emerge, are still highly relevant.

So far, forest cover decline and degradation due to human activities in Ethiopia's southwest increased the pressure on forest-based livelihoods. This primarily fueled the transition from forest-based to agriculture-based livelihoods and not migration. However, Kassa et al. (2017) also observed increasing, and in many places irreversible, soil degradation due to the changes in agricultural practices. If the main income source of the rural households increasingly relies on intensive farming, in the long-run soil degradation could in principle increase out-migration needs by reducing agricultural production, as observed in the northern highlands. Yet, farmers in the southwest neither have to cope with shifting rainfall regimes and droughts, nor are such changes predicted for southwest Ethiopia (Osima et al. 2018). As a result, environmental stress, and a related increase in migration need, is, compared to the northern highlands, currently relatively low. However, in the recent past existing tensions and conflicts over land and resource use between the local population and northern migrants forced the migrants to temporarily abandon their homes and relocate to other kebeles in the study area for a few months (chapter 5; Debonne, 2015). Such tensions are often related to different resource use practices, shrinking land availability and legal tenure pluralism resulting from a poor land and resource governance (Chapter 5; Wood 1993, Stellmacher and Eguavoen 2011, Hammond 2011). Therefore, land conflicts and host-migrant tensions are assumed to be the main cause of forced short-term and -distance migration in the recent past, yet, resource scarcity and degradation likely exacerbated these tensions. As shown in this thesis, government policies that regulate land tenure and resource access are important amplifiers of environmental degradation in southwestern Ethiopia, but also key for the emergence of resource conflicts (Van Leeuwen and Van Der Haar 2016, Seter et al. 2018). Moreover, current legal migration restrictions that prevent migrants from regions other than the SNNPR from obtaining formal land titles may actually exacerbate land tenure conflicts in the future, increasing the likelihood of unsustainable resource use (Codjoe and Bilsborrow 2012, McLeman 2017). Further, as shown in chapter 4, migration is a selective process and environmental change, and other stressors such as tensions and conflicts, can even undermine the necessary resources to migrate and bear the risk of reducing people's ability to migrate.

I therefore argue that if government policies do not address the underlying causes (primarily land tenure and agriculture policies) of resource degradation and growing tensions, there is a risk of a self-enforcing feedback loop with increased forced migration, as has already been observed in the study area, or people remaining trapped in a degrading and tension-filled environment. However, if the above amplifiers are addressed and rural residents are enabled to migrate, voluntary migration from or within the forest frontier could actually contribute to rural resilience.

6.4. Avenues for future research

Whereas the unit of analysis in this thesis were households, I also considered factors at larger scales and thereby revealed important **interactions across scales**. For example, environmental conditions at the mesoscale influence migration enabling mechanisms for households (chapter 4). Furthermore, political factors at the macroscale co-determine household engagement in forest activities (chapter 5). While these multiscale linkages are scientific consensus (e.g., Black et al. 2011, Cattaneo et al. 2019), a review by Borderon et al. (2019) on environment-related migration in Africa found that only few empirical studies actually apply multiscale frameworks and approaches; instead they address either the micro- (individual or household scale) or the macroscale (national to global scale). This risks that important contextual factors, e.g. at the mesoscale, are neglected or that at an aggregated level relevant nuances are missing. In addition, my findings from the southwestern Ethiopian case study (chapter 5) suggest that spatial variations in population composition, forest loss rates and aspects of remoteness may co-determine livelihood transitions and explain the observed differences among the studied kebeles. Based on this, I recommend for future research to explicitly consider multiscale approaches to better account for cross-scale interactions and in particular include mesoscale factors of migration-environment linkages.

Furthermore, in this thesis I revealed the importance of **migration enabling mechanisms**, which are central to understand the circumstances under which people facing environmental change or stress are able to adopt migration as a strategy. In the same vein, it is crucial to understand which conditions might hinder people (besides their own aspiration to stay put) to engage in migration and, thus, which circumstances could trap people in vulnerable environments (Zickgraf 2018, Wiederkehr et al. 2019). **Barriers to migration** could originate from various scales and are not necessarily the opposite or absence of enabling factors. On the microscale, individual factors, such as age or gender, also influence migration abilities, e.g. social dependencies or norms. A growing – yet, still small – body of literature investigates, for example, how gender norms and rules constrain adaptation options, including migration, for women (Mersha and Van Laerhoven 2016, Ayeb-Karlsson 2020). These recent developments on the microscale are important as they reveal fine-scaled social inequalities contributing to trapped populations or forced types of non-migration (immobility). At a larger scale, for example, border policies or legal frameworks could hinder as well as increase people's abilities to move to certain places (McLeman 2019). Unpacking such `macrostructures` by using concepts from political ecology or economy could help to further investigate their influence on local power imbalances (Hunter 2015). Consequently, accounting for migration enabling mechanisms as well as barriers should be an integral part of future migration research. This could help to support policies to reduce migration barriers and increase people’s ability to choose migration if they want to and therewith, reduce underlying inequalities.

In chapter 4, I conceptualized changes in rainfall or land degradation as how farmers *perceive* them, as perceptions constitute the basis for human decisions and behavior, including migration. Yet, these **perceptions** might differ from measured changes depending on vulnerability, cultural and psychological aspects (Meze-Hausken 2004, Adimassu et al. 2014, De Longueville et al. 2020). However, most of the existing empirical studies on environment-related migration are based on measured environmental changes, partially as perceptions are difficult to quantify (Hunter et al. 2015, Borderon et al. 2019) and as a result, fail to account for these subjective, yet theoretically crucial components of environment-related migration processes (e.g., Black et al. 2011). Thus, I propose that future research explicitly accounts for people’s perception to better understand their migration response. A stronger consideration of social and psychological concepts could be helpful for future research to integrate perceptions systematically in environment-related migration studies.

Despite affecting billions of people globally, so far **land degradation** has received less attention in the research field compared to climatic and non-environmental migration drivers (Olsson et al. 2019). An important finding from chapter 4.3 is that land degradation can reduce farmers' agricultural production and thus increase their need to migrate, while also undermining the necessary resources for migration. In line with this, existing research shows that migration is indeed a commonly chosen strategy in degraded areas and emphasizes that the influence of land degradation on migration processes depends on a broad range of socio-ecological conditions, including options for in-situ adaptation strategies, as well as on its interplay with climatic and socioeconomic factors (McLeman 2017). In the Ethiopian highlands, for example, frequent droughts, insecure land tenure and lack of institutional support for soil restoration amplify land degradation (Morrissey 2013; chapter 4.3). However, overall the empirical evidence on the linkages between land degradation and out-migration remains scarce and inconclusive and a comprehensive conceptual understanding is lacking (McLeman 2017, Hermans and McLeman 2021). The lack of a universal definition of land degradation and (the resulting) challenges to measure its effect on migration patterns constitute major hurdles to further explore degradation-migration linkages (McLeman 2017, Olsson et al. 2019). Furthermore, Hermans and McLeman (Hermans and McLeman 2021) suggest that the influence of demographic and socioeconomic factors, as well as the perceptions of land users, which shape migration processes, need to be better understood to enhance our understanding of the (conceptual) complexities of degradation-migration linkages. Based on this, I propose that interactions of land degradation and socioeconomic inequalities – which are key to understand migration enabling mechanisms (as outlined above) – are put at the top of future research agendas. An improved understanding is particularly important to reduce vulnerabilities of affected populations in degraded areas and enable voluntary migration.

In general, the **influence of migration on the environment in receiving area**s deserve more attention, as this linkage is, compared to the influence of environmental change on migration, understudied. Here, in particular more empirical evidence on the conditions (aka mediators) under which migration contributes to resource degradation is required. Existing research suggests that institutional and political framing conditions, especially tenure security, are decisive for resource degradation in receiving areas (Unruh et al. 2005; chapter 5, Codjoe 2006, Caviglia-Harris et al. 2013). Yet, the majority of existing research is limited to tropical rainforests while other rural immigration regions largely remain blind spots on the research agenda.

Furthermore, I observed how migration was inter alia important for livelihood transitions and resource degradation in a receiving area by transferring intensive farming practices from the Ethiopian highlands to the more humid and forested landscapes in the southwest (chapter 5). Yet, interestingly, the diffusion of farming practices in this case was unidirectional (from migrants to locals, not vice versa), likely because of macroscale factors, such as agricultural policies and (inter)national market demands, encouraging this on-sided transfer (see chapter 5). In general, the diffusion of skills, ideas and practices by migrants, e.g. back to their places of origin (known as social remittances), emerge through the movements of people and is shaped by interpersonal relationships between migrants and non-migrants, which are themselves embedded in local to international dynamics and historical contexts (Lacroix et al. 2016). Exploring such social transfers between migration systems, including those from places of origin to destination, as, for example, promoted by the concept of translocal social resilience (e.g., Sakdapolrak et al. 2016), allows for a more comprehensive understanding of migration. However, to date, **multidirectional social transfers** between migration systems and their influence on e.g. land use or resource use in receiving areas and/or sending area have not been widely taken up in empirical research (Borderon et al. 2019).

Another interesting avenue for future research, which so far received only little attention, is the **influence of migration on the environment in sending areas** and the question of whether increased out-migration releases pressure on the natural resources base. Empirical evidence on this topic is mainly from Latin America and focuses on the use of financial remittances and its effect on land use decisions and forest transition (Hecht and Saatchi 2007, Robson and Nayak 2010, Aguilar-Støen et al. 2016, Ospina et al. 2019, Angelsen et al. 2020). The findings are rather mixed and suggest that contextual factors and structural forces, such as market access, investment opportunities, governmental policies, institutional conditions and land tenure, mediate how remittances are used, what land use decisions are made and thus, how forest cover changes. Some scholars hypothesize that remittances from early and temporary or survival migration are more likely to be invested in urgent consumption needs, while remittances from a later migration stage are rather used for land investments and thus, increase pressure on the natural resource base (Carte et al. 2019, Angelsen et al. 2020).

Based on this, I suggest that future research should further question the common assumption that migration reduces pressure on natural resources in sending areas while increasing it in receiving areas, with a particular focus on the mediating factors. Therefore, migration impacts in both sending and receiving areas have to be considered. Moreover, to enhance our understanding of the multiple ways the movement of people, their resources, and ideas (as outlined above) connects different places, concepts and methods are needed that facilitate a perspective on how processes in different places can influence each other. The concept of **translocality** (as mentioned earlier), which considers social dynamics and processes across geographical boundaries, could be one way to address some of these questions. Frameworks such as **telecoupling**, which explicitly considers 'socioeconomic and ecological interactions between coupled human and natural systems across distances' (Liu et al. 2013 p. 3) and thus explicitly account for understudied flows and feedback mechanisms between different systems, could be also promising, yet have rarely been applied in the context of migration (Radel et al. 2019).

Further, there is even less known about the magnitude, determinants and destinations of out-migration from forest frontiers (Caviglia-Harris et al. 2013). Based on this and what is outlined above, I would suggest the following questions for future research to be explored in different world regions and biomes: **Under which conditions turns the destination into the origin due to environmental degradation?** Do people become trapped as environmental degradation is undermining the necessary resources to migrate?

Lastly, conducting **empirical fieldwork** in rural Ethiopia was, though a rewarding experience, not always an easy endeavor. During the data collection phases of this thesis, I had to overcome certain challenges, such as spontaneously arising local conflicts and resulting travel limitations, which ultimately hindered data collection or required short-term change of research plans. In light of this, it was certainly crucial to closely engage with local research partners and involve them during most of the research stages of my dissertation. This included, involving them as local advisors and facilitators during the research planning and data collection phases and as a co-researchers and authors for the interpretation and contextualization of the analytical results. Recent developments, such as the COVID-19 crisis and the on-going war in northern Ethiopia, demonstrate that such disruptions as experienced during my dissertation project are not unique but a widespread challenge for place-based research. Thus, flexible research designs, application of remote methods and empowerment of local research partners have become more relevant than ever for future place-based research (for more details see Hermans et al. 2021).

6.5. Conclusion

This work has addressed critical knowledge gaps and methodological challenges in the research on a complex but socially relevant topic – migration in the context of environmental change – and has helped advance current scientific debates. Furthermore, it has also provided place-based and novel insights from Ethiopia that can support local decision makers tackle current challenges in Ethiopia.

By applying qualitative, participatory and quantitative – and partially novel – methods, I showed that the bi-directional linkages between migration and environmental change are mediated by various environmental and non-environmental factors interacting across and within various scales. In the northern rural highlands, changing rainfall patterns and land degradation undermine key household income sources, such as agricultural production, and thus while increasing migration needs, also reduce the ability to migrate. I found that financial and social resources are crucial for households to be able to migrate and are more important than push factors for migration. In Ethiopia's southwestern rainforests, I revealed that agricultural policies, land tenure insecurity, and restricted forest access amplified the impact migration had on the uptake of agricultural activities and the expansion of cropland at the expense of forest. Ultimately, this thesis substantiates that the linkages between migration and environmental change in Ethiopia are multicausal and non-linear.

The empirical evidence provided with this thesis can support local decision makers in Ethiopia to identify promising leverage points with the aim to 1) reduce vulnerabilities and enable voluntary migration out of degrading areas in the northern highlands for farmers and 2) to curb deforestation and adverse impacts for local and migrant communities at the southwestern forest frontier. Supporting in-situ livelihood diversification, e.g. with non-farm activities or mixed agriculture and forest activities, is crucial to diversify income sources and reduce the vulnerability towards environmental change of subsistence farmers, as well as to reduce the pressure on natural resources in both the sending and receiving areas. Further, fostering bottom-up strategies integrating farmers' knowledge and perspectives for soil rehabilitation is most promising to overcome existing hurdles to combat land degradation, and a key leverage on the local level to reduce migration needs in the northern highlands. In addition, improving the land tenure of rural residents and addressing barriers to participate in forest management could help to ease existing tensions and avoid marginalizing diverse communities with different resource use at the southwestern frontier.

APPENDICES

APPENDIX A

(Chapter 4.2)

1. Household characteristics

Table A.1: Household characteristics

Case	Kebele	Household members (past 5 years)	Years of primary and/or secondary education of household head	Months household can sustain from own harvest	Cultivated land (own and shared land) in hectare	Household activities (1=Livestock 2=Cropping 3=Home Gardening 4=Selling eggs 5=Eucalyptus tree 6=Governmental support 7=Wage labor 8=Trading 9=Tailor 10=Honey 11=Renting 12=Cafeteria)	Wealth level (based on household land size, number of oxen and housing)	Household members between 15-49 years (past 5 years)
1	Tincha	5	5	11	1	1, 2, 8	middle	2
2	Tincha	6	1	12	0,375	2, 4	better off	4
3	Tincha	2	4	4	0,25	2, 8, 11	low	2
4	Tincha	7	6	12	1,5	1, 2, 5, 8, 9, 11,12	better off	4
5	Tincha	7	0	11	1	1, 2, 3, 8	middle	4
6	Tincha	2	0	3	0,5	2, 6, 8, 7	low	2
7	Tincha	12	4	12	1,25	1, 2, 8	better off	6

8	Tincha	12	7	12	1,5	1, 2, 8, 12	better off	6
9	Adej	4	0	9	0,75	1, 2, 3, 4, 6	middle	3
10	Adej	5	5	8	1	1, 2, 4, 5	middle	2
11	Adej	4	0	12	1	1, 2, 3, 4, 5, 6	better off	3
12	Adej	4	0	12	1	1, 2, 3, 5, 6	better off	4
13	Adej	2	0	6	0,5	6	low	0
14	Adej	7	0	8,5	1,625	1, 2, 3, 4, 5, 6	middle	4
15	Adej	8	0	8,5	1,5	1, 2, 3, 5	better off	5
16	Adej	4	0	4,5	0,5	1, 2, 4, 6	low	3
17	Teikake	8	4	6	1,5	1, 2, 4	middle	5
18	Teikake	7	2	6	0,875	1, 2, 7, 8	low	4
19	Teikake	5	0	10	0,5	1, 2, 3	middle	2
20	Teikake	7	0	12	1,625	1, 2, 3	better off	2
21	Teikake	2	0	9	1,75	1, 2, 3,7	middle	2
22	Amba Gibi	5	0	12	1,375	1, 2, 4, 5, 8	better off	5
23	Amba Gibi	6	0	11	1,25	1, 2, 4, 5	better off	5

24	Amba Gibi	6	0	6	1	1, 2, 4, 5, 8	middle	3
25	Amba Gibi	6	3	7,5	0,875	1, 2, 5	low	3
26	Amba Gibi	5	4	7	0,625	1, 2, 4, 5, 8	middle	3
27	Amba Gibi	7	8	5	0,625	1, 2, 4, 5, 8	middle	5
28	Amba Gibi	3	4	8	0,625	1, 2, 4, 5, 8	low	1
29	Kundi	10	0	12	1,5	1, 2, 3, 5	better off	8
30	Kundi	9	0	12	1	1, 2, 5	better off	8
31	Kundi	6	7	12	1	1, 2, 5	middle	5
32	Kundi	5	0	9	0,5	1, 2, 4, 5	middle	3
33	Kundi	2	0	7	0,25	2, 6	low	1
34	Kundi	8	7	6	0,375	1, 2, 5, 10	middle	4
35	Kundi	8	0	6	1	1, 2, 5, 6	low	7
36	Alansha	8	0	2	0,25	1, 2, 5, 7	middle	4
37	Alansha	8	0	4	0,5	1, 2, 3, 5, 7	low	5

38	Alansha	6	11	12	0,5	1, 2, 3, 4	better off	4
39	Alansha	5	3	7,5	0,75	1, 2, 3, 5, 7	better off	3
40	Alansha	6	0	4,5	0,5	1, 2, 3, 4, 5, 6	low	5
41	Alansha	5	7	4,5	0,5	1, 2, 3, 7	middle	2
42	Alansha	6	0	9	0,5	1, 2, 4, 7	middle	3

2. Calibrated data[21]

Table A.2: Calibrated data set, which was used to produce the truth table

Case	landscar	non-farm	belgonly	marketroad	migratexper	migration
1	0	0	0	1	0	0
2	1	0	0	1	1	1
3	1	1	0	1	0	1
4	0	1	0	1	0	1
5	1	0	0	1	0	0
6	1	1	0	1	0	0
7	0	0	0	1	0	0
8	1	1	0	1	1	1
9	1	0	1	0	1	0
10	0	1	1	0	0	0
11	0	1	1	0	0	0
12	1	1	1	0	0	0
13	1	0	1	0	1	0
14	1	1	1	0	1	1
15	0	1	1	0	1	1
16	1	0	1	0	1	0
17	1	0	0	0	1	1
18	1	1	0	0	1	1
19	0	0	0	0	0	0
20	0	0	0	0	0	0

[21] Calibrated data are also openly available on https://osf.io/5tm92/(DOI 10.17605/OSF.IO/5TM92)

21	1	0	0	0	0	0
22	1	1	0	0	1	1
23	0	1	0	0	0	0
24	1	1	0	0	0	0
25	1	1	0	0	0	0
26	1	1	0	0	0	1
27	1	1	0	0	1	1
28	1	1	0	0	1	1
29	0	1	0	1	1	1
30	0	1	0	1	1	1
31	0	1	0	1	1	1
32	1	1	0	1	0	0
33	1	0	0	1	0	0
34	1	1	0	1	0	0
35	0	1	0	1	1	1
36	1	1	0	1	1	1
37	1	1	0	1	0	0
38	1	0	0	1	1	1
39	0	1	0	1	1	1
40	1	1	0	1	1	1
41	0	1	0	1	0	0
42	1	1	1	1	0	0

3. Necessity analysis

Table A.3: Results for necessity analysis

Condition	Consistency
landscar	0.65
~landscar	0.35
non-farm	**0.85**
~non-farm	0.15
belgonly	0.10
~belgonly	**0.90**
marketroad	0.60
~marktroad	0.40
migratexper	**0.85**
~miratexper	0.15

The absence of *belgonly (~belgonly)* passed the respective threshold of 0.9 and hence, is a quasi-necessary condition for migration. The next highest values for consistency were reached by the presence of *non-farm* and *migratexper*, with each 0.85. This implies that 85% of the migration households employ non-farm in-situ diversification and/or have migration experience.

4. Truth table

Table A.4: Truth table which was used for the logical minimization process

lands car	non-farm	belg only	market road	migrat exper	number	migra tion	raw	consist.	PRI
0	1	1	0	1	1	1	1.0000	1.0000	1.0000
1	0	0	0	1	1	1	1.0000	1.0000	1.0000
1	1	1	0	1	1	1	1.0000	1.0000	1.0000
1	0	0	1	1	2	1	1.0000	1.0000	1.0000
1	1	0	1	1	3	1	1.0000	1.0000	1.0000

1	1	0	0	1	4	1	1.0000	1.0000	1.0000
0	1	0	1	1	5	1	1.0000	1.0000	1.0000
0	1	0	1	0	2	0	0.5000	0.5000	0.5000
1	1	0	0	0	3	0	0.3333	0.3333	0.3333
1	1	0	1	0	5	0	0.2000	0.2000	0.2000
0	1	0	0	0	1	0	0.0000	0.0000	0.0000
1	0	0	0	0	1	0	0.0000	0.0000	0.0000
1	1	1	0	0	1	0	0.0000	0.0000	0.0000
1	1	1	1	0	1	0	0.0000	0.0000	0.0000
0	0	0	0	0	2	0	0.0000	0.0000	0.0000
0	0	0	1	0	2	0	0.0000	0.0000	0.0000
0	1	1	0	0	2	0	0.0000	0.0000	0.0000
1	0	0	1	0	2	0	0.0000	0.0000	0.0000
1	0	1	0	1	3	0	0.0000	0.0000	0.0000

5. Robustness tests

In total, I performed 15 tests and five different types of tests. First, I briefly summarize the main outcomes for each test type. All tests performed including detailed explanations and respective parameters can be found in Table E.2. The additional condition sets used for the robustness test are listed in Table E.1. The consistency of all solutions yielded 1.00.

Changing parameters[22]**:** I increased the frequency threshold up to two (test 1), which means that only the combinations of conditions which are covered by two empirically observed cases enter the QCA algorithm. The resulting solution formula is a superset[23] of the main solution as only *non-farm diversification* is not part of the solution anymore. The solution coverage decreases slightly to 0.75.

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[22] For a truth table row, only consistency scores of 0.75 or above are considered acceptable for including them in the logical minimization (Schneider and Wagemann 2012). As all our rows passing this threshold had a consistency of 1.00, there was no room for modified analyses here.

Altering cases: For four tests I altered the set of cases included in the analysis. First, after one another, I excluded the kola (test 2), weyna dega (test 3) and lastly the dega kebeles (test 4) from the analysis (see Table E.2). Second, I excluded the kebele Teikake (test 5) as it is characterized by slightly different livelihood activities and socioeconomic features as compared to the other kola kebele (Kundi). The main solution is reproduced by three tests; the exception is the test excluding the dega kebeles. The condition *belgonly* becomes irrelevant without the dega kebeles, as no cases which are fully dependent on Belg remain for the analysis. The pathway including the main solution has the highest coverage among all tests. Without the dega kebeles, migration experience alone is sufficient for 79% of the migrating households (raw coverage 0.79).

Altering causal conditions: For another four tests, I substituted the condition *non-farm* by a condition related to the usage of eucalyptus trees (*trees*) and selecting households engaged in *trees* (test 6). Eucalyptus is a comparatively undemanding tree species and once the seedlings are sufficiently strong a lack in rainfall or season failure may decelerates their growth but will not destroy them quickly. Eucalyptus trees are mainly used for construction work and some farmers sell their surplus at the local markets to generate additional income (every 5-6 years). Additionally, I substituted *non-farm* by only extracting households running small businesses such as a cafeteria (*smallbusi)* (test 7). In the modified analyses, *trees* substitute *non-farm* for the first causal pathway, whereas *smallbusi* did not appear in the solution term. Second, I added the condition *rainimp* and *edu10* as I expect them to motivate migration (test 8 and 9). R*ainimp* relates to the perceived impact of rainfall variability or changes and included any perceptions of changes in season duration, start and end date as well as intensity of amount of rainfall. *Edu10* includes households having members with at least 10 years of formal education and which are between 15 and 49 years old (peak migration age). Both analyses reproduced the main solution.

Altering calibrations: For four additional tests I altered the calibration decisions slightly. First, I excluded one after another Alansha (test 10) and Tincha (test 11) form *marketroad* as both kebeles fulfil one of the two specifications only (i.e., having an own market or an asphalt road). The main solution was exactly reproduced (test 11) or a subset of the result (test 10). Second, I excluded eucalyptus trees from the set of *non-farm* (test 12), as eucalyptus trees depend on natural resources (soil and water conditions) and as such are potentially vulnerable to environmental changes. Third, two households (ID 12 and 16), which were excluded from the initial set of migrating households as migration happened because of marriage and education were recalibrated as migrating households (test 13). For test 12 and 13 the main solution was in a sub- or superset relationship[23].

Excluding groups of cases: For two final robustness tests, I excluded certain groups of cases. First, I excluded all female-headed households from the analysis as these households are considered as particularly vulnerable towards environmental change (test 14). In a second test, I excluded the household which reported not to suffer any considerable impacts of rainfall changes and/or variability as they can be considered as less vulnerable at least towards the respective changes (test 15). Both tests reproduced the main solution and slightly increased (test 14) or decreased (test 15) the solution coverages.

Table A.5: Additional sets used for robustness test

Cases	trees	smallbusi	rainimp	edu10
1	0	1	0	0
2	0	0	1	0
3	0	1	1	1
4	1	1	1	1
5	0	1	1	0
6	0	1	1	0
7	0	1	1	1
8	0	1	1	0
9	0	0	1	0
10	1	0	1	0
11	1	0	1	0
12	1	0	1	1
13	0	0	1	0
14	1	0	1	0
15	1	0	1	0

[23] A subset relationship implies for instance that a condition x is (fully) part of the outcome y. A superset relationship implies that y (fully) covers x.

16	0	0	1	0
17	0	0	1	1
18	0	1	1	0
19	0	0	0	0
20	0	0	0	0
21	0	0	1	0
22	1	1	1	1
23	1	0	0	0
24	1	1	1	0
25	1	0	1	1
26	1	1	1	0
27	1	1	0	1
28	1	1	1	0
29	1	0	0	0
30	1	0	1	1
31	1	0	1	0
32	1	0	1	0
33	0	0	1	0
34	1	0	1	1
35	1	0	1	1
36	1	0	1	1
37	1	0	1	1
38	0	0	1	1
39	1	0	0	1
40	1	0	1	1
41	0	0	1	0
42	0	0	1	0

Table A.6: Robustness tests and description for the main solution and consistency for the conditions during the necessity analysis[24]

Nb.	Type	Test	Solution formula	Coverage [25]	Consistency during the necessity analysis
0	**/**	**Main analysis**	**migratexper*(~belgonly+non-farm) -> migration**	**0.85**	**~belgonly: 0.90** **non-farm: 0.85** **migratexper: 0.85**
1	Changed parameters	Frequency cut-off 2	migratexper*~belgonly-> migration	0.75	~belgonly: 0.90 non-farm: 0.85 migratexper: 0.85
		I increased the frequency threshold up to two, which means that only the combinations of conditions which are covered by two empirically observed cases enter the QCA algorithm. The resulting solution formula is a superset of the main solution as only *non-farm* is not part of the solution anymore. .			
2	Altering cases	Without kola kebeles	migratexper*(~belgonly+non-farm+marketroad) -> Migration	0.79	~belgonly: 0.86 non-farm: 0.86

[24] Robustnesstest data are also openly available on https://osf.io/5tm92/(DOI 10.17605/OSF.IO/5TM92)
[25] The consistency value for all solution formulas for sufficiency is 1.00.

					migratexper: 0.79
		I excluded all cases located in the kebeles Teikake and Kundi (kola agro-ecological zone). The main solution is still a subset of the solution term and has still the highest raw coverages (0.64 and 0.64). The additional pathway (*migratexper**marketroad*) has a raw coverage of 0.43.			
3		Without Weyna dega kebeles	migratexper*(~belgonly+non-farm) -> migration	1.00	~belgonly: 0.83 non-farm: 0.83 migratexper: 1.00
		I excluded all cases located in the kebeles Tincha and Amba Gibi (weyna dega agro-ecological zone). The solution term does not differ from the main analysis. The raw coverage of the two pathways is 0.83 for both and the solution coverage increases.			
4		Without dega kebeles	migratexper + (~landscarc*non-farm *marketroad) -> migration	0.86	~belgonly: - non-farm: 0.86 migratexper: 0.79
		I excluded all cases located in the kebeles Adej and Alansha (deag agro-ecoogical zone). Cases only using Belg rain deleted as well. *Migratexper* has the highest raw coverage with 0.79. The second pathway has a raw coverage of 0.36.			
5		Without Teikake	migratexper*(~belgonly+non-farm+marketroad) -> migration	0.83	~belgonly: 0.89 non-farm: 0.89

					migratexper: 0.83
		I excluded the kebele Teikake as it is characterized by slightly different livelihood activities and socioeconomic features The main solution is still a subset of the solution term and has still the highest raw coverages (0.72 and 0.72). The additional pathway (*migratexper*marketroad*) has a raw coverage of 0.55.			
6		+ *trees* - *non-farm*	migratexper*(~belgonly+trees) + (~landscar*trees*marketroad) -> migration	0.9	
		I substituted *non-farm* by a new condition called *trees*, which only included activities related to eucalyptus trees. The raw coverage for the first pathway *(~belgonly*migratexper*) remains with 0.75, the coverage for the second pathway (*trees*migratexper*) is 0.6 and for the third pathway 0.3.			~belgonly: 0.86 non-farm: 0.86 migratexper: 0.79
7	Altering causal conditions	+ *smallbusin* - *non-farm*	migratexper*(~belgonly+~landscar) -> migration	0.8	~belgonly: 0.90 non-farm: - migratexper: 0.85
		I substituted *non-farm* by a new condition called *smallbusi*, which includes only small business activities as renting own house, running a cafeteria, trading with agriculture products or producing cloths or handcrafts. The first pathway remains with the same coverage but absence of *landscar* becomes - in combination with *migratexper* - a second causal pathway to explain *migration* (raw coverage 0.3).			
8		+ *rainimp*	migratexper*(~belgonly+non-farm) -> migration	0.85	~belgonly: 0.90

					non-farm: 0.85 migratexper: 0.85 rainimp: 0.85
		I added *rainimp* (households perceived changed rainfall patterns). The solution term and coverage do not differ from the main analysis.			
9		+ *edu10*	migratexper*(~belgonly+non-farm) + (~landscar*non-farm*edu10) -> migration	0.9	~belgonly: 0.90 non-farm: 0.85 migratexper: 0.85
		I added *edu10* (a household having at least one member with at least 10 years of formal education). The main solution is still a subset of the solution term and has still the highest raw coverage scores (0.7 and 0.75). The additional pathway has a raw coverage of 0.20.			
10	Altering calibrations	Alansha remote	migratexper*(~belgonly+non-farm) + (~landscar*non-farm*marketroad) -> migration	0.9	~belgonly: 0.86 non-farm: 0.86 migratexper: 0.80
		Alansha has an asphalt road but not an own market and hence, is an intermediate category within *marketroad*. I re-calibrated all households located in Alansha as absent within this condition. The main solution is still in a subset relationship and has still the highest coverage.			

11		Tincha remote	migratexper*(~belgonly+non-farm) -> migration	0.85	~belgonly: 0.90 non-farm: 0.85 migratexper: 0.85
		Tincha has an own market but not an asphalt road and hence, is an intermediate category within *marketroad*. I re-calibrated all households located in Tincha as absent within this condition. The solution term and coverage do not differ from the main analysis.			
12		Non-farm (in-situ) diversification excl. eucalyptus trees	migratexper*(~belgonly+~landscar) -> migration	0.80	~belgonly: 0.90 non-farm: 0.35 migratexper: 0.85
		I re-calibrated *non-farm*. Any activities regarding eucalyptus trees are not considered as non-farm in-situ diversification. Coverage decreases to 0.8 and *non-farm* disappears from the solution. Instead, absence of *landscar* becomes in combination with *migratexper* a causal pathway to explain *migration*.			
13		ID 12 and ID 16 as migrating hh	migratexper*(~belgonly+non-farm) + (landscarc*non-farm*belgonly*~marketroad) -> migration	0.81	~belgonly: 0.82 non-farm: 0.82 migratexper: 0.82

		In the households with ID 12 and ID 16 members migrated for exclusively marital or educational purposes, and hence are not considered as migrants based on my definition. Nevertheless, I re-calibrated these two households as migrating households. The main solution is still in a subset relationship and has still the highest coverage. The additional pathway has a raw coverage of 0.09 as it only appears due to the two re-calibrated households.			
14	Exclude potential outliers	Exclude female headed households (7 cases)	migratexper*(~belgonly+non-farm) -> migration	0.88	~belgonly: 0.88 non-farm: 0.88 migratexper: 0.88
		I excluded all female-headed households. The main solution is exactly reproduced.			
15		Exclude household without rainfall variability impact (7 cases)	migratexper*(~belgonly+non-farm) -> migration	0.82	~belgonly: 0.88 non-farm: 0.82 migratexper: 0.82
		I excluded all households which experienced no impacts of rainfall changes or variabilities. The main solution is exactly reproduced.			

* = and   + = or   ~ = absence of   -> = sufficient for

6. Interview guideline for semi-structured household interviews

HH type (migrant/non-migrant)

1. Household ID and REC		2. Date of interview	
3. Time of interview (start)		4. Woreda	
5. Kebele		6. Subkebele	
7. Village		8. Agroecology	
9. Household ethnicity		10. Religion	
11. Household mother tongue		12. Nb. of household members[1]	

12.1 Household member (past 20years)	12.2 Sex and age	12.3 Relationship to hh head	12.4 Marital status	12.5 Years of education	12.6 Migration status	12.7 Migration type[2] (1=temporary, 2= seasonal, 3=permanent)	12.8. 1= Present, 2= absent (>1month) currently	12.9 Main activity
*								

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">* fill respondent in first line</td></tr>
<tr><td colspan="9">Relationship: 1= head, 2= husband/wife, 3= son/daughter, 4=father/mother, 5= brother/sister, 6= uncle/aunt, 7= cousin, 8= niece/nephew, 9=children in law, 10=parent in law, 11= other (specify)</td></tr>
<tr><td colspan="9">Marital status: 1=single, 2=married, 3= widowed, 4=divorced, 5=separated, 6=other (specify)</td></tr>
<tr><td colspan="9">Migration status: 1=never migrated, 2=current internal, 3=current international, 4= returned internal, 5= returned international</td></tr>
<tr><td colspan="9">Employment: 1=farmers, independent, 2=cattle raiser, 3=farm worker, 4=road construction worker, 5=trade/retail, 6= transport, 7=household service, 8=community service, 9=student, 10=unemployed, 11=daily labor, 12=other (specify)</td></tr>
</table>

13. Which rainy season(s) does your hh use? (Belg, Kiremt, Both)
14. Which harvest season(s) does your hh use? (Belg, Meher, Both)
15. Which harvest season(s) does your hh use? (Belg, Meher, Both)
16. How many months after harvest can your hh sustain without external input or support in order to feed all hh member? What kind of input and support and from whom? Indicated month of harvest
17. Wealth indicators

Number of oxen:

Number of iron sheets used for roof:

Months household is food secure:

Average yield per year:

18. Are you or another hh member part of any organization? (e.g. village/regional council, farmer organization, church, etc.)
19. Does your hh own land? If yes, what type of land and what is the current size of your households land (in timad)? What is the current size of your hh cultivated land (in timad)? For Belg and for Meher?

Own land:

Irrigated land:

Cultivated land:

Grazing land:

Do you share this land with someone else?

Do you rent this land to someone else?

Total cultivated land:

20. Does your hh own land? If yes, what type of land and what is the current size of your households land (in timad)? What is the current size of your hh cultivated land (in timad)? For Belg and for Meher?

21. Does your hh work on somebody else's land or on shared land? What is the current size of this land (in timad)? What is the current size of your hh cultivated land (in timad)? For Belg and for Meher? (mägazo or fixed cash rent)

Rented land:

Shared land:

22. What were major events for your household within the past 20 years?

23. What were major changes for your household within the past 20 years?

24. What challenges do you face in your everyday life?

25. How does your household earn a living?

26. How would you describe your land use

27. How would you describe the status of you hh land and changes over past 20 years?

28. Could you describe the direct and indirect impact of land degradation on your hh resources, assets and activities?

29. What did you do to overcome the mentioned impacts of land degradation?

30. How do you feel about your land size?

31. Could you describe the direct and indirect impacts of small/no land size on your hh resources, assets and activities?

32. What did you do to overcome the mentioned impacts of small land size/no land holdings?

33. How would you describe rainfall today and changes within past 20 years?

34. Could you describe the mentioned direct and indirect impacts rainfall variability on your hh resources, assets and activities?

35. What did your household do to overcome the impacts of rainfall variability?

36. What markets do your household use and how you get to these markets?

37. Do you think your household location hampers or adversely affect the frequency of the market visits?

38. What would your hh need to improve its overall well-being?

39. What else could be supportive for your household to deal with (changes in) land degradation (and land size)?

40. What else could be supportive for your household to deal with rainfall variability?

Migration part (*only if hh has migrants)

41. *HH member ID	41.1 Trips and duration (specify year and month of departure (and return))	39.2 Destination (specific) and activity	39.3 Reasons for leaving and returning	39.4 Economic activity before moving

42. *Can you describe what shaped the decision of migration in your household? Which arguments/circumstances etc. were relevant for the most recent <u>temporary</u> migratory decision?

43. *Can you describe what shaped the decision of migration in your household? Which arguments/circumstances etc. were relevant for the most recent <u>permanent</u> migratory decision?

44. *Did impacts of rainfall variability (specify impacts from sections above) affect the decision to move to other places within your household?

45. *Did impacts of land degradation (specify from sections above) affect the decision to move to other places within your household?)

46. *Did impacts of land availability (specify from sections above) affect the decision to move to other places within your household?)

47. *What was the reason of household member who returned?

48. *Do household members who are currently away intend to return?

49. *Has your household ever received money, materials or other sort of help from member who migrated?

50. *Does migration changed the overall situation of your household?

For migrant and non-migrant households

51. If somebody in the household has to migrate, who is the most likely migrant from your household?

52. Who is the least likely person from your household to migrate and why?

53. What would be possible reasons for you to leave the Kebele?

54. Which are the reasons why you did not move away and stayed home?

55. How have your household earned a living within the past 2 years? Which household member(s) are involved in these activities? Which products are gained and what (share) your hh need for its own subsistence?

56. What is your average total household income (in birr) and yield per season within the past 2 years? Do you have additional savings? Do you have loans? From whom do you get them? What are the reasons for borrowing money?

APPENDIX B

(Chapter 4.3)

1. **Questionnaire for the quantification of the Bayesian network**

Name:

Affiliation:

Position:

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1. **Environmental condition for agriculture**

Q1.1.1: Imagine a situation with low soil degradation, low precipitation variability and in which Belg & Kiremt are available as rain seasons. In which state do you think would the environmental condition for agriculture be – poor or good?

☐ poor ☐ good

Q1.1.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the environmental conditions would be in the state you chose in question Q1.1.1.

______ out of 10

Q1.2.1: Imagine a situation with high soil degradation, high precipitation variability and in which only Belg is available as rain season. In which state do you think would the environmental condition for agriculture be – poor or good?

☐ poor ☐ good

Q1.2.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the environmental conditions would be in the state you chose in question Q1.2.1.

______ out of 10

Q1.3.1: Imagine a situation with high soil degradation, low precipitation variability and in which Belg & Kiremt are available as rain seasons. In which state do you think would the environmental condition for agriculture be – poor or good?

☐ poor ☐ good

Q1.3.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the environmental conditions would be in the state you chose in question Q1.3.1.

______ out of 10

Q1.4.1: Imagine a situation with low soil degradation, high precipitation variability and in which Belg & Kiremt are available as rain seasons. In which state do you think would the environmental condition for agriculture be – poor or good?

☐ poor ☐ good

Q1.4.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the environmental conditions would be in the state you chose in question Q1.4.1.

______ out of 10

Q1.5.1: Imagine a situation with low soil degradation, low precipitation variability and in which only Kiremt is available as rain season. In which state do you think would the environmental condition for agriculture be – poor or good?

☐ poor ☐ good

Q1.5.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the environmental conditions would be in the state you chose in question Q1.5.1.

______ out of 10

Q1.6.1: Imagine a situation with low soil degradation, low precipitation variability and in which only Belg is available as rain season. In which state do you think would the environmental condition for agriculture be – poor or good?

☐ poor ☐ good

Q1.6.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the environmental conditions would be in the state you chose in question Q1.6.1.

______ out of 10

----

2. Agricultural production

Q2.1.1: Imagine a situation with high land size / average HH size (i.e. above 0.5 ha per household), good environmental condition for agriculture and technologies available to the household. Would you think the agricultural production to be sufficient or not sufficient to fulfill household's subsistence needs?

☐ sufficient ☐ not sufficient

Q2.1.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the agricultural production would be in the state you chose in question Q2.1.1?

______ out of 10

Q2.2.1: Imagine a situation with low land size / average HH size (i.e. below 0.5 ha per household), poor environmental condition for agriculture and no technologies available to the household. Would you think the agricultural production to be sufficient or not sufficient to fulfill household's subsistence needs?

☐ sufficient ☐ not sufficient

Q2.2.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the agricultural production would be in the state you chose in question Q2.2.1?

______ out of 10

Q2.3.1: Imagine a situation with low land size / average HH size (i.e. below 0.5 ha per household), good environmental condition for agriculture and technologies available to the household. Would you think the agricultural production to be sufficient or not sufficient to fulfill household's subsistence needs?

☐ sufficient ☐ not sufficient

Q2.3.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the agricultural production would be in the state you chose in question Q2.3.1?

______ out of 10

Q2.4.1: Imagine a situation with high land size / average HH size (i.e. above 0.5 ha per household), good environmental condition for agriculture and no technologies available to the household. Would you think the agricultural production to be sufficient or not sufficient to fulfill household's subsistence needs?

☐ sufficient ☐ not sufficient

Q2.4.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the agricultural production would be in the state you chose in question Q2.4.1?

______ out of 10

Q2.5.1: Imagine a situation with high land size / average HH size (i.e. above 0.5 ha per household), poor environmental condition for agriculture and technologies available to the household. Would you think the agricultural production to be sufficient or not sufficient to fulfill household's subsistence needs?

☐ sufficient ☐ not sufficient

Q2.5.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the agricultural production would be in the state you chose in question Q2.5.1?

______ out of 10

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3. Non-farm activities besides cropping and livestock keeping

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Q3.1.1: Imagine a situation with ample job opportunities and good environmental condition for agriculture. Would you think a household would be engaged in non-farm activities besides cropping and livestock keeping or not?

☐ yes ☐ no

Q3.1.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the non-farm activities would be in the state you chose in question Q3.1.1?

______ out of 10

Q3.2.1: Imagine a situation with ample job opportunities and poor environmental condition for agriculture. Would you think a household would be engaged in non-farm activities besides cropping and livestock keeping or not?

☐ yes ☐ no

Q3.2.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the non-farm activities would be in the state you chose in question Q3.2.1?

______ out of 10

Q3.3.1: Imagine a situation with low job opportunities and good environmental condition for agriculture. Would you think a household would be engaged in non-farm activities besides cropping and livestock keeping or not?

☐ yes ☐ no

Q3.3.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the non-farm activities would be in the state you chose in question Q3.3.1?

______ out of 10

Q3.4.1: Imagine a situation with low job opportunities and poor environmental condition for agriculture. Would you think a household would be engaged in non-farm activities besides cropping and livestock keeping or not?

☐ yes ☐ no

Q3.4.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the non-farm activities would be in the state you chose in question Q3.4.1?

______ out of 10

----

4. Migration

Q4.1.1: Imagine a situation in which the household's agricultural production is sufficient to fulfill household's subsistence needs, the household member has a positive personal attitude towards migration and the household is engaged in non-farm activities. Would you think the household member would migrate or not?

☐ yes ☐ no

Q4.1.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the migration would be in the state you chose in question 4.1.1?

______ out of 10

Q4.2.1: Imagine a situation in which the household's agricultural production is not sufficient to fulfill household's subsistence needs, the household member has a negative personal attitude towards migration and the household is not engaged in non-farm activities. Would you think the household member would migrate or not?

☐ yes ☐ no

Q4.2.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the migration would be in the state you chose in question 4.2.1?

______ out of 10

Q4.3.1: Imagine a situation in which the household's agricultural production is not sufficient to fulfill household's subsistence needs, the household member has a positive personal attitude towards migration and the household is engaged in non-farm activities. Would you think the household member would migrate or not?

☐ yes ☐ no

Q4.3.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the migration would be in the state you chose in question 4.3.1?

______ out of 10

Q4.4.1: Imagine a situation in which the household's agricultural production is sufficient to fulfill household's subsistence needs, the household member has a negative personal attitude towards migration and the household is engaged in non-farm activities. Would you think the household member would migrate or not?

☐ yes ☐ no

Q4.4.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the migration would be in the state you chose in question 4.4.1?

______ out of 10

Q4.5.1: Imagine a situation in which the household's agricultural production is sufficient to fulfill household's subsistence needs, the household member has a positive personal attitude towards migration and the household is not engaged in non-farm activities. Would you think the household member would migrate or not?

☐ yes ☐ no

Q4.5.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the migration would be in the state you chose in question 4.5.1?

______ out of 10

---

5. Personal attitude towards migration

Q5.1.1: Imagine a situation with positive social norm and migration experience available in the social network of the household. Would you think the household member to have a positive or negative attitude towards migration?

☐ positive ☐ negative

Q5.1.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the attitude towards migration would be in the state you chose in question Q5.1.1?

______ out of 10

Q5.2.1: Imagine a situation with positive social norm and migration experience is not available in the social network of the household. Would you think the household member to have a positive or negative attitude towards migration?

☐ positive ☐ negative

Q5.2.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the attitude towards migration would be in the state you chose in question Q5.2.1?

______ out of 10

Q5.3.1: Imagine a situation with negative social norm and in which migration experience is available in the social network of the household. Would you think the household member to have a positive or negative attitude towards migration?

☐ positive ☐ negative

Q5.3.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the attitude towards migration would be in the state you chose in question Q5.3.1?

______ out of 10

Q5.4.1: Imagine a situation with negative social norm and in which migration experience not available in the social network of the household. Would you think the household member to have a positive or negative attitude towards migration?

☐ positive ☐ negative

Q5.4.2: Imagine that 10 households would be in this situation. Estimate for how many of these ten households the attitude towards migration would be in the state you chose in question Q5.4.1?

______ out of 10

Current state of the entry nodes

---

1. **Soil degradation**

Q1.1: What is the current state of soil degradation averaged over all sites in South Wollo? Low or high?

☐ low ☐ high

Q1.2: Imagine 10 sites in South Wollo. Estimate for how many of these sites the soil degradation on their land is in the state you chose in Q1.1?

______ out of 10

---

2. **Precipitation variability**

Q2.1: What is the current state of precipitation variability averaged over all sites in South Wollo? Low or high?

☐ low ☐ high

Q2.2: Imagine 10 sites in South Wollo. Estimate for how many of these ten sites the precipitation variability is in the state you chose in Q2.1?

______ out of 10

----

3. Rain season

Q3.1: What is the current state of using rain seasons for cropping in South Wollo? Belg, Kiremt or Both?

☐ Belg ☐ Kiremt ☐ Both

Q3.2: Imagine 10 households in South Wollo. Estimate for how many of these ten households use Belg, Kiremt and both seasons?

______ out of 10 use Belg ______ out of 10 use Kiremt ______ out of 10 use both

4. Land size / HH size

Q4.1: What is the current state of land size / HH size averaged over all households in South Wollo? Low or high?

☐ low ☐ high

Q4.2: Imagine 10 households in South Wollo. Estimate for how many of these ten households land size / average HH size is in the state you chose in Q4.1?

______ out of 10

----

5. Availability of technologies

Q5.1: What is the current state of using technologies in South Wollo? Yes or no?

☐ yes ☐ no

Q5.2: Imagine 10 households in South Wollo. Estimate for how many of these ten households using technologies in the state you chose in question Q5.1?

______ out of 10

----

6. Job opportunities

Q6.1: What is the current state of job opportunities in South Wollo? Low or high?

☐ low ☐ high

Q6.2: Imagine 10 households in South Wollo. Estimate for how many of these ten households the job opportunities is in the state you chose in Q6.1?

______ out of 10

----

7. Migration experience in social network

Q7.1: What is the current state of having migration experiences in households' social network in South Wollo? Available or not available?

☐ available ☐ not available

Q7.2: Imagine 10 households in South Wollo. Estimate for how many of these ten households migration experience in social network is in the state you chose in Q7.1?

______ out of 10

----

8. Social norm

Q8.1: What is the current state of social norms regarding migration in South Wollo? Positive or negative?

☐ positive ☐ negative

Q8.2: Imagine 10 households in South Wollo. Estimate for how many of these ten households the social norm is in the state you chose in Q8.1?

______ out of 10

2. Definitions and possible states of influence factors

Factor	States
Soil degradation	Low: No or only very little reduction in soil capacity to provide goods and services for human well-being mainly driven by soil erosion, i.e. the loss of topsoil and nutrients High: Substantial loss of soil capacity to provide goods and services for human well-being mainly driven by soil erosion, i.e. the loss of topsoil and nutrients
Precipitation variability	Low: Precipitation pattern is almost constant over the years High: Precipitation pattern is very different from year to year
Rainy season	Belg: Only Belg season is used for cropping Kiremt: Only Kiremt season is used for cropping Both: Belg and Kiremt season are used for cropping
Environmental condition for agriculture	Poor: Disastrous or poor conditions to perform agriculture due to soil degradation, precipitation variability and which rainy season(s) are/is used for cropping Good: Good or very good conditions to perform agriculture due to soil degradation, precipitation variability and which rainy season(s) are/is used for cropping
Availability of technologies	Yes: Any of the technologies such as SWC measures (e.g. terracing, composting, checkdam, shrubs), availability of agricultural inputs (e.g. fertilizer) and loan is/are available No: No technology such as SWC measures (e.g. terracing, composting, checkdam, shrubs), availability of agricultural inputs (e.g. fertilizer) and loan is available
Land availability	Low: Land per average household size is low, i.e. less than 0.5 ha land per household available High: Land per average household size is high, i.e. more than 0.5 ha land per household available
Job opportunities	Low: No or only very few possibilities to find work outside agriculture

	High: Several or many possibilities to find work outside agriculture
Agricultural production	Not-sufficient: Agricultural production is not sufficient to fulfill household's subsistence need Sufficient: Agricultural production is sufficient to fulfill household's subsistence needs
Non-farm activities	Yes: At least one household member is engaged in non-farm activities such as wage and daily labor (e.g. construction work), running a cafeteria and growing/selling of eucalyptus trees No: No household member is engaged in non-farm activities such as wage and daily labor (e.g. construction work), running a cafeteria and growing/selling of eucalyptus trees
Personal attitude towards migration	Positive: A person thinks of migration as something that is desirable Negative: A person thinks of migration is seen as something that is not desirable
Social norm	Positive: The village community see migration as something that is desirable Negative: The village community see migration as something that is not desirable
Migration experience in social network	Available: Migration experience exists in social network (family members, neighbors or friends) Not available: No migration experience in social network (family members, neighbors or friends)
Migration	Yes: Household member leaves ones household for at least one month, excluding migration for purely marital or educational purposes No: Household member does not leave household for at least one month, excluding migration for purely marital or educational purposes
Additional influence factors discussed during the workshop	

Natural hazards (e.g. landslides and floods)	Was not included in the BN since it is not a slow-onset hazard and thus, beyond the scope of this analysis.
Overgrazing	Is included in the factor soil degradation
Forest covers	Is included in the factor soil degradation

APPENDIX C

(Chapter 5)

1. Forest tenure

Table C.1: Forest tenure and forest products

Forest products/ Tenure system	Customary forest tenure (kobbo system)	State tenure system
Timber	Kobbo owners have use rights and right to inherit, share, rent and divide their forest patches[1].	Permission for harvesting timber from state authorities or (if existent) from forest user group is required. Only selected trees can be harvested. The maximum number of trees, which can be harvested per year, is limited per kebele.
Fuelwood	Kobbo owners have use rights and right to inherit, share, rent and divide their forest patches[1].	Only dead wood can be used.
Honey and wild coffee	Kobbo owners have use rights and right to inherit, share, rent and divide their forest patches (Kassa et al. 2017).	Collecting honey and wild coffee in the forest requires permission from the state authorities or (if existent) from forest user group.
Since when relevant in study area (year)	Traditional forest tenure in the study area and currently still recognized by locals.	Enforced in the study area around 2014.

2. Data preparation

- I received three data sets (one for each kebele) from the survey campaign
- Each data set was cleaned, in order to excluded missing response variables
- Sample was reduced from a total of 230 conducted surveys to 224 surveys (due to large inconsistencies or missing information) which were used for further analysis
- Misspellings were corrected and I created a subset of response and predictors relevant for further analysis
- I imputed missing values for the predictor variables with an iterative nonparametric imputation approach using random forest, which is suitable for mixed data types. I implemented the imputation in R with the 'missForest' package (Stekhoven and Buhlmann 2012). Imputation was done for each kebele data set separately.
- I excluded from imputation all values which were indicated as 'not relevant for a household', e.g. if a household indicated that it never collected honey, the amount of honey collected was excluded from the imputation procedure
- I combined the three kebele data set to one and changed the data format from wide to long, in order to create variables for the year and kebele
- I calculated further numerical variables: e.g. *total available forest area*, *tlu*, etc. based on existing variables
- Dummy variables were created
- I created two subset for each year: 2003 and 2018 (see Table 6 in the main text for all variables included in the final analysis)
- Data preparation was done in R (R Core team 2015)

3. **Distribution of all continuous variables included in the analysis for 2003**

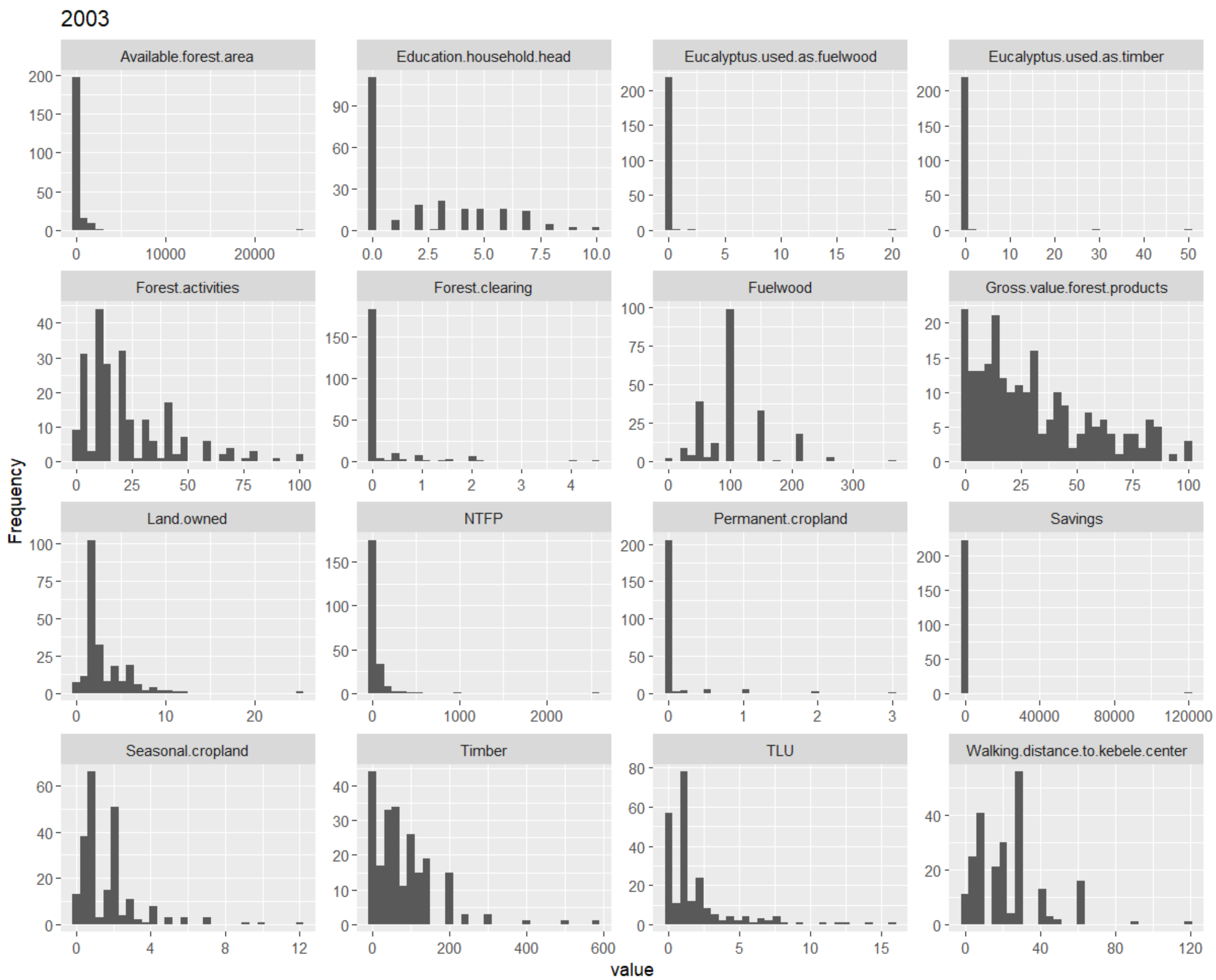

Figure C.1: Histograms of continuous variables in 2003

4. Distribution of all continuous variables included in the analysis for 2018

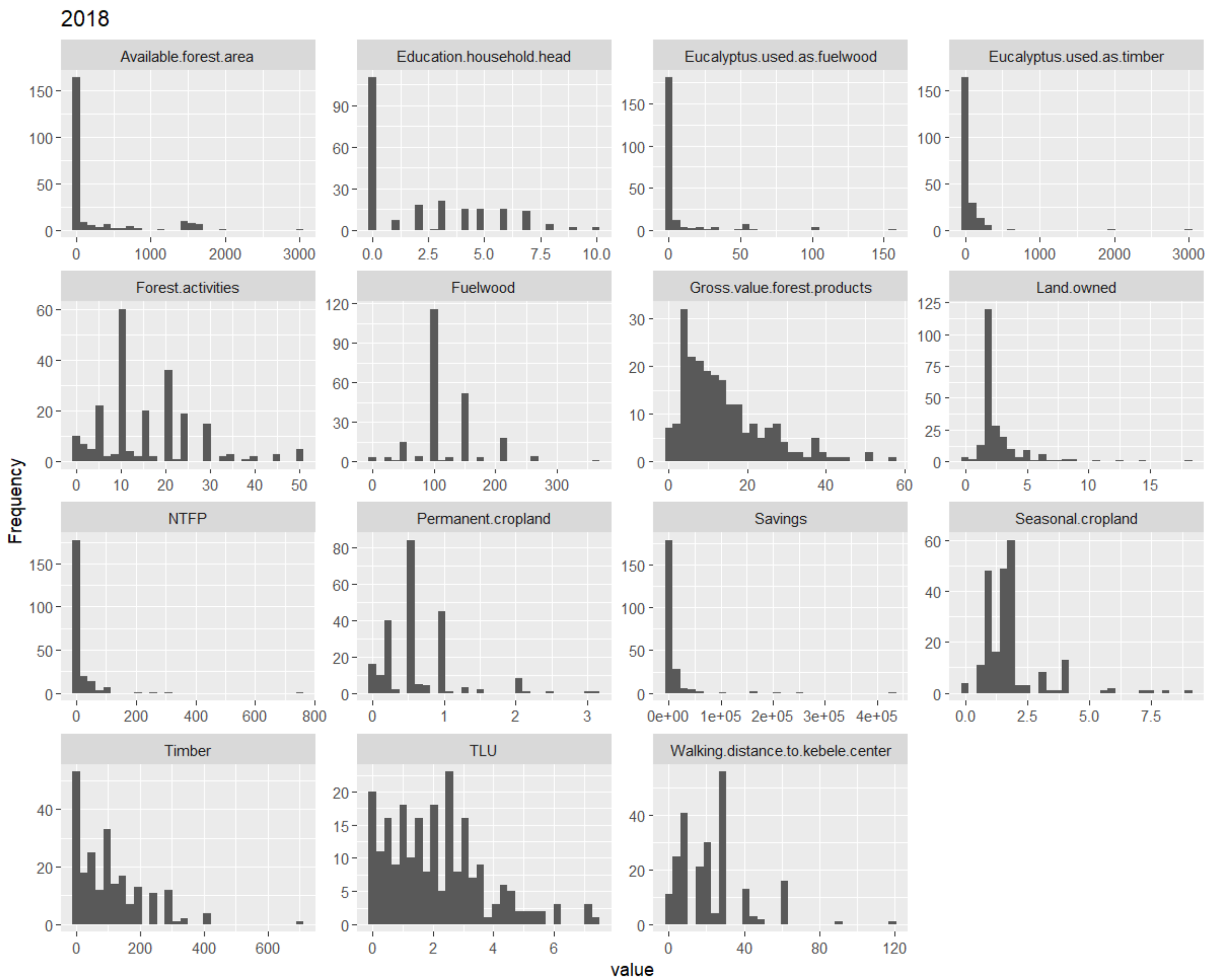

Figure C.2: Histograms of continuous variables in 2018

5. Means per group and standard error for all continuous variables included in the analysis in 2003 and 2018

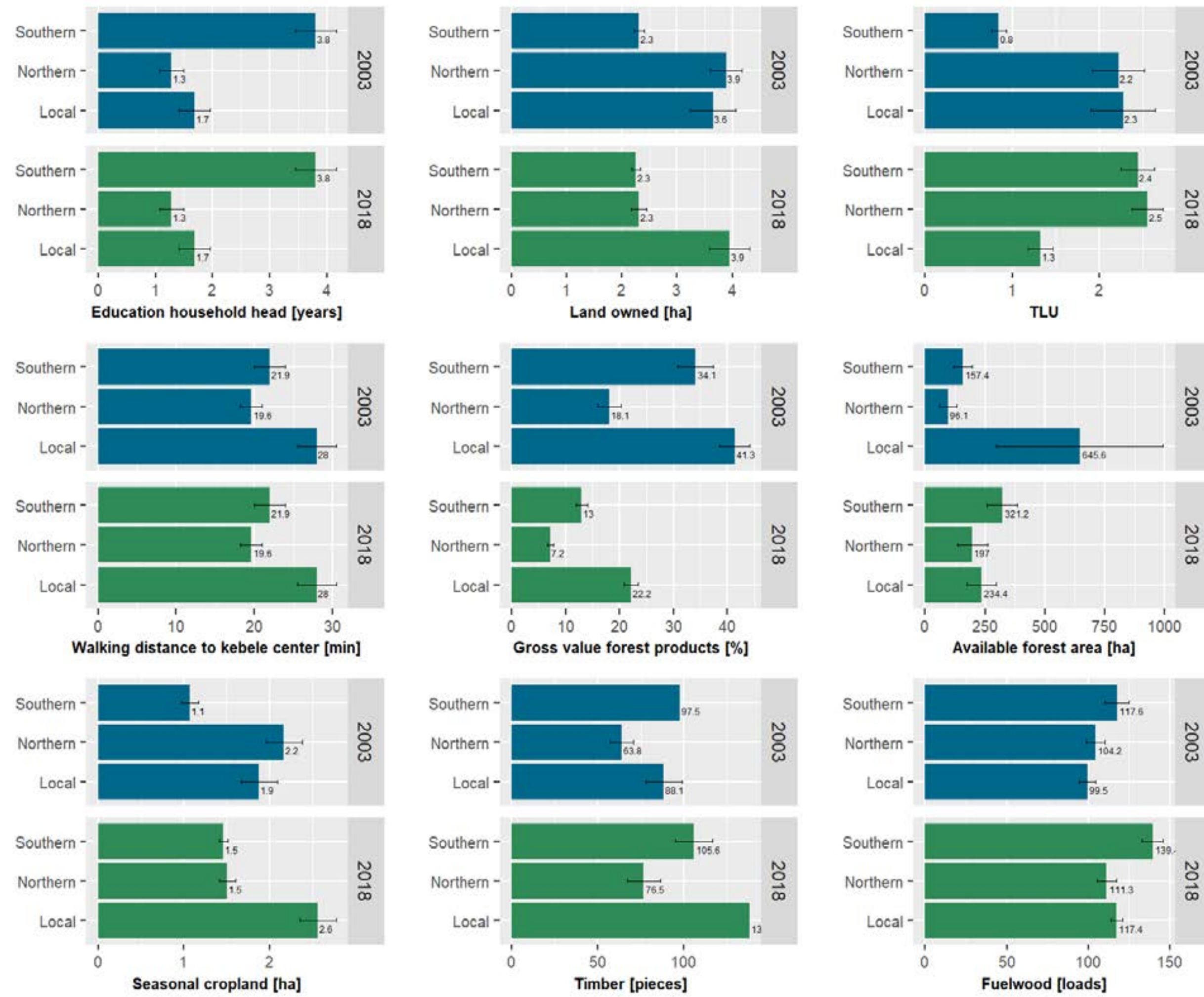

Figure C.3: Means per group and standard error for continuous variables in 2003 (blue) and 2018 (green)

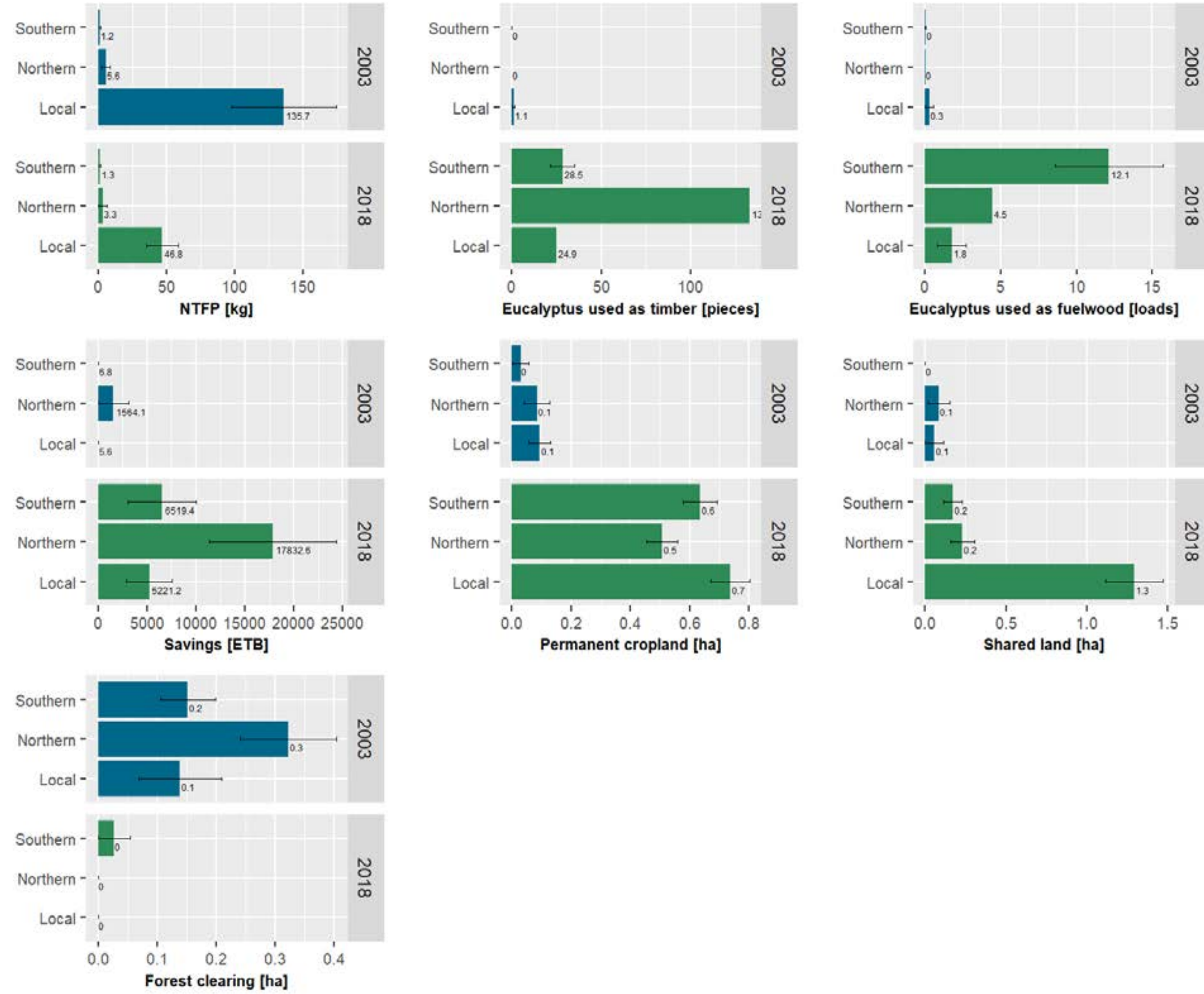

Figure C.3 continued: Means per group and standard error for continuous variables in 2003 (blue) and 2018 (green)

6. Frequencies for all discrete variables included in the analysis in 2003 and 2018

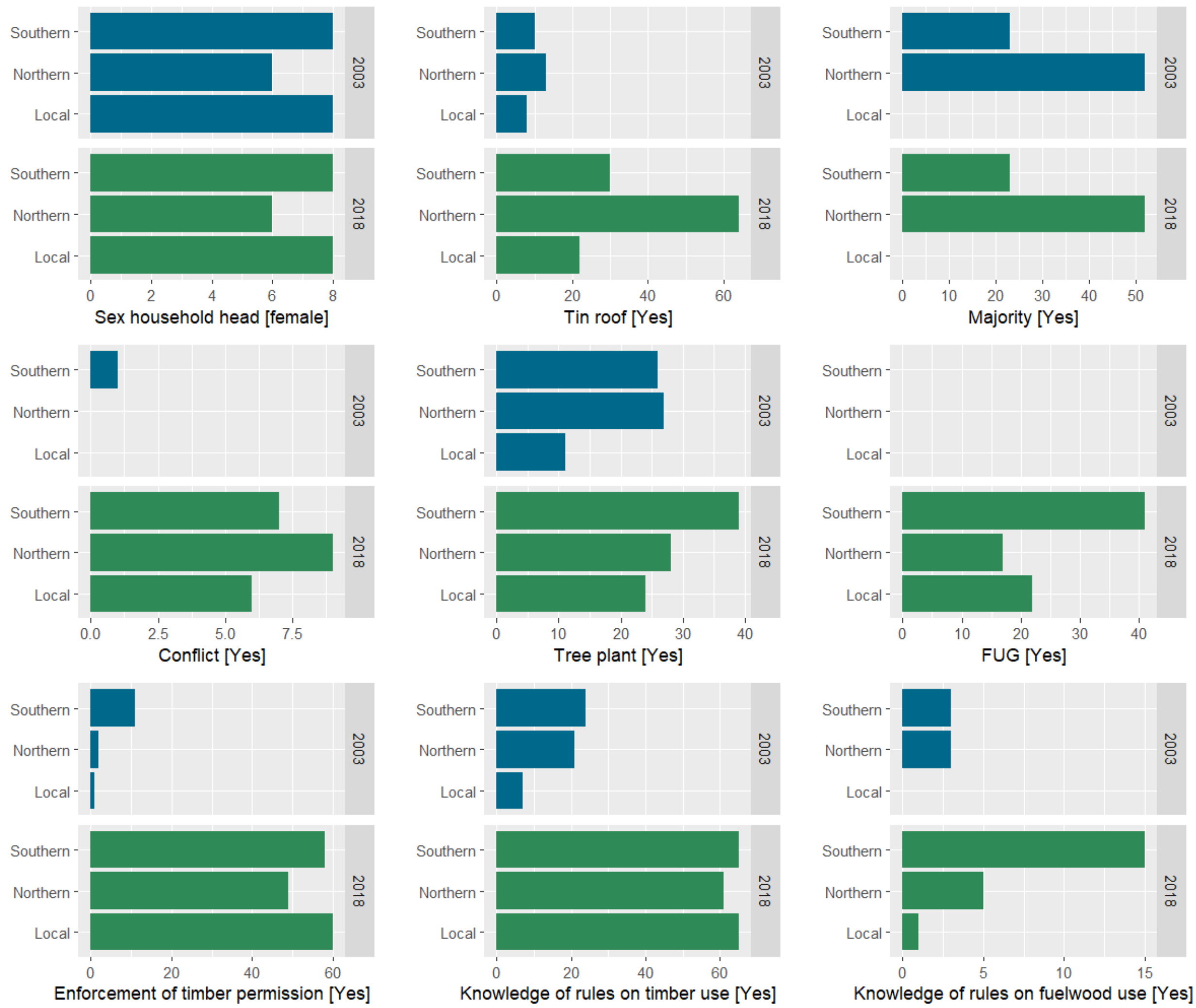

Figure C.4: Frequencies per group of discrete variables in 2003 (blue) and 2018 (green)

7. Model uncertainties

For the pruned regression tree in 2003, the uncertainty of the model increases from low to higher shares of forest activities.

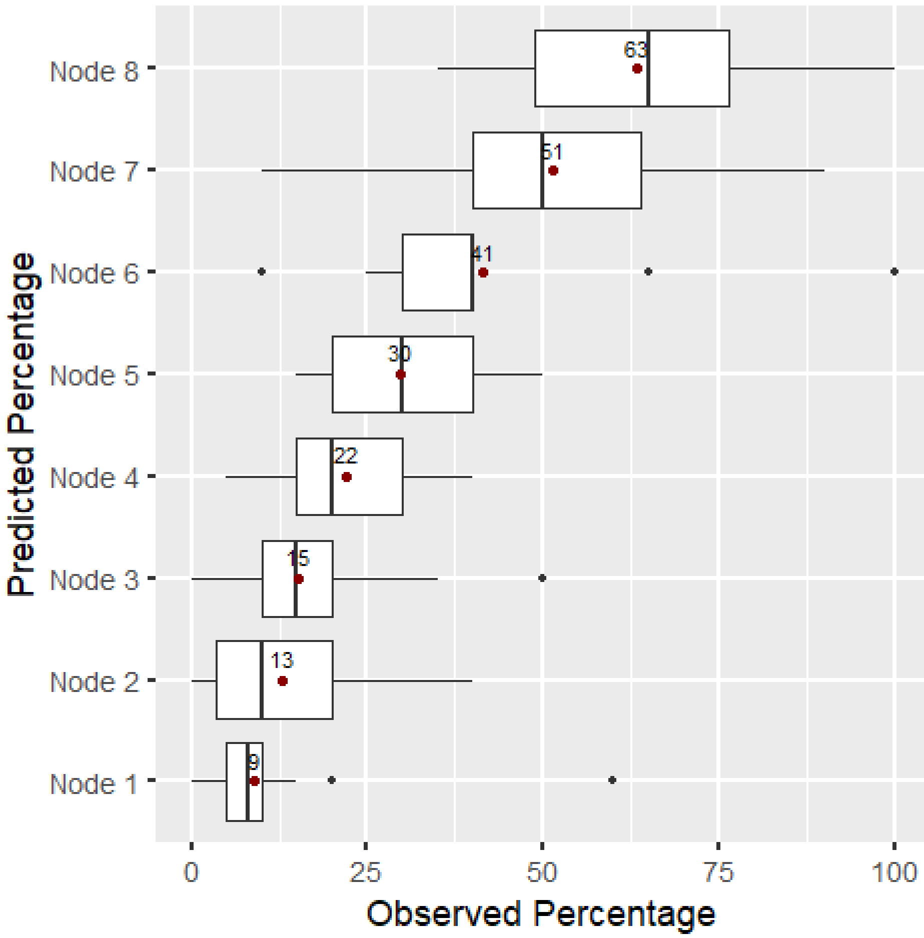

Figure C.5: Boxplots of predicted shares of forest activities based on the pruned regression tree for 2003 (Figure 4) against the observed shares of forest activities. The red dots indicate the predicted means of the final nodes

For the pruned regression tree in 2018, model uncertainty stays more or less the same from low to high shares of forest activities.

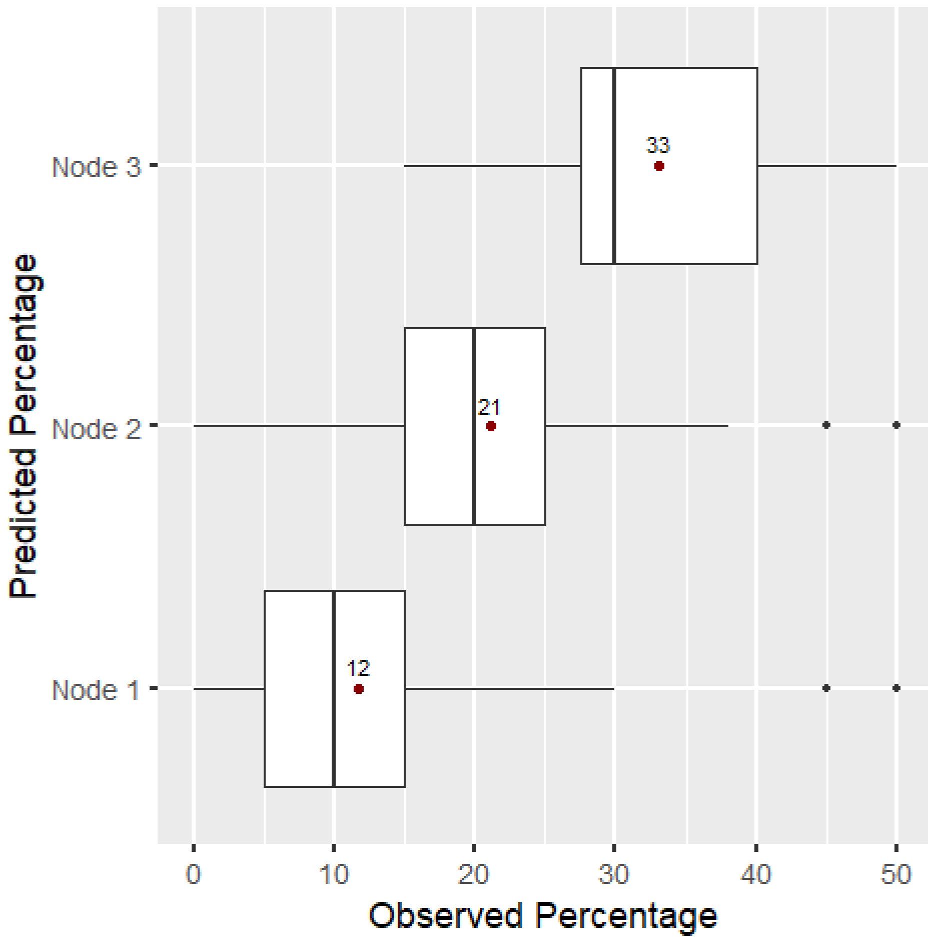

Figure C.6: Boxplots of predicted shares of forest activities based on the pruned regression tree for 2018 (Figure 5) against the observed shares of forest activities. The red dots indicate the predicted means of the final nodes

8. Population group comparison test results

Table C.2: Results of group comparison using Kruskal-Wallis and post hoc pairwise Wilcox test

Forest clearing [ha] ~ group		
Null Hyp.: There is no relation between forest clearing [ha] and population group.		
Alt. Hyp.: There is a relation between forest clearing [ha] and population group.		
Kruskal-Wallis test results		
chi-squared = 6.4882	df = 2	p-value = **0.039***
Post hoc pairwise Wilcox test results		
	Local	Northern
Northern	**0.036***	-
Southern	0.191	0.251

*significance at the 5% level

9. Interviewed officials

Table C.3: Interviewed officials

Position	**Organizational unit**	**Meeting type**
Area Program Coordinator	Ethio-Wetlands and Natural Resources Association	Expert interview
Zonal Social Advisor	Bench Maji Zone	Expert interview
Zonal Administration	Bench Maji Zone	Expert interview
Agricultural expert, soil and water conservation	Guraferda woreda	Data meeting
Health expert	Guraferda woreda	Data meeting
Finance officer	Guraferda woreda	Data meeting
Kebele leader	Alenga kebele	Group discussion
Kebele manager	Alenga kebele	Group discussion
Religious leader	Alenga kebele	Group discussion
Development agent, Agroecologist	Alenga kebele	Group discussion
Farmer representatives	Alenga kebele	Group discussion
Representative northern migrant community	Alenga kebele	Key informant interview
Representative southern migrant community	Alenga kebele	Key informant interview
Representative local community	Alenga kebele	Key informant interview
Kebele leader	Gelit kebele	Group discussion

Development agent, Agroecologist	Gelit kebele	Group discussion
Farmer representatives	Gelit kebele	Group discussion
Religious leaders	Gelit kebele	Group discussion
Elder	Gelit kebele	Group discussion
Representative northern migrant community	Gelit kebele	Key informant interview
Representative southern migrant community	Gelit kebele	Key informant interview
Representative local community	Gelit kebele	Key informant interview
Kebele leader	Semerta kebele	Group discussion
Development agent, Natural resource manager	Semerta kebele	Group discussion
Religious leaders	Semerta kebele	Group discussion
Elder	Semerta kebele	Group discussion
Representative northern migrant community	Semerta kebele	Key informant interview
Representative southern migrant community	Semerta kebele	Key informant interview
Representative local community	Semerta kebele	Key informant interview

10. Household survey

Consent seeking

Dear Participant,

- You have been randomly selected to be part of this questionnaire. Which will be conducted by ___________.
- Purpose: The interview is part of a PhD student project from Juliane Groth from Helmholtz Centre for Environmental Research in Leipzig. The project is on population and the forest resource dynamics within the last two decades. Therefore, the research team will spent approx. 2 weeks in this Kebele to survey households.
- Benefits: As the interview is part of a research project, you or your household will not have any direct benefits from participating in this interview. The findings from this research project may only improve the situation in a broader context e.g. within the Woreda/Region.
- Time: The interview will take approximately **120 minutes** and captures questions about you and your household.
- Confidentially: The information you provide will be used for research purpose only and treated with confidentiality. Your name and other personal information will be anonymized by using a code. Hence your name will not be used to identify your answers.
- Participation: is totally voluntary and you can withdraw or choose not to answer particular questions if you feel uncomfortable!

Date **Signature of respondent**

Check before you start: Did the household live in this kebele and was formed **before 1997**? Household formed/arrived here after 1996 cannot be included!

Control information

Tasks	Date(s)	By whom?	Missing questions?
Interview			
Checking questionnaire			
Entering data			
Checking data entry			

Technical notes:

- The numbers of the questions and lines and columns in the tables will be used to give each data cell a unique digital code, and should not be changed.
- The following generic codes shall be used, although not being specified for each question:
  - **– 8 (minus eight)** is to be used to indicate that the question ‘does not apply’ to the circumstances of the respondent(s).
  - **– 9 (minus nine)** is to be used for the alternative ‘I don’t know’ or ‘‘The respondent doesn’t know’. Naturally, one should aim to minimize use of this response, but in some cases it’s unavoidable.
- Use **Ethiopian calendar** only.
- ⦰ **3 recent** refers to the average of the past 3 recent years (the annual average for the period 2008/09 to 2010/11).

- Don't fill the grey cells.
- The wording of the questions as specified here must be maintained, making allowances, of course, for translation into other languages.
- For **additional notes** always indicate section and question!

A. Identification

1. Household code	*(HID)*	
2. GPS Position household *(if survey conducted at homestead)*	*(latitude)*	*(longitude)*
3. Kebele name and code	*(name)*	*(KID)*
4. District name and code	*Guraferda*	*01* (DID)
5. PID (see B. below) of primary respondent	*(PID)*	

B. Household composition

Note: see definitions of household

1. Who are the members of the household?

1. Personal Identification number (PID)	**2. Relation to household head** *(see codes below)*	**3. Age** *(years)*	**4. Sex** *(0=male 1=female)*	**5. Education** *(number of years completed)*	**6. Religion** *(1=orthodox, 2= muslim, 3=protestant, 4= traditional, 5= other, specify:*
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

13					
Relationship: 0= head; 1= spouse, 2= son/daughter, 3=father/mother, 4= brother/sister, 5= uncle/aunt, 6= cousin, 7= niece/nephew, 8=children in law, 9=grandchild, 10=parent in law, 11= other family (specify), 12=not related (e.g., servant).					

2. How many members your household had in 1996?	

3. We would like to ask some questions regarding the <u>head</u> of this household.

1. What is the marital status of household head? *Codes: 1=married and living together; 2=married but spouse working away; 3=widow/widower; 4=divorced; 5=never married; 6=other, specify:*		
2. When was <u>this</u> household formed? (*If after 1996, stop survey!) (Year when current head became head of this household, indicate if there was another spouse before and year!)*		*year*
3. Was the household head born in this kebele?		*(1-0)*
4. If 'no': When has the household head arrived in the kebele? *(If after 1996, stop survey!)*		*year*
5. How did the head came here? *Codes: 1=resettlement program, voluntary, 2= resettlement program, involuntary/forced 3=spontaneous, without resettlement program, 4=other, specify:*		
6. Where did the household head come from?	Kebele	
	Woreda	
	Zone	
	Region	
7. Why the household head did come here? *(Go Fishing for good answer!)*		
8. How you got access to land after arriving here?		
9. To which ethnic group does the household head belong to?		*(name)*

3. Household events, shocks and crisis *(<u>only</u> question where you are allowed to provide examples)*
3.1 Has your household faced any unexpected shocks or crisis **<u>since 1990</u>** such as crop failure, illness or death of family members, land loss, livestock loss, other asset loss, loss of wage employment, fine or penalties etc.?
3.2 When did it happen?
3.3 Had this shock any influence on your livelihood activities (harvest more/less agriculture/forest products, do extra causal labor, sold land, livestock or other asset, etc.)?
If yes, please specify what changed due to the shock/crisis. If not, write 0.

1. What shock was it?	**2. When did it happen?** *(year)*	**3. How were your livelihood activities influenced?**

4. Household assets, products and food security
(Remember to give an event for the recall period!) Code 0 = no, Code 1 = yes), all household members!

Assets		**Time**	**1-0**
1. Do you own a house?		Current	
		in 1996	
2. Is your roof (most of it) made with tin/iron sheet/metal?		Current	
		in 1996	
3. Do you (or a household member) have a mobile phone?		Current	
		in 1996	
4. Do you (or a household member) have a TV?		Current	
		in 1996	
5. Do you have livestock? *(1-0)* *If yes, continue with the following questions… And mark the most important livestock types after you got the Quantity!*		Ø 3 recent	
		in 1996	
5. Type of Livestock	**Is it most important? (1-0)**	**Time**	**Quantity**
1. Cattle (excl. ox)		Ø 3 recent	
		in 1996	
2. Goats or sheeps		Ø 3 recent	
		in 1996	
3. Poultry		Ø 3 recent	
		in 1996	
4. Donkey or Mule		Ø 3 recent	
		in 1996	
5. Horse		Ø 3 recent	

		in 1996	
6. Oxen		Ø 3 recent	
		in 1996	
Food security		**Time**	**How long?**
7. How many months after harvests can your household sustain without any external input or support in order to feed all household members?		Normal <u>recent</u> year	*months*
		Normal year 1995-1998	*months*
8. What is your household doing to cover the remaining months? (only if food gap in recent years)			
9. Which agriculture products your household uses? Out of them, which are the most important ones?			
1. Products		**2. MIPs**	

C. Land use

1. Please indicate the amount of land (in hectar) your **household use(d).** All household members! *See definitions of land categories Note: All land household uses for harvesting or collecting forest products. This is not only about own land! If multiple ownership indicate area for each*

Category	**Area in ha**	**2. Ownership**[1] *(multiple answers possible)*	**3. Three main products which <u>household</u> collects/grow/harvest**		
Forest:					
1. Natural forest (incl. natural forest on own land, especially in 1996)					
Current					
in 1996					
2. Plantation forest, Which species:					
Current					
in 1996					
Agricultural land:					

3. Seasonal cropland (really used for cropping, otherwise its maybe fallow land, grazing land or forest land)					
Current					
in 1996					
4. Permanent cropland (incl. coffee land, Permanent cropland is NOT seasonal cropland)					
Current					
in 1996					
5. Coffee land					
Current					
in 1996					
6. Grazing land					
Current					
in 1996					
7. Fallow land					
Current					
in 1996					
Other land categories (shrubs, wetlands, stone land, ect)					
8. Other, specify:					
Current					
in 1996					
9. **Total land owned** *(the sum of own land (code 3), some categories are part of others, i.e. coffee land is part of permanent cropland)*					
Current					
in 1996					
10. Land rented out (**included** in 1-10)					
Current					
in 1996					
11. Land rented in (**not included** in 1-10)					
Current					
in 1996					
12. Shared land					
Current					
in 1996					
13. Any **land size changes** since 1996? If yes, indicate **hectar of gain or loss** and **reason.**					

1) *Codes: 1=state, 2=community, 3=Your household land, 4= Individual kebele people 5=Investors, individual outside kebele*

D. ***Forest institutions (****ask which products they use and where they get/got it from. Note: Every household needs a firewood source and from time to time timber)*

Do first all questions (1.-9.) for coffee, then for honey, then timber and then for firewood, if used by household

	1. Coffee from forest	**2. Honey from forest**	**3. Timber from forest & homestead**	**4. Firewood from forest &homestead**
1. Where do you get the product? (1=natural forest, 2=plantation forest, 3=eucalyptus from homestead, 4=natural trees from homestead (i.e. trees within coffee plantation or single trees left from natural forest), multiple answers possible				
Current				
in 1996				
2. Who are the 'owners' of this forest *Codes: 1=state, 2=community, 3=your households forest/trees, 4= Individual kebele people 5=Investors, individual outside kebele; multiple answers possible*				
Current				
in 1996				
3. Are there any rules (customary and/or government and/or informal) rule regulating the use of the product or the forest? *Codes: 0=none/very few; 1=yes, but vague/unclear; 2=yes, clear rules exist*				
Current				
in 1996				
4. **If 'yes'**: are the rules regarding product use enforced /respected by you? Codes: *0=no/very littles; 1=to a certain extent; 2= yes; 9=no particular rules exist*				
Current				
in 1996				
5. Do you require any permission to harvest the product? *Codes: 0=no; 1=yes, users have to inform the authorities; 2=yes, written permission needed*				
Current				
in 1996				
6. **If 'yes' (code '1' or '2' above):** do you have to pay for the permission?				
Current				
in 1996				
7. **If 'yes'**: who issues this permit? *multiple answers possible* *Codes: 1=kebele head; 2=FUG; 3= other kebele official; 4=woreda official; 5=other, specify:*				
Current				
in 1996				

8. Which product and forest?	9. Explain the rule	10. Who made it?	11. Since when?	12. Why not respected?

Knowledge informal rules?				

E. ***Forest resource base***

*(Only natural forest and plantation forest, and homestead timber & firewood, **EXCLUDING eucalyptus** trees/plantation)*

1. How far is it from the house/homestead to the edge of the nearest natural or planted forest that you have access to and can use?	1.in km
	2.in min of walking
2. How far is it from the house/homestead to the kebele center?	1.in km
	2.in min of walking

3. Please list for each category all relevant forest products for your household. *Forest coffee, honey and spices would be included under '3. Food from forest'*		4. How has the overall **availability** of the products in this **category** changed **after 1996**? *Codes: 1=declined; 2=about the same; 3=increased* *It is NOT about use or production, the question is about **availability**!*
1. Firewood or charcoal from the forest & homestead		
2. Timber or other wood from the forest & homestead		
3. Food from the forest		
4. Medicine from the forest		
5. Forage from the forest		

6. Other, specify		

5. What are the 5 most important **forest products** (MIPs) for your household? *(Ranking!!See guideline)*	Rank 1: Rank 2: Rank 3: Rank 4: Rank 5:

6. How has the overall **availability** of the **products** changed **after 1996**? *Codes: 1=declined; 2=about the same; 3=increased* *It is NOT about use or production, the question is about **availability**!*		**1. Coffee from forest**	**2. Honey from forest**	**3. Timber from forest & homestead**	**4.Firewood from forest & homestead**
7. If the availability has **declined**, what are the reasons? *Do **ranking** of 3 most important reasons, see guideline! **NEVER provide answers!! Go fishing!***	**Reasons**	**Coffee Rank 1-3**	**Honey Rank 1-3**	**Timber Rank 1-3**	**Firewood Rank 1-3**
	1. Reduced forest area due to small-scale clearing for agriculture				
	2. Reduced forest area due to large-scale projects (plantations, new settlements,etc.)				
	3. Reduced forest area due to people from outside buying land and restricting access				
	4. Increased use of MIP due to more local (kebele) people collecting more				
	5. Increased use due to more people from outside collecting more				
	6. Restrictions on use by central or state government (e.g., for forest conservation)				
	7. Local restrictions on forest use (e.g., community rules)				
	8. Climatic changes, e.g., drought and less rainfall				
	9. Timber harvesting				
	10. Charcoal burning				
	11. Brick burning				
	12. Poor harvesting practices				
	13. Product attacked/consumed by forest dwelling vermin				
	14. Bush burning				

	15. Increased marketing potential for product				
	16. Other, specify				
8. If the availability has **increased**, what are the reasons? *Do **ranking** of 3 most important reasons, see guideline!* ***NEVER provide answers!! Go fishing!***	**Reasons**	**Rank 1-3**	**Rank 1-3**	**Rank 1-3**	**Rank 1-3**
	1. Less clearing of forests for agriculture (incl. pastoralism)				
	2. Fewer local (kebele) people collecting less				
	3. Fewer people from outside collecting less				
	4. Reduced use from large-scale commercial users/projects				
	5. Changes in management of forests				
	6. Climatic changes, e.g., more rainfall				
	7. Forest clearing that increases supply of product (e.g. fuelwood)				
	8. Tree planting				
	9. More illegal access of protected area				
	10. Improved access rights to product				
	11. More secondary forest (as people clear land and forest regenerates)				
	12. Other, specify:				

9. **If declined**, how has your household responded to the decline? ***NOT future or plans!!***
(For instance: invest more time in production/collection, planting trees, cutting trees, reduce the need, substitute the product, using improved technology, restricting access, conserving areas/trees, others…)

1. Coffee from forest	
2. Honey from forest	
3. Timber from forest	
4. Firewood from forest	

F. Forest clearing and tree planting

1. Did the household clear any forest since 1996? ***(If not**, go to Q9.)*	*1-0*	
2. **If yes**, which years? 3. How much forest was cleared? (in hectare)	**1. Year**	**2. Area in ha**

4. In general, what was the cleared forest (land) used for? *Codes: 1=cropping; 2=tree plantation; 3=pasture; 4=non-agric uses (**Ranking!**, max 3)*	1.Rank 1	2.Rank 2	3.Rank 3
5. What type of forest did you clear? *1= natural, 2= plantation*			
6. **If secondary forest**, what was the age of the forest?	*years*		
7. What was the ownership status of the forest cleared? *Codes: 1=state, 2=community, 3=Your household land, 4= Individual kebele people 5=Investors, individual outside kebele; multiple answers possible*			
8. How far from the house was the forest cleared located?	*km*		
9. How much land used by the household has since 1996 been abandoned (left to convert to natural re-vegetation)?	*ha*		
10. **Has your household planted any woodlots or trees __on farm__** since 1996? In which years? What species? How many? *(List all years the planted woodlots or trees or code 0 if they did not plant)*	**1. Year**	**2. Specie**	**3. Amount**
11. **If yes:** what are the main purpose(s) of the trees planted? *Please **rank** the most important purposes, max 3.*	**1-0**	**Rank 1-3**	
1. Firewood for domestic use			
2. Firewood for sale			
3. Fodder for own use			
4. Fodder for sale			
5. Timber/poles for own use			
6. Timber/poles for sale			
7. Other domestic uses			
8. Other products for sale			
9. Carbon sequestration			
10. Other environmental services			
11. Land demarcation			
12. To increase the value of my land			
13. To allow my children and/or grandchildren to see these trees			
14. Other, specify:			

G. Forest User Groups (FUG)

First explain what is meant by a FUG! See guideline!

1. Are you or any household member a member of a FUG?	*1-0*
2. **If yes**, since when	*year*
3. If yes, in which one?	

4. Does someone in your household normally / regularly attend the FUG meetings?		*1-0*
5. What are your households' reasons for joining the FUG? *Please **rank** the most important reasons (**max 3**)*	***1-0***	***Rank 1,2,3***
1. Increased access to forest products		
2. Better forest management and more benefits in future		
3. Access to other benefits, e.g., government support or donor programs		
4. My duty to protect the forest for the community and the future		
5. Being respected and regarded as a responsible person in kebele		
6. Social aspect (meeting people, working together, fear of exclusion, etc.)		
7. Forced by Government/chiefs/neighbors		
8. Higher price for forest product		
9. Better quality of forest product		
10. Receipt of direct payments		
11. Makes harvest of forest products more efficient		
12. Know forest resource better		
13. Learn new skills/information		
14. Reduce conflicts over resource		
15. More secure land title		
16. Other, specify:		
6. Overall, how would you say the existence of the FUG has affected the benefits that the household gets from the forest? *Codes: 1=large negative, 2=small negative, 3=no effect, 4=small positive, 5=large positive*		
7. If you don't participate in a FUG, why? ***Please rank the most important reasons (max 3)***	***1-0***	***Rank 1,2,3***
1. No FUG exists in the kebele		
2. I'm new in the kebele		
3. FUG members generally belong to other group(s) (ethnic, political party, religion, age, etc.) than I do		
4. Cannot afford to contribute the time		
5. Cannot afford to contribute the required cash payment		
6. FUG membership will restrict my use of the forest, and I want to use the forest as I need it		
7. I don't believe FUG is very effective in managing the forest		
8. Lack of forest products		
9. Not interested in the activities undertaken by existing FUGs		
10. Corruption in FUG		
11. Interested in joining but needs more information		
12. FUG exists in kebele, but household is unaware of its presence		
13. Forest authorities		
14. Other, specify:		

H. ***Sources of livelihood***

1. What is your household doing to make a living? Include all household members!

Category	**Time**	**1. Share (%) among other activities in terms of source for livelihood** *(use stones!)*	**2. Average total income of sale and own use per year (Gross Value)**
1. Forest activities (EXCL. eucalyptus)	⦸ 3 recent		
	in 1996		
2. Cropping **(seas. & permanent)**	⦸ 3 recent		
	in 1996		
3. Livestock	⦸ 3 recent		
	in 1996		
4. Renting land	⦸ 3 recent		
	in 1996		
5. Remittance	⦸ 3 recent		
	in 1996		
6. Pension	⦸ 3 recent		
	in 1996		
7. Own business (i.e. cafeteria)	⦸ 3 recent		
	in 1996		
8. Fishing	⦸ 3 recent		
	in 1996		
9. Daily labor / wage labor /casual labor	⦸ 3 recent		
	in 1996		
10. Government support	⦸ 3 recent		
	in 1996		
11. Eucalyptus	⦸ 3 recent		
	in 1996		
12. Other, specify:	⦸ 3 recent		
	in 1996		

1. What is **the total level of income** of your household per year?	⦸ 3 recent	
	in 1996	
2. What is the **level of savings** your household have?	⦸ 3 recent	
	in 1996	

	1.Average quantity collected per year		Unit	2.Own use	3.Sold	4.Price per Unit in Birr received
I9.What is your households average quantity of **eucalyptus for timber** collected per year	⦸ 3 recent					
	in 1996					

I10.What is your households average quantity of **eucalyptus for firewood** collected per year	⊘ 3 recent					
	in 1996					

I. MIPs quantity and income (agriculture and forest)

1. Please indicate the average quantity collected per year for each product.
2. Please indicate what was used for own household consumption for each product.
3. Please indicate what was sold for each product
4. Indicate the average price RECEIVED per unit.
5. Please indicate the total income per year for each product.

Excluding eucalyptus

Product name and unit	**Time**	1. Average quantity collected per year	Unit	2. Own use	3. Sold	4. Average price per unit **received**	5. Total income per year (1*4)
1. Coffee from forest	⊘ 3 recent						
	in 1996						
2. Honey from forest	⊘ 3 recent						
	in 1996						
3. Timber from forest & homestead	⊘ 3 recent						
	in 1996						
4. Firewood from forest & homestead	⊘ 3 recent						
	in 1996						
5. Rice	⊘ 3 recent						
	in 1996						
6. Maize	⊘ 3 recent						
	in 1996						
7. Sorghum	⊘ 3 recent						
	in 1996						
8. Coffee from permanent cropland (plantation)	⊘ 3 recent						
	in 1996						

Unit conversion:

J. Social capital

1. Do you consider your kebele to be a good place to live? *Codes: 1=no; 2=partly; 3=yes*	
2. Do you **in general** trust people in the kebele? *Codes: 1=no; 2=partly, trust some and not others; 3=yes*	
3. Can you get help from other people in the kebele if you are in need, for example, if you need extra money because someone in your family is sick? *Codes: 1=no; 2= can sometimes get help, but not always; 3=yes*	
4. Did you ever have any severe conflict with someone in the kebele?	*1-0*
5. If yes, with whom and which year? Ask for relation (i.e. neighbor, relative etc.) and **ethnic group and in which year?**	

6. What was the reason for the conflict?	
7. How was the conflict solved?	

K. ***Enumerator/researcher assessment of the household***

1. During the last interview, did the respondent smile or laugh? *Codes: (1) neither laughed nor smiled (somber); (2) only smiled; (3) smiled and laughed; (4) laughed openly and frequently.*	
2. Based on your impression and what you have seen (house, assets, etc.), how well-off do you consider this household to be compared with other households in the kebele? *Codes: 1=worse-off; 2=about average; 3=better-off*	
3. How reliable is the information provided by this household? *Codes: 1=poor; 2=reasonably reliable; 3=very reliable*	
4. Did the household receive the 50 Birr for compensation of the consumed time? *Don't forget to use a receipt for reimbursements with Juliane*	

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DECLARATION UNDER OATH

I declare under penalty of perjury that this thesis is my own work entirely and has been written without any help from other people. I used only the sources mentioned and included all the citations correctly both in word or content.

14.02.2022

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