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Mechanisms between Irrigation and Migration,
Case Study Ethiopia

A Systematic Literature Review

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Abstract (engl.)

As a result of the ongoing and accelerating climate change, food and water security as well as overall livelihoods are increasingly threatened, particularly in sub-Sahara Africa. Effective and accessible adaptation strategies are of utmost importance. The concept of adaptation has been receiving growing attention over the past few decades. Both, irrigation and migration represent valuable adaptation strategies to tackle increasing environmental changes.

Irrigation plays a vital role in fostering a more reliable, predictable, and sustainable agricultural system, leading to increased profitability, improved livelihoods, and enhanced food security and income. Consequently, it can help reduce distress migration and enable migration for skilled labour or educational purposes. Additionally, migration can provide supplementary income and knowledge to households, aiding in the establishment, implementation, and maintenance of irrigation systems. Furthermore, migration facilitates the execution of large-scale irrigation projects, as labour migrants are crucial for dam construction and seasonal work on such farms.

This master thesis aims to highlight the key mechanisms of agricultural irrigation in Ethiopia in the context of migration patterns within Ethiopia and across its borders. It provides a comprehensive synthesis of existing research with conducting a systematic literature review. Literature was retrieved from different databases via search strings. 31 publications fulfilled the inclusion criteria and were analysed and assessed in detail by using MAXQDA. By examining and discussing existing research it sheds light on the implications of irrigation practices on migration patterns in Ethiopia, place them into the overall (research) context, and highlight potential avenues for further exploration in this field.

The results show that improved governmental support as well as (better) education on sustainable agricultural practices and adaption strategies like irrigation are important factors to improve the livelihoods of smallholders. Additionally, more recognition and appreciation of the knowledge about sustainably using natural resources of pastoralists and indigenous can be of great value. While irrigation and migration have often been viewed as distinct strategies, this thesis demonstrates their interconnection and mutual dependence, even if not immediately apparent. It also highlights the lack of comprehensive studies on the irrigation-migration nexus in Ethiopia and beyond.

Abstract (dt.)

Infolge des fortschreitenden Klimawandels sind die Nahrungsmittel- und Wassersicherheit sowie die Lebensgrundlagen insgesamt zunehmend bedroht, insbesondere in Subsahara-Afrika. Wirksame und zugängliche Anpassungsstrategien sind daher von größter Bedeutung. Das Konzept der Anpassung hat in den letzten Jahrzehnten zunehmend an Bedeutung gewonnen. Sowohl die Bewässerung als auch die Migration stellen wertvolle Anpassungsstrategien zur Bewältigung der zunehmenden Umweltveränderungen dar.

Bewässerung spielt eine entscheidende Rolle bei der Förderung eines zuverlässigeren, berechenbareren und nachhaltigeren Agrarsystems, das zu höherer Rentabilität, verbesserten Lebensgrundlagen sowie größerer Ernährungssicherheit und höherem Einkommen führt. Folglich kann sie dazu beitragen, die Abwanderung aufgrund von Notlagen zu verringern und Migration zu Bildungszwecken oder als qualifizierte Arbeitskräfte zu ermöglichen. Darüber hinaus kann Migration den Haushalten zusätzliches Einkommen und Wissen verschaffen und bei der Einrichtung, Umsetzung und Wartung von Bewässerungssystemen helfen. Darüber hinaus erleichtert/ermöglicht Migration die Durchführung großer Bewässerungsprojekte, da Arbeitsmigrant:innen für den Bau von Staudämmen und die Saisonarbeit in entsprechend großen Betrieben unerlässlich sind.

Diese Masterarbeit zielt darauf ab, die wichtigsten Mechanismen der landwirtschaftlichen Bewässerung in Äthiopien im Zusammenhang mit dem Migrationsverhalten innerhalb Äthiopiens und über seine Grenzen hinweg zu beleuchten. Sie bietet eine umfassende Synthese der bestehenden Forschung durch eine systematische Literaturrecherche. Die Literatur wurde mit Hilfe von Suchbegriffen aus verschiedenen Datenbanken abgerufen. 31 Publikationen erfüllten die Einschlusskriterien und wurden mit Hilfe von MAXQDA im Detail analysiert und bewertet. Durch die Untersuchung und Diskussion bestehender Forschungsarbeiten werden die Auswirkungen von Bewässerungspraktiken auf die Migrationsmuster in Äthiopien beleuchtet, in den allgemeinen (Forschungs-) Kontext eingeordnet und mögliche Wege für weitere Untersuchungen in diesem Bereich aufgezeigt.

Die Ergebnisse zeigen, dass eine verbesserte staatliche Unterstützung sowie eine (bessere) Aufklärung über nachhaltige landwirtschaftliche Praktiken und Anpassungsstrategien wie Bewässerung wichtige Faktoren sind, um die Lebensgrundlage von Kleinbauern zu verbessern. Darüber hinaus können eine stärkere Anerkennung und Wertschätzung des Wissens über die nachhaltige Nutzung von natürlichen Ressourcen von Hirtenvölkern und Indigenen von großem Wert sein. Während Bewässerung und Migration oft als getrennte Strategien betrachtet wurden, zeigt diese Arbeit ihre Verflechtung und gegenseitige Abhängigkeit auf, auch wenn dies nicht sofort ersichtlich ist. Sie verdeutlicht auch den Mangel an umfassenden Studien über den Zusammenhang zwischen Bewässerung und Migration in Äthiopien.

Key Words

Irrigation
Migration
Ethiopia
Mitigation
Climate change and variability (CCV)
Adaption strategies
Resilience
Sustainable agriculture
Systematic literature review (SLR)

Abbreviations

ASAL: Arid and Semi-Arid Lands

CCV: Climate Change and Variability

CSA: Ethiopia's Central Statistical Agency

FDI: Foreign Direct Investment

GERD: Great Ethiopian Renaissance Dam

IOM: International Organization for Migration

IPCC: Intergovernmental Panel on Climate Change

LSI: Livelihood Sustainability Index

QCA: Qualitative Content Analysis

SLR: Systematic Literature Review

UN: United Nations

UNHCR: United Nations High Commissioner for Refugees

UNSD: United Nations Statistics Division

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1. Introduction

Global change, including climate change, pose a key challenge to societies worldwide. In the field of climate change, the concept of adaption has been receiving growing attention over the past few decades (Kidane et al., 2022). Here, both migration and agricultural irrigation are playing an increasingly important role, in view of the steadily growing world population, combined with ongoing environmental change (IPCC, 2022). Sub-Sahara Africa is particularly affected by manifold hazards and risks which are connected to migration and irrigation in relation to climate change (IPCC, 2022). Hazards, such as changing rainfall patterns and/or increasing temperatures can lead to droughts impacting environment and society (IPCC, 2022). Water is a key factor for ensuring a sustainable livelihood as it is needed by people as drinking water and for sanitation, for keeping livestock, and for agricultural production, e.g., irrigation or rainfed agriculture (FAO, 2017). According to the Intergovernmental Panel on Climate Change (IPCC, 2022) climate change and variability (CCV) could further increase future numbers of migrants, as temperatures and the frequency and magnitude of extreme (weather) events increase.

In the regard of the above-mentioned issues, Ethiopia offers an interesting study area. It is the most populated and largest country (by area) in the Horn of Africa (Country Reports, 2023) and has the second highest population in Africa (The World Bank, 2023). Hence, the arable land is limited, although most of the population (86 %) depend on subsistence farming (The World Bank, 2023).

It is emphasized, that the research topic is a very geographic topic as the two main branches of Geography interact here. Generally, Geography is the study of the Earth’s landscapes, environments, and relationships between people and their natural surroundings (Freytag et al., 2016; Glaser et al., 2010). It is a multifaceted field and is broadly divided into two main branches:

Physical Geography, focusing on the Earth’s physical aspects, such as landforms, climate, vegetation, soils, and natural hazards as well as natural processes and their impact on the environment (Glaser et al., 2010).

Human Geography, concentrating on the relationships between humans and their environment and exploring topics such as population distribution, urbanization, cultural landscapes, migration, economic activities, and political boundaries (Freytag et al., 2016).

Irrigation is an important topic when studying agricultural impacts on the environment, as it can increase soil erosion, siltation, or salination and may use large amounts of water resources (Glaser et al., 2010). Even though, in this thesis the socio-economic impacts are emphasized, many important aspects and impacts are found and are to be in Physical Geography. Migration is one of the main research fields of Human Geography (Freytag et al., 2016).

Here, a link between irrigation and migration is established that can provide valuable information, especially for migration research, as there is little literature to date on the mechanisms occurring between the two subject areas.

1.1. Relevance

Even though the population growth rate is slowing down, the global population is still growing rapidly (DESA, 2022). Most countries experiencing rapid population growth are located in sub-Sahara Africa (DESA, 2022). The effects of enhanced globalization processes have significantly influenced their societies and economies as well as ecological systems (Zhang et al., 2022). Among other challenges, those countries also need to ensure food and nutrition security as well as employment opportunities and livelihoods for an increasing number of population (DESA, 2022).

Food systems are non-static and change due to globalization, urbanization as well as demographic and environmental shifts (Fanzo, 2018). Most natural resources are decreasing, associated to this, risks and hazards are increasing due to global change (Fanzo, 2018). Resource scarcity, as well as loss of livelihoods can be a major factor for conflict and migration (Groth et al., 2021; Schewel & Asmamaw, 2022). The ongoing Russian war in the Ukraine, the resulting global economic crisis and increasing food shortages due to missing wheat exports currently display the importance for countries to be more independent and self-sustaining.

The global South is especially affected by global change and prone to related crises such as drought and hunger which have negative impacts on socio-economic dimensions (IPCC, 2022). Poverty and food insecurity are major issues in sub-Sahara Africa. Here, most low-income households are situated in rural areas where subsistence farming dominates (OECD/FAO, 2016). Agriculture is mostly practiced rainfed, and is a widespread way of sustaining livelihoods (AGRA, 2019; Berhe et al., 2022; Groth et al., 2021; You et al., 2010). Thus, those people are vulnerable to increasingly irregular rainfall patterns and extreme climate conditions (AGRA, 2019). Additionally, climate change is increasing uncertainties and risks associated with agriculture (Groth et al., 2021). Communities in sub-Sahara Africa, that rely on rainfed agricultural systems while mostly producing weather-sensitive crops may be hit harder by effects of climate change. Due to poverty, they often have very little and/or weak adaption possibilities (Bedeke et al., 2018). Smallholder farming households can only benefit from their traditional farming systems, when temperature is adequate and the amount of rainfall suitable for the crops (Etana et al., 2021). Due to the increasing uncertain climate conditions, agricultural development is a crucial factor to counteract poverty and to ensure food security (You et al., 2010). Generally, "water is a key factor in attaining the Sustainable Development Goals (SDGs) of poverty elimination and hunger eradication" (Ahmed et al., 2022, p. 539). In this context, irrigation plays a key role in the process of agricultural development (FAO, 2023b)

Herein, **irrigation** may represent an alternative strategy for a more independent and self-sustaining society. It can contribute to a more effective, safe, and predictable yield and allows more than one cultivation season per year (You et al., 2010). Therefore, irrigation has the potential to subsequently result in positive economic change for families and households (new job opportunities), smallholder farmers (introduction of irrigation), and regions (bigger irrigation projects) (Etana et al., 2021). In sub-Sahara Africa, small-scale irrigation is a focus of development "[…] to increase agricultural production, ensure food security and reduce poverty levels of rural smallholders" (Berhe et al., 2022, p. 1). Further it is seen as an effective way to mitigate climate change effects while also providing significant employment opportunities to rural communities (Berhe et al., 2022). Yet, irrigation is only practiced on about 6 % of irrigable land in Africa (G. G. Haile & Kasa, 2015; You et al., 2010) and sub-Sahara Africa has developed only 28 % of its potential irrigated areas (Ringler, 2021). Of all the world's major regions, it has the lowest availability of irrigated land per capita (Behnke & Kerven, 2011). Therefore, it becomes clear that the potential in the respective countries is far from being exhausted.

The uneven distribution of resources, risks, and economic opportunities as well as the uneven distribution of population and low agricultural productivity are key drivers of (domestic) **migration** (Groth et al., 2021; Schewel & Asmamaw, 2022). Migration represents a key livelihood strategy with multifaceted reasons and impacts on the place of destination as well as the place of origin of a person or household (Ayele & Degefa, 2020). Temporary migration as well as permanent migration, internal or international, have always been taken place as a response to or to counteract environmental changes and threats to food security and health (Warner et al., 2010). The influence of environmental change on migration is complex (Groth et al., 2021). Drought events can be a major factor for migration of members of a household to diversify income or migration of an entire household if in-situ adaption strategies do no longer enable a livelihood (Etana et al., 2022). However, it is not mere economic or hazard reasons that make people migrate (Asfaw et al., 2010). Reasons may also be social, political, or cultural and many people migrate to places with job opportunities to increase their livelihood sustainability (Etana et al., 2021). Usually, with economic change, the migration situation changes. Better economic stability can enable people to stay (Groth et al., 2021).

In some countries in Africa, water availability is a main criterion, that hinder irrigation practices. But there are also countries like **Ethiopia**, where water is available but is not being used effectively. Despite a considerable amount of rainfall (A. Siebert, 2014), variations due to climatic changes are to be expected (Gelete et al., 2020; A. T. Haile et al., 2017; A. Siebert, 2014). The non-effective water use is problematic as Ethiopia has one of the lowest rates of accesses to freshwater, sanitation, and hygiene services in Africa (Kidanewold et al., 2014).

49.6 % of people in Ethiopia have access to basic water supply coverage and only 8.9 % of Ethiopians have access to basic sanitation coverage (UNICEF, 2022b). Additionally, 84 % of the population depend on rainfed agriculture (Gelete et al., 2020). Currently there are 4.5 million internally displaced persons across the country due to conflict and the consequences of drought (WFP, 2022). Migration in Ethiopia interacts with changes in the environmental, social and economic system (Sugden et al., 2022).

The nexus of food security, demography and climate change is very important in highly populated countries in Africa like Ethiopia (Conway et al., 2015; IPCC, 2022; Ringler et al., 2021). Here the question of irrigation is especially important, as the potential of irrigation is far from exhausted (FAO, 2017; Ringler, 2021). As economic change and agricultural productivity are key drivers for migration (Asfaw et al., 2010; Etana et al., 2022; Nyssen et al., 2018) the question arises, in how far economic change through the introduction and implementation of irrigation affects the mobility behaviour within Ethiopia and across its borders. Hence it is important to explore the mechanisms that initiate the decision to migrate and, in this case, in which ways the implementation of irrigation interacts with them.

1.2. Research Questions

This thesis aims to contribute to research by providing an overview of the mechanisms that occur between migration and irrigation in Ethiopia, derived from available publications. In this way, the state of the art in how far migration and irrigation in Ethiopia influence each other can be given. In order to tackle the above-mentioned issues, the following questions were developed. Under the umbrella of the main research question, several sub-questions have been identified to explore the dynamics between irrigation and migration in Ethiopia.

To what extend and with which key mechanisms is agricultural irrigation in Ethiopia linked with the migration behaviour within Ethiopia and across its borders?

a) What are the socio-economic consequences of the implementation of irrigation in Ethiopia?
b) What are challenges associated with (the introduction and implementation of) irrigation?
c) In what way does the implementation of irrigation and its potential socio-economic consequences influence migration behaviour/patterns?
d) What types of migration are associated with irrigation?
e) What are challenges associated with migration connected with irrigation?
f) To what extent, if any, does migration have an influence on the introduction and implementation of irrigation?

1.3. Structure of the Thesis

Following this introduction including the research questions (*Chapter 1*), the theory, literature research methodology and literature analysis are explained in C*hapter 2.* The theory

(*Chapter 2.2*) represents the basis for the methodology. First the qualitative content analysis after Udo Kuckartz is outlined (*Chapter 2.2.1.*) to secondly, apply the adapted approach in this thesis (*Chapter 2.2.2.*). The research methodology explains how the literature was identified and evaluated (*Chapter 2.3.*) followed by the content analysis (*Chapter 2.4.*), where the procedure from coding the data in MAXQDA to the evaluation of the content is described. The study area is described in detail in *Chapter 3*. Here, besides general information on Ethiopia (*Chapter 3.1.*), both the natural environment (*Chapter* 3*.2.*) and the socio-economic environment (*Chapter 3.3.*) are discussed to be able to place it in the overall context of the focus of the research. *Chapter 4* outlines the state of the art with an overview of irrigation (*Chapter 4.1.1.*) and migration (*Chapter 4.1.2.*) in general, as well as the specific situation of the two topics in Ethiopia (*Chapter 4.2.* and *Chapter 4.3.*). In *Chapter 5*. the results of the literature review are presented. The results are discussed in *Chapter 6*, where they are interpreted and utilized to answer the research question(s). In addition, the limitations of the thesis are discussed here. Finally, conclusions are drawn in *Chapter 7* and perspectives for further research and development interventions are given in *Chapter 8*.

2. Theory, Methods, and Data

For this thesis a variety of literature and data have been analysed. Google, Google Scholar, Web of Science, and Scopus were used as databases. The search was conducted using key words related to the different chapters, often followed by the snowball principle. Various types of literature such as reports (e.g., United Nations), peer reviewed publications, books, and websites were used.

The main method for answering the research questions is a **Systematic Literature Review (SLR)** (*Chapter 2.1.)*. The theory of qualitative content analysis (*Chapter 2.2.1.*) was adjusted to the approach used in this thesis (*Chapter 2.2.2.*). The exact procedure how the SLR was conducted is described and illustrated step by step (*Chapter 2.3.*) During the analysis (*Chapter 2.4.*) the collected data was qualitatively analysed most according to Udo Kuckartz.

It is emphasized, that the focus for the literature identification in this thesis is only on migration in connection to irrigation. However, in order to understand the mechanisms of migration more comprehensively it is important to explore those as well in detail in the results (*Chapter 5.2.*). However, only information on migration found in the literature also dealing with irrigation is elaborated.

2.1. Systematic Literature Review (SLR)

"To push the knowledge frontier, we must know where the frontier is" (Xiao & Watson, 2019, p. 93). SLRs are an essential feature of academic research and a useful tool as a form of providing state of the art knowledge about a specific topic or research, or gathering existing information from previous research on a topic to pose new research questions or test a specific hypothesis (Marcos-Pablos & García-Peñalvo, 2018; Xiao & Watson, 2019). By reviewing relevant literature on a particular topic, the full extent of previous research findings can be determined. Therefore, research and knowledge gaps can be identified as well as the validity and quality of existing work can be evaluated against one or several criterion/criteria (Xiao & Watson, 2019). The methodology to identify, analyse, and interpret all available information related to a specific topic is systematic, explicit, unbiased, and to a degree repeatable (Marcos-Pablos & García-Peñalvo, 2018; Moher et al., 2009). Due to an increasing amount of literature in all scientific fields, the popularity of SLRs has increased during the last decade, because it summarizes all existing knowledge i.e. provides a valuable scientific status quo on a specific topic (Marcos-Pablos & García-Peñalvo, 2018).

2.2. Theory

Unlike the statistical analysis of quantitative data, there are many different and competing methods for the analysis of qualitative data. These include, among others, qualitative content analysis, grounded theory, phenomenological analysis, frame analysis, metaphor analysis, and discourse analysis (Kuckartz, 2014). In this thesis, the content structuring qualitative content analysis after Udo Kuckartz was found to be the most applicable analysis method. The approach is explained in the following chapter which outlines the qualitative content analysis after Udo Kuckartz (*Chapter 2.1.*). Key elements of the approach were applied in this thesis, as explained in the subsequent chapter (*2.2.*).

2.2.1. Qualitative Content Analysis (QCA)

Qualitative content analysis "[…] is one of the most commonly used methods for analysing qualitative data" (Kuckartz, 2019, p. 181). It is a research method used to analyse qualitative data by systematically categorizing and interpreting the content of text-based materials, such as interviews, surveys, focus groups, and other documents. It is not a uniform or standardized method. There are different forms that have evolved in the past decades. Unlike the analysis of quantitative data, the process contains more circular elements. According to Mayring (2014) "the basic approach of qualitative content analysis is to retain the strengths of quantitative content analysis and against this background to develop techniques of systematic, qualitatively oriented text analysis" (Mayring, 2014, p. 39). Bazeley (2020) has formulated the general process of qualitative data analysis simply as describe, compare, and relate. According to Kuckartz (2014) the following key points can be found in most of the qualitative analysis methods:

- Themes and categories are identified,
- groups are differentiated and compared,
- categories are being related to each other, and
- types of similar cases are formed.

Kuckartz's approach involves several steps, including data collection, data coding, and data analysis (Kuckartz, 2014). It emphasizes the importance of a systematic and transparent approach to coding and analysis. The categories (also so called "codes") are a result of the classification of units. Their purpose is to reduce complexity of the selected literature (and/or available data) and help to extract relevant information from it (Kuckartz, 2014). QCA is a reliable and robust method, that is easy to learn and can be designed very transparent which makes it easy to understand and repeatable for others who want to understand the applied procedure (Kuckartz, 2019). Consequently, the QCA represents the appropriate methodological approach for this thesis.

The flow chart below (*Figure 1*), shows the process of the qualitative content analysis according to Kuckartz (2014) from research question to the presentation of results.

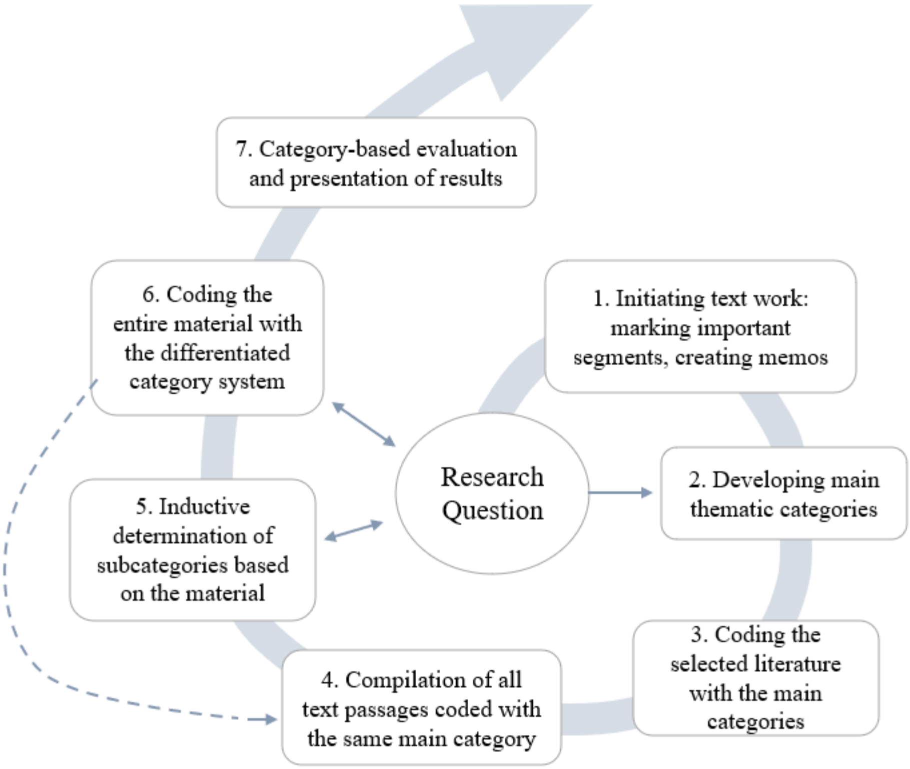

Figure 1: Flow chart of the content structuring qualitative content analysis. Translated from Kuckartz (2014)

The first step (1) is to familiarize with the selected data, by reading the entire material. First thoughts, ideas and theories/hypotheses should be collected in memos or notes which guide the subsequent analysis. Memos can often be very short texts or comments (Kuckartz, 2014). The first run-through of material also serves to form categories (2) that are systematically assigned to text segments in later analysis phases. Categories can have very different characteristics and functions. They are labels used to describe phenomena identified in the data. Generally, the formation of categories and sub-categories can be inductively based on the material as well as deductively based on prior theoretical knowledge and literature study. In most cases both approaches are combined (Kuckartz, 2014). After the exploratory phase guided by the research question, a two-staged coding process is carried out. During the first stage (3), the material is assigned to thematic main categories. Then all segments of the material assigned to a main category are compiled (4) and sub-categories can be created (5) based on the material of each main category. Here,, the categories are specified by differentiating and refining them (Kuckartz, 2014). The second coding stage is the subsequent recoding of the material (6), where segments are assigned to the differentiated subcategories. Finally, the resulting more differentiated categorization and structuring of the material in terms of content is then the basis for the further steps of evaluation and presentation of results (7) (Kuckartz, 2014). There are various possibilities for the presentation of results. Connections and relationships of different categories can be presented in tabular form or as concept-map, for instance (Kuckartz, 2014). The way of presenting the results should be chosen to fit the content of the research and the key messages or generally which statements are to be made.

The categories are of crucial importance for content analysis. They form the basis for the results an analysis or study can deliver and are "[…] the substance of the research" (Kuckartz, 2019, p. 183). According to Kuckartz (2019) there are 3 principal ways to develop categories:

- "Concept-driven ('deductive') development of categories; in this case the categories:
  - are derived from a theory or,
  - derived from the literature (the current state of research) or,
  - derived from the research question (e.g. directly related to an interview guide).

- Data-driven ('inductive') development of categories; the characteristics here are:
  - the step-by-step procedure,
  - the method of open coding until saturation occurs,
  - the continuous organization and systematization of the formed codes, and
  - the development of top-level codes and subcodes at different stages.

- Mixing a concept-driven and data-driven development of codes:
  - the starting point here is usually a coding frame with deductively formed codes and
  - the subsequent inductive coding of all data coded with a specific main category"

(Kuckartz, 2019, pp. 184–185)

2.2.2. Approach of the Analysis in this Thesis

In this thesis the content from numerous publications dealing with the research topic, is to be analysed, categorized, structured, and interpreted. The results are then to be described and compared and related to the overall context. Therefore, the QCA after Kuckartz proves to be the most suitable method for extracting and structuring relevant information from the literature to then analyse and present the results for this thesis.

For the development of the codes, the concept-driven and data-driven development of codes are mixed (*Chapter 2.2.1.*). The main codes are derived from the research question (deductive). The sub-codes are added in a step-by-step procedure while coding the data contained in one main code (inductive).

Figure 2 shows a slightly modified QCA approach which was applied in this thesis. First, (1) the selected literature is to be read to get an idea of the available information. (2) Then codes are created appropriate to the research questions. (3) During the coding process, segments in the literature are assigned to the codes. During this stage, sub-codes can already be created if applicable/suitable/necessary. (4) Then the main codes are reviewed more closely and if necessary, individual segments assigned to sub-codes. Here, more sub-codes can also be added if necessary. (5) The content of the coded data is analysed and reviewed again. (6) Finally, the codes built the structure for the chapter of the results, where the content of the segments is presented and evaluated. The research questions form the basis for each of the six steps and are the central element of the entire procedure.

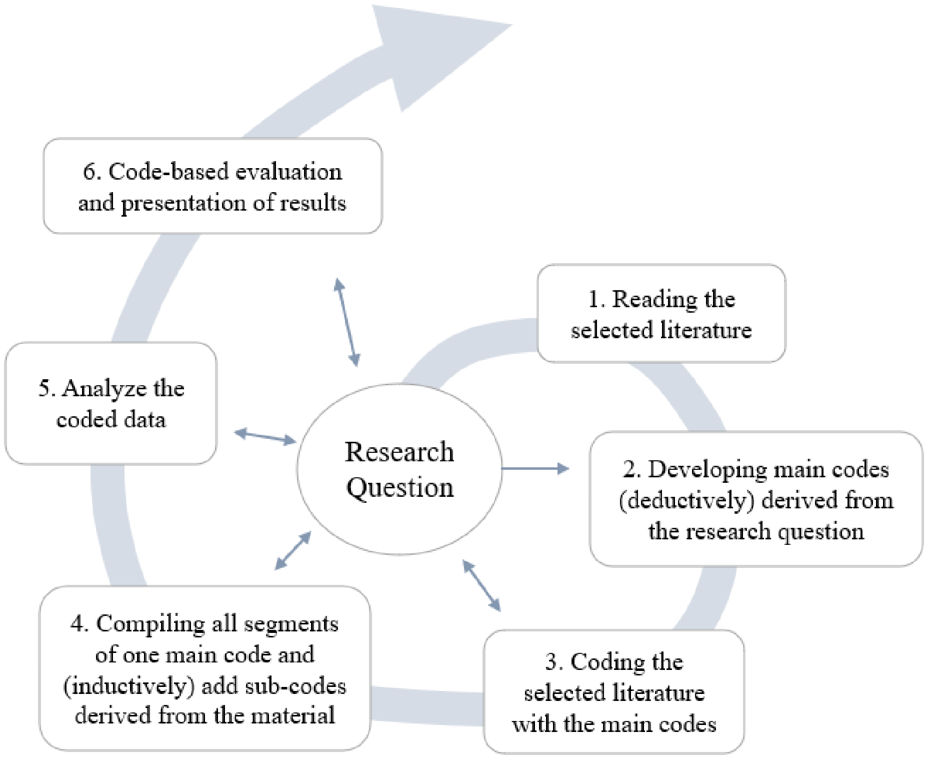

Figure 2: The six steps of Qualitative Content Analysis (QCA) applied in this thesis. Modified from Kuckartz (2014) and Kuckartz (2019)

At this point, the importance of transparency, reproducibility, and traceability needs to be emphasized. This especially applies for the process of literature selection as well as the creation of the codes. When assigning the segments to the codes, objectivity is unpreventable.

2.3. Literature Research Methodology for this Thesis

Determining keywords and devising the research strategy is a critical step in conducting a SLR as it determines the information that can be retrieved from the selected literature and therefore conditions the rest of the review and finally the results (Marcos-Pablos & García-Peñalvo, 2018). The base structure of most of the methodologies for SLRs is defined as the SALSA (Search, Appraisal, Synthesis, and Analysis) framework. In the *Search* phase, the preliminary list of literature is collected. During the *Appraisal* stage, the collected literature is evaluated to eliminate for the SLR irrelevant publications. During the *Synthesis,* relevant information is extracted from the selected literature and brought together in the final step, the *Analysis* (Marcos-Pablos & García-Peñalvo, 2018).

The following chapters explain and illustrate the procedure from retrieving relevant literature from databases (*Search* and *Appraisal,* in *Chapter 2.3.1.*), over coding and analysing selected literature to then evaluate and summarize (*Synthesis* and *Analysis* in *Chapter 2.3.2.*) the results.

2.3.1. Literature Identification

Primary sources of information for this review were electronic journal databases of Web of Science, Scopus, and Google Scholar. Web of Science and Scopus were searched via a self-developed search string. Google Scholar was searched, using keywords for finding additional literature. The search was conducted in February 2023.

Only studies that include information on irrigation and migration in Ethiopia were included. For both terms, all associated terms such as "*migrant(s)*", "*immigration*", or "*immigrant(s)*" and "*irrigated*" were included by using an asterisk at the beginning and end of the core word. Literature from the subject area of *"health sciences"* was excluded because it is often associated with the migration of bacteria or similar. All other subject areas were included. Only studies published in the year 2000 or later which were peer-reviewed publications and only studies written in English were included.

The following **search strings** were created, to extract relevant literature from databases.

Scopus1: *(PUBYEAR > 1999) AND (TITLE-ABS-KEY (ethiopia AND *migra* AND irrigat*)) AND NOT SUBJAREA(medi OR nurs OR vete OR dent OR heal OR mult) AND (LIMIT-TO (LANGUAGE,"English"))*

Results: 30 documents.

Additionally, the following search string was applied in Scopus. The only difference to the first search string are the brackets for the main key words "*ethiopia*", "**migra**", and "*irrigat**". This version finds all documents, where "*ethiopia*" is in the title, abstract, or listed keywords and "**migra**" and "*irrigat**" is in all other fields.

Scopus2: (PUBYEAR > 1999) AND (TITLE-ABS-KEY (ethiopia) AND (*migra*) AND (irrigat*)) AND NOT SUBJAREA(medi OR nurs OR vete OR dent OR heal OR mult) AND (LIMIT-TO (LANGUAGE,"english"))

Results: 215 documents.

For Web of Science, the same criteria were applied, except from the exclusion of the subject area *"health sciences"*, as there were no results showing for this category.

Web of Science: *((PY=(2000-2023)) AND ALL=(ethiopia AND irrigat* AND (migra* OR immigra*))) AND LA=(English) NOT Citation Topics Meso:3.2 Marine Biology or 8.19 Oceanography, Meteorology & Atmospheric Sciences*

Further, the Citation Topic "*3.2 Marine Biology*" was excluded.

Results: 26 documents.

Google Scholar: Additional literature was found using keywords: "*irrigation*", "*migration*", "*ethiopia*", "*population*", "*migrant labour*" "*population*". The first three keywords were always included. Articles were selected, if they dealt with agricultural practices and irrigation or migration, socio economic changes in the agricultural sector through irrigation or migration, livelihood impacts and agriculture, migration or displacement, labour migration in the agricultural sector, or similar topics. Articles that were already extracted through the previous searches via search strings were not included. In total, 16 documents were added using Google Scholar.

2.3.2. Literature evaluation

All bibliographical details of the results of *Web of Science* and *Scopus1* were imported into Citavi (reference manager) to manage the references and eliminate duplications. 14 documents were listed in both databases. Then the results of the broader search string *Scopus2* were analysed. Since the main criterion of this search is that only "*ethiopia*" appears in the title, abstract, or keywords and the other terms anywhere else, many results found here are not relevant for this review because terms concerning migration or irrigation were often only mentioned in the references. Criteria for an article to be selected for further screening, were the same as for the selection of literature via Google Scholar (*Chapter 2.3.1.*). Duplicates from results of previous searches were not considered. After removal of duplicated documents, the usability of the selected 122 documents was examined.

The articles were screened by reading titles and abstracts. Articles irrelevant to the research question were removed, resulting in 85 potentially relevant articles.

Lastly, the eligibility of the selected documents was examined. General criteria were a sufficient peer-review process and the availability through the access via the University of Vienna. For the remaining 82 documents, the quality and eligibility of the studies was further evaluated by skimming through the full text. Documents were excluded if terms associated with irrigation and migration only appeared in the references. If only one of the terms only appeared in the references, the context in which the other term was mentioned, was looked at closer. Documents chosen for the review, dealt in some way with irrigation and/or migration as mitigation strategy for improving livelihood or, at best, both terms (or associated terms) mentioned in the same context. In total, 31 documents were selected using Web of Science, Scopus, and Google Scholar. This entire selection process is visualized and quantified in *Figure 3*.

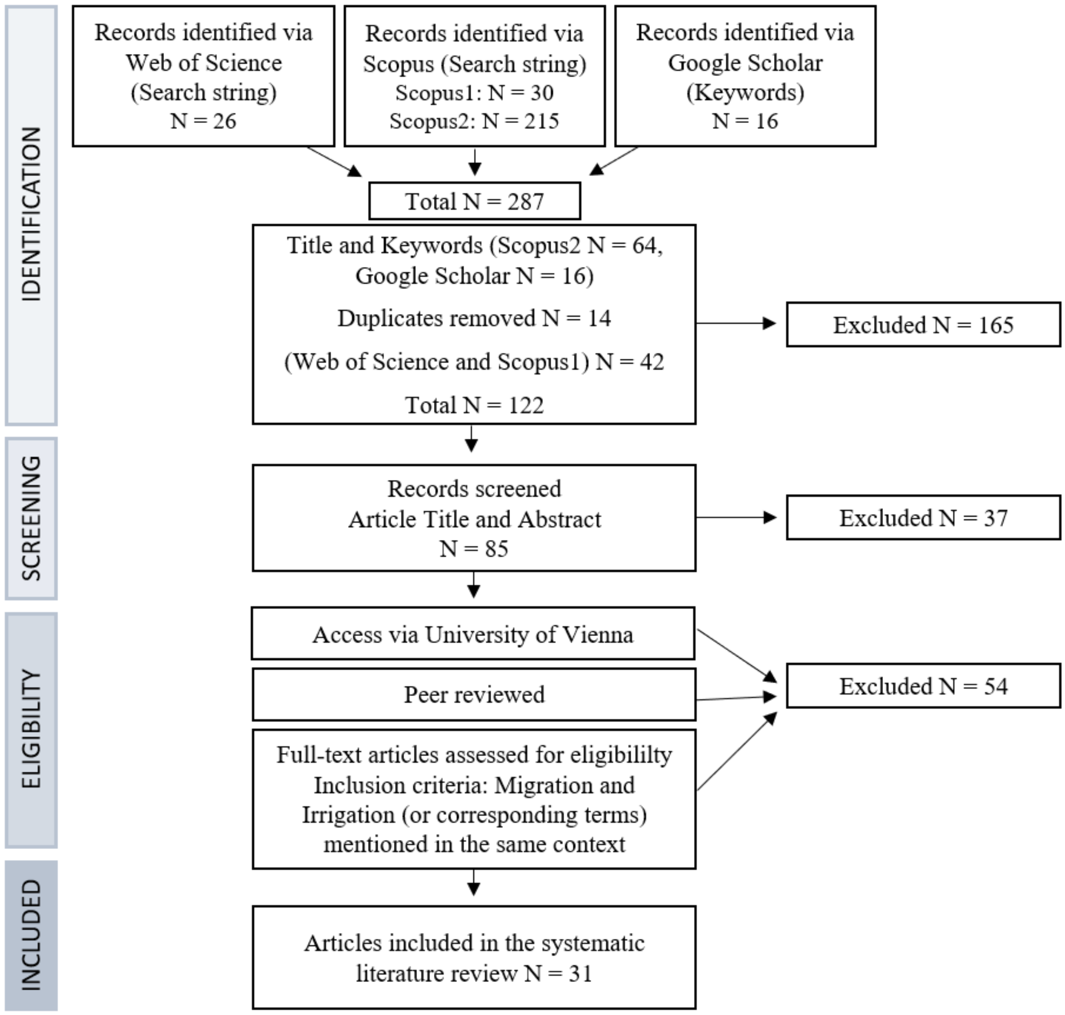

Figure 3: Flow diagram of the process from database search to the selection of articles for a systematic review. Modified from Moher et al. (2009).

Table 1 lists all references, that were analysed in the subsequent review process and of which all results are derived.

Table 1: List of references reviewed for this thesis

Author(s)	Year	Title
Aberra, Y.	2004	Problems of the solution: Intervention into small-scale irrigation for drought proofing in the Mekele Plateau of northern Ethiopia
Adem, M.; Tadele, E.; Mossie, H.; Ayenalem, M.	2018	Income diversification and food security situation in Ethiopia: A review study
Asfaw, W.; Tolossa, D.; Zeleke, G.	2010	Causes and impacts of seasonal migration on rural

		livelihoods: Case studies from Amhara Region in Ethiopia
Ayele, L.; Degefa, T.	2020	Temporary rural–rural labor migration from Quarit District, Northwest Ethiopia: a search for the determinants
Benonnier, T; Millock. K.; Taraz, V.	2019	Climate change, migration, and irrigation
Bantider, A.; Hurni, H.; Zeleke, G.	2011	Responses of rural households to the impacts of population and land-use changes along the Eastern Escarpment of Wello, Ethiopia
Bedeke, S. B.; Vanhove, W.; Wordofa, M. G.; Natarajan, K.; van Damme, P.	2018	Perception of and response to climate change by maize-dependent smallholders
Bedeke, S. B.; Tebeje, M.	2022	Does local cognition of climate change really matters in adaptation: farmer perspectives
Behnke, R.; Kerven, C.	2011	Replacing Pastoralism with Irrigated Agriculture in the Awash Valley, North-Eastern Ethiopia: Counting the Costs
Cochrane, L.; Thornton, A.	2021	Individual and Institutional Drivers of Inequality in Rural Agricultural Contexts: Evidence from Southern Ethiopia
Dorosh, P. A.; Mellor, J. W.	2013	Why agriculture remains a viable means of poverty reduction in Sub-Saharan Africa: The case of Ethiopia
Eguavoen, I.; Tesfai, W.	2012	Social impact and impoverishment risks of the Koga irrigation scheme, Blue Nile basin, Ethiopia
Eshetu, S.; Belete, B.; Goshu, D.; Kassa, B.; Tamiru, D.; Worku, E.; Lema, Z.; Delelegn, A.; Tucker, J.; Abebe, Z.	2010	Income diversification through improved irrigation in Ethiopia: impacts, constraints and prospects for poverty reduction
Eshetu, F.; Haji, J.; Ketema, M.; Mehare, A.	2023	Impact of rural out-migration on poverty of households in southern Ethiopia
Etana, D.; Snelder, D..; van Wesenbeeck, C.; De Cock Buning, T. C.	2021	The impact of adaptation to climate change and variability on the livelihood of smallholder farmers in central ethiopia
Etana, D.; Snelder, D. J.R.M.; van Wesenbeeck, Cornelia F.A.; Buning, Tjard De Cock	2022	Climate change, in-situ adaptation, and migration decisions of smallholder farmers in central Ethiopia
Fried, S.; Lagakos, D.	2021	Rural electrification, migration and structural transformation: Evidence from Ethiopia

Gebeyehu, A. K.; Snelder, D.; Sonneveld, B.; Abbink, J.	2021	How do agro-pastoralists cope with climate change? The case of the Nyangatom in the Lower Omo Valley of Ethiopia
Gebresenbet, F.; Kefale, A.	2012	Traditional coping mechanisms for climate change of pastoralists in South Omo, Ethiopia
Grasham, C. F.; Charles, K. J.; Abdi, T. G.	2022	(Re-)orienting the Concept of Water Risk to Better Understand Inequities in Water Security
Headey, D.; Taffesse, A. S.; You, L.	2014	Diversification and Development in Pastoralist Ethiopia
Headey, D.; Dereje, M.; Taffesse, A.S.	2014	Land constraints and agricultural intensification in Ethiopia: A village-level analysis of high-potential areas
Hodbod, J.; Stevenson, E.G.J.; Akall, G.; Akuja, T.; Angelei, I.; Bedasso, E. A.; Buffavand, L.; Derbyshire, S.; Eulenberger, I.; Gownaris, N.; Kamski, B.; Kurewa, A.; Lokuruka, M.; Mulugeta, M. F.; Okenwa, D.; Rodgers, C.; Tebbs, E.	2019	Social-ecological change in the Omo-Turkana basin: A synthesis of current developments
Kidane, R.; Wanner, T.; Nursey-Bray, M.; Masud-All-Kamal, Md.; Atampugre, G.	2022	The Role of Climatic and Non-Climatic Factors in Smallholder Farmers' Adaptation Responses: Insights from Rural Ethiopia
Mengistu, M.A.	2022	Rural livelihood vulnerabilities, contributing factors and coping strategies in Takusa Woreda, North Western Ethiopia
Minten, B.; Mohammed, B.; Tamru, S.	2020	Emerging Medium-Scale Tenant Farming, Gig Economies, and the COVID-19 Disruption: The Case of Commercial Vegetable Clusters in Ethiopia
Nyssen, J.; Fetene, F.; Dessie, M.; Alemayehu, G.; Sewnet, A.; Wassie, A.; Kibret, M.; Walraevens, K.; Derudder, B.; Nicolai, B.; Annys, S.; Tegegne, F.; van Passel, S.; Frankl, A.; Verleyen, E.; Teklemariam, D.; Adgo, E.	2018	Persistence and changes in the peripheral Beles basin of Ethiopia
Nyssen, J.; Negash, E.; van Schaeybroeck, B.; Haegeman, K.; Annys, S.	2022	Crop Cultivation at Wartime – Plight and Resilience of Tigray's Agrarian Society (North Ethiopia)

Ruffeis, D.; Loiskandl, W.; Spendlingwimmer, R.; Schonerklee, M.; Awulachew, Seleshi Bekele; Boelee, Eline; Wallner, K.	2008	Environmental impact analysis of two large scale irrigation schemes in Ethiopia
Teweldebrihan, M.D.; Pande, S.; McClain, M.	2020	The dynamics of farmer migration and resettlement in the Dhidhessa River Basin, Ethiopia
Teweldebrihan, M. D.; Lyu, H.; Pande, S.; McClain, M. E.	2021	Smallholder Farmer's Adaptability to Anthropogenic and Climate-Induced Variability in the Dhidhessa River Sub-basin, Ethiopia
Tizazu, A. T.; Derluyn, I.; Lietaert, I.	2020	Towards a definition for returnees' reintegration processes in the context of rural Ethiopia

Note: *The publication by Benonnier et al. (2019) was identified via the search and selection criteria for this thesis (Chapter 2.3.1.). However, it deals with the impact of irrigation on climate migration and whether access to irrigation modulates the climate migration poverty trap. In many aspects, it deals with the research question of this thesis on a global scale and Ethiopia is only mentioned as one of the countries classified as 'poor'. Therefore, it is very well suited as a reference to place this thesis in the global context, which is done in the discussion under Chapter 6.2. Therefore, the publication is listed in this list of reviewed references, even though it is not integrated in the literature review and is subsequently not taken into consideration in the results (Chapter 5).*

2.4. Content Analysis via MAXQDA

The selected literature was coded via MAXQDA (VERBI Software, 2021) (*Chapter 2.4.*) and analysed with an approach, close to the qualitative content analysis according to Udo Kuckartz (*Chapter 2.2.1.*). A combination of a deductive and inductive approach was applied.

About MAXQDA

MAXQDA is a professional software for qualitative and mixed methods data analysis. Generally, it helps to systematically analyse and interpret data (VERBI GmbH, 2023). For a content analysis, as conducted in this thesis, text documents can be imported and analysed, using an individual coding system, assigning key words, and creating notes as memos and to help organize the data. Further, finding connections in the selected data (in this case the articles) and aggregating the coded segments by summarizing it on the dimensions of the created code system are key components of the software. Finally, results can be visualized (VERBI GmbH, 2023).

Coding Process

The approach for qualitative content analysis after Kuckartz emphasizes the importance of a systematic and transparent process that can be easily understood by others, when working with qualitative data (Kuckartz, 2019). To meet this, great value was placed on designing the process of extracting relevant literature as objective and repeatable as possible. However, a limitation of this approach is that it is hardly avoidable to bring in subjectivity here since it is a matter of deciding in which category a statement or text passage fits best.

The conducted content analysis is a combination of deductive and inductive procedures (see *Figure 2, Chapter 2.2.2.*). For each step, the research questions play a vital role and are always the centre of the process. First, main codes (below) were deductively created based on the research questions that were elaborated in the introduction. These help to examine and roughly categorize the material according to the specific content that is to be extracted, to answer the research questions.

Initial/Main codes:

- *Location of the study*
- *Methodology of the study*
- *Type of irrigation*
- *Reasons for implementation of irrigation*
- *Challenges of irrigation*
- *Impact of irrigation*
- *Socio-economic consequences (of irrigation projects)*
- *Type of migration (associated with irrigation)*
- *Reasons for (non-) migration*
- *Challenges of migration*
- *Impact of migration*
- *Socio-economic consequences of migration*
- *Mechanisms between migration and irrigation*

In the coding process, the selected literature was read, and respective segments marked and assigned to the appropriate codes. The scope of the coded segments varies greatly. The smallest coding unit consist of sentence fragments. The largest units can be up to several paragraphs. The length of most of the coded segments is one sentence up to one paragraph. Memos were created for each reviewed document (document memos) with thoughts on the respective content and comments or references to linked coded segments that seemed particularly relevant. Further comments were added directly at some segments.

During this process, additional sub-codes were created inductively, based on the material that was reviewed. The sub-codes were mainly created while reviewing the segments of a main category. Some main codes were rearranged or merged into subcodes. The code system changed slightly and continuous throughout the process. The final code structure was as follows:

Sub-codes:

- *Location of the study*
- *Methodology of the study*
- *Irrigation situation*
    - *Type of irrigation*
    - *Reasons for implementation of irrigation*
    - *Challenges of irrigation*
    - *Impact of irrigation*
    - *Socio-economic consequences (of irrigation projects)*
- *Migration*
    - *Type of migration (associated with irrigation)*
    - *Reasons for (non-) migration*
    - *Challenges of migration*
    - *Socio-economic consequences of migration*
- *Mechanisms between migration and irrigation*
    - *Impact of irrigation on migration*
    - *Type of migration associated with irrigation*
    - *Dam-induced displacement/migration*
    - *Impact of migration on Irrigation*

Content Evaluation

The content of each code was reviewed and then presented in *Chapter 5*. Each chapter consists of one or more codes. If a chapter contains more than one code, its structure is given by the respective codes. The segments were worked through in sequence and written in a context specific manner.

When reviewing the literature, selected for this thesis (*Chapter 2.3.*), the code “type of irrigation” turned out to be irrelevant. In most publications the type of irrigation was not mentioned. The focus was mostly on the size of the irrigation scheme or the size of the farm.

3. Study Area

This chapter provides an overview of information about Ethiopia, relevant for this thesis. This includes information on the natural environment such as climate, geology, and soil as well as socio-economic information like the development of population, political situation, economy, and the agricultural sector.

3.1. General Information

Ethiopia is located in the tropical zone and part of the Horn of Africa, which lies in eastern sub-Sahara Africa (see *Figure 4*). Its capital city is Addis Abeba, located in the centre of the country. Ethiopia borders Eritrea, Sudan, Kenya, Somalia, and Djibouti and has a total area of around 1.112.000 square kilometres, which is about twice the size of France (Country Reports, 2023). With about 120.3 million inhabitants, it is the country with the second highest population in Africa (The World Bank, 2023) and the most populated and largest country (by area) in the Horn of Africa. Only 12 % of the country's area is arable, with 86 % of the population dependent on agriculture or animal husbandry for subsistence (Country Reports, 2023).

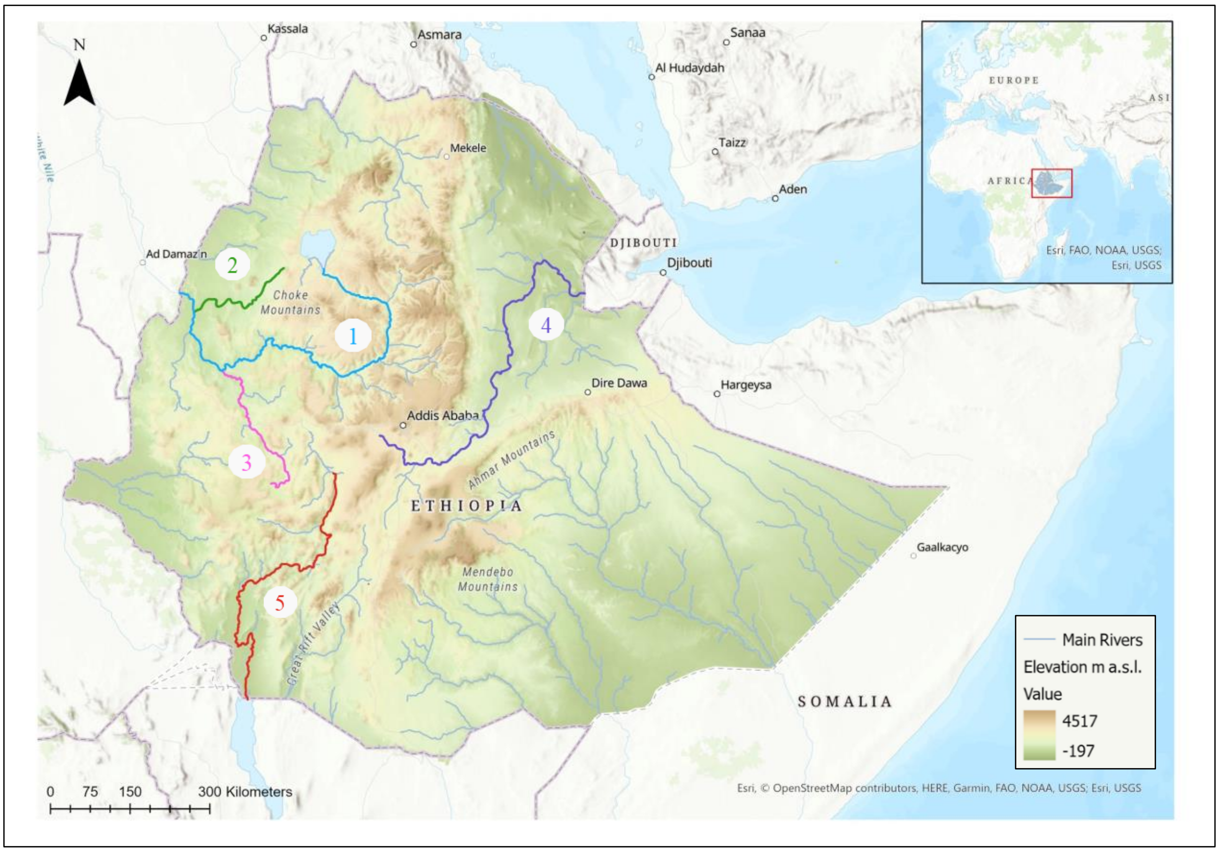

Figure 4: Map of Ethiopia. (Data source, ArcGIS Pro (ESRI, 2023)). The following numbers indicate the different rivers that are important for this thesis: 1) Blue Nile River; 2) Beles River; 3) Dedessa River; 4) Awash River; 5) Omo River.

3.2. Natural Environment

Ethiopia is characterized by a wide variety of landscapes (Fazzini et al., 2015). Its terrain consists of high plateaus and mountains, deep canyons and abysses, dry lowlands, savannas and deserts (Country Reports, 2023). Elevations range from 125 m below sea level in the Danakil Depression (central), which is one of the lowest and hottest places on earth (H. A. Mengistu et al., 2019), to 4533 m above sea level in the Semien Mountains (North) (Asefa et al., 2020). The central mountain range is divided into two distinct highlands by the Great Rift Valley, located in the northwestern and southeastern regions called the western and the eastern Ethiopian highlands (Asefa et al., 2020; H. A. Mengistu et al., 2019) (see *Figure 4*).

3.2.1. Climate

The large land area, the diverse topography, the geographic position close to the equator and the Indian Ocean promote a disparity of temperature and precipitation resulting in different climates across the country (Fazzini et al., 2015). There are high rainfall and humidity in Ethiopia's equatorial rain forests in the South and Southwest. Desert-like conditions are present in the Semien and Bale Mountains as well as in the Northeast, East and Southeast lowlands. Cooler, subtropical climates are found in the highland regions (Central and North). The climate in the sparsely populated semi-desert north-eastern, eastern, and south-eastern regions is arid and due to very little rainfall prone to drought (Climate Change Knowledge Portal, 2021; H. A. Mengistu et al., 2019). Mean annual precipitation range from approximately 2000 mm over the south-western highlands to less than 300 mm over the south-eastern and north-eastern lowlands (Climate Change Knowledge Portal, 2021). The regional distribution of the amount of annual precipitation is displayed in *Figure 5*. The highest average (89.4 mm/24h) and absolute (181.4 mm/24h) rainfall intensities were recorded in Gambela (Fazzini et al., 2015). Seasonal precipitation and the resulting effects on the climate is primarily driven by the migration of the Intertropical Convergence Zone (ICP) and associated atmospheric circulations in combination with the diverse topography (Fazzini et al., 2015). There are three main rainy seasons and one minor season, called: Bega, Belg, Kiremt, and Tseday (*Table 2*). The most intensive rainfall occurs during the primary rainy season Kiremt from mid-June to mid-September, where 50 – 80 % of annual rainfall occurs.

Table 2: Rain seasons in Ethiopia. Data Source: SeasonsYear.com, 2023

Bega	**Belg**	**Kiremt**	**Tseday**
December-February	March-May	June-August	September-November
- Dry season - Frost can occur in the morning	- Sporadic secondary wet-season - Occasional showers -May is the hottest month of the year	- Primary rainy season - 50 - 80 % of annual rainfall	Harvest season

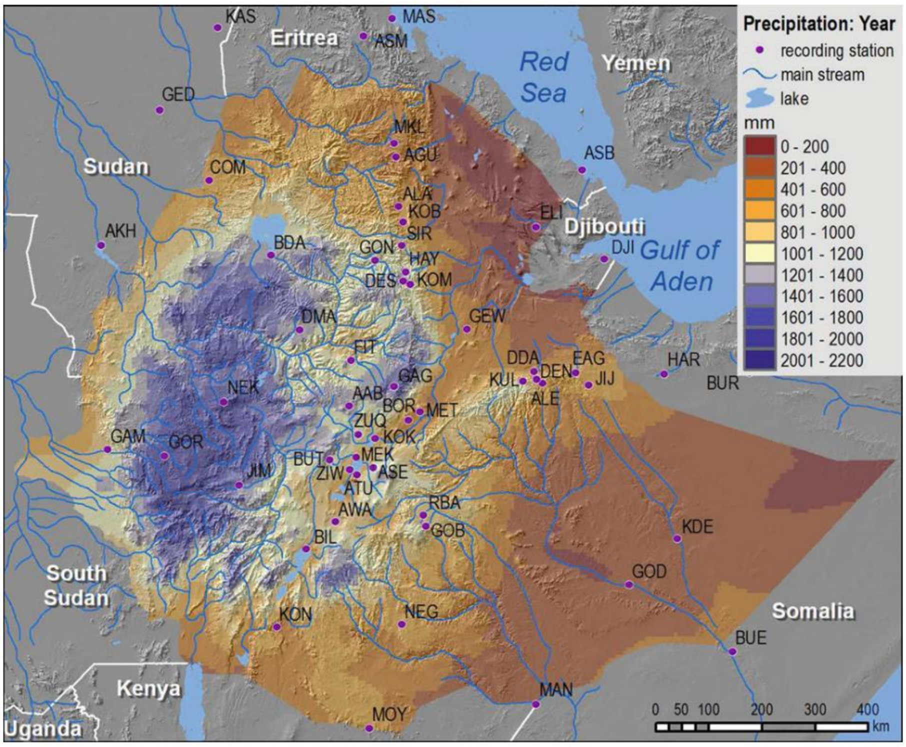

Figure 5: Distribution of annual precipitation (Fazzini et al., 2015).

Mean annual air temperatures range from -15°C in the highlands, to above 25°C in the lowlands (Climate Change Knowledge Portal, 2021). Broadly speaking, as displayed in *Figure 6*, in northeastern and southeastern Ethiopia, as well as some western regions along the country’s border, average temperatures reach form 25°C to 32°C, while cooler average tempe-

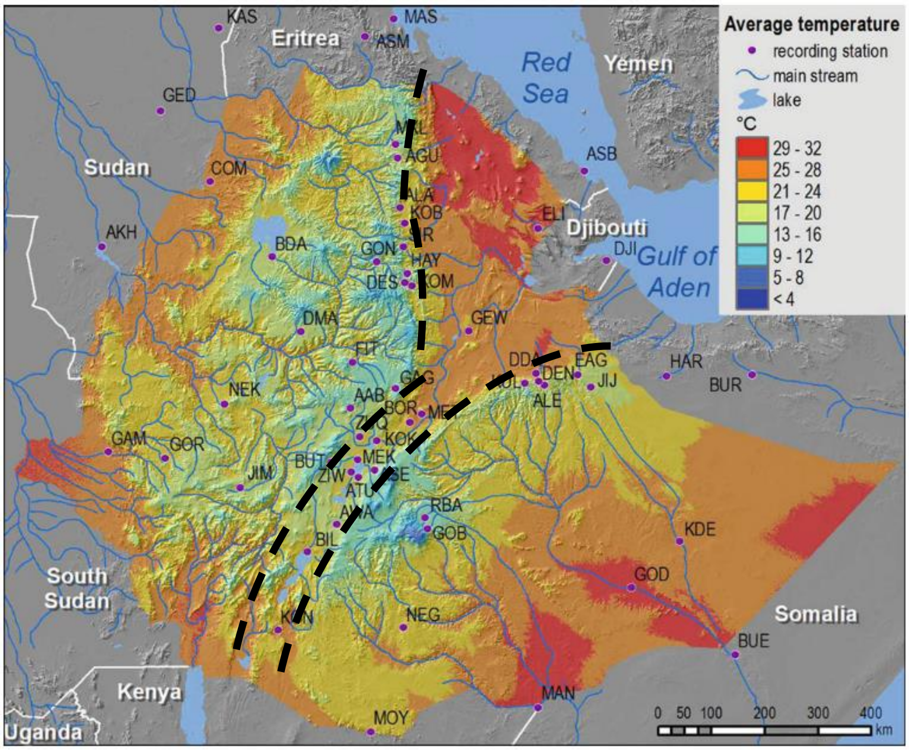

Figure 6: Mean annual air temperature of Ethiopia (Fazzini et al., 2015). Dashed line indicates the course of Great Rift Valley (added by the author of this thesis).

ratures of 9°C to 25°C are found in central and western regions (Fazzini et al., 2015). Generally, the air temperature varies mostly with altitude and daily air temperatures vary more than annually (Fazzini et al., 2015). What stands out in *Figure 6* is that the mean annual air temperatures show the course of the Great Rift Valley (dashed line in *Figure 6*).

3.2.2. Geology

The development of Ethiopia's geology "[…] is characterized by periods of highland uplift and rift formation" (Asefa et al., 2020, p. 303). The assembly and breakup of Gondwana as well as the present-day rifting of Africa had a major impact on the geology of Ethiopia (Abbate et al., 2015). The oldest geological units are around 880 to 550 million years old and were formed by the East African Orogeny, which caused the closure of the ancient Mozambique Ocean (Abbate et al., 2015). Marine sediments of the early Jurassic, which were deposited as a result of a regional marine transgression, cover much of those older geological units (Abbate et al., 2015). The resulting rocks, that exist in Ethiopia today, include sandstone, limestone, shale, marl, and evaporites (Abbate et al., 2015). Geology represents an important preconditioning factor of soil formation which is explored in the following chapter.

3.2.3. Soil

According to the World Reference Base for Soil Resources (WRB), five principal types of soil can be classified in Ethiopia.

1) The first type can be found in the western and eastern highlands and is composed of Nitosols and Andosols, which are formed from volcanic material. They have a medium to high potential for rainfed agriculture (ZGEC, 2020).
2) In the Simien plateau of the western Highlands, Cambisols and Luvisols (second type) are found. Due to their low nutrient retention, surface crusting, and erosion hazards, they are of medium agricultural potential when proper management is applied (ZGEC, 2020).
3) The third type is dark clay, composed of Vertisols, which have a medium to high potential for agriculture and is found in the western Lowlands and at the foothills of the western Highlands. Some of Ethiopia's profitable coffee regions are found on these soils (ZGEC, 2020).
4) The fourth group consists of saline soils, that are found in desert areas of the Eastern Lowlands and the Denakil Plain. They have little to no potential for rainfed agriculture but are very suitable for livestock and can be cultivated through irrigation (ZGEC, 2020).
5) The fifth type is Lithosols and is found in the Denakil Plain. This type has a shallow profile and lacks moisture, which precludes cultivation of these soils (ZGEC, 2020).

3.2.4. Vegetation

The diverse landscapes, climates, geologies and soils of Ethiopia, result in a just as diverse vegetation, "[…] which range from Afroalpine vegetation in the mountains to the arid and semi-arid vegetation type in the lowlands" (Asefa et al., 2020, p. 302). Highland uplift and rift formation due to volcanic forces created new habitats with different topography and climatic conditions, which ultimately favoured the diversification of vegetation (Asefa et al., 2020). The following eight vegetation types have been identified, mainly based on elevation and climate gradients: Afroalpine and sub-Afroalpine (3200-4533 m a.s.l.), dry evergreen montane and grassland complex (1800-3000 m a.s.l.), moist evergreen montane forest (500-2600 m a.s.l.), Acacia-Commiphora woodland (900-1900 m a.s.l.), lowland semi-evergreen forest (450-650 m a.s.l.), desert and semi-desert scrubland (<400 m a.s.l.), and aquatic vegetation (lowlands to highlands) (Asefa et al., 2020).

3.2.5. Hydrology

Scientific literature on the hydrology in Ethiopia is sparse. Detailed information on the characteristics of surface water, groundwater water availability, and water management are rather rare which shows the necessity of more research in this field. The available information is compiled as follows.

Surface Water

Generally, Ethiopia has large resources of surface water, which is located in rivers and lakes (S. Kebede et al., 2018). There are 12 river systems of which one is the Abay/Blue Nile, located in western Ethiopia. The Abay/Blue Nile is with a length of 1.610 km and a watershed of about 176.000 km^2 Ethiopia's largest river in Ethiopia (Billi et al., 2015) and along with the White Nile one of the two main branches in the Nile river system. The Nile is an important water vein through Africa, that supplies multiple countries with water and flows in Egypt into the Mediterranean Sea. The Blue Nile originates from Lake Tana, which is fed by smaller rivers (Billi et al., 2015). Like the Abay/Blue Nile, the two other western rivers Tekeze and Baro also flow into the Mediterranean Sea after confluencing with the Nile (Tekeze) and White Nile (Baro), while the eastern draining rivers flow into the Indian Ocean and the river systems in between are closed basins (Billi et al., 2015). Other smaller endorheic river systems in the western main basins flow into lakes or structural basins (Billi et al., 2015). The variety of Ethiopia's landscape is also reflected in the drainage network of the rivers. Generally, rivers are an important geomorphological factor when it comes to the genesis and transformation of landscapes. Through fluvial erosion they can cut deep into the terrain and create valleys. The northeastern plateau in Ethiopia clearly shows this process as it is deeply dissected by large perennial rivers like the Abay/Blue Nile (Billi et al., 2015). There are also several large lakes, of which the biggest is Lake Tana in the North. Most of the lakes are a result of the Great African Rift Valley (S. Kebede et al., 2018).

EXCURSUS 1: HYDROPOWER

Due to the fast-growing economy (*Chapter 3.3.3.*), meeting the increasing energy demand in the industrial, agricultural, and service sector as well as rising household consumption because of rising standards of living, is a great challenge (Degefu et al., 2015). Most of Ethiopia's electricity is generated through hydropower (about 88 %) that uses the flow energy of rivers and further expansion of capacity is planned (Degefu et al., 2015; S. Kebede et al., 2018). Ethiopia has the second largest hydropower potential in Africa of which less than 10 % are exploited to date (Hailu, 2022). At present there are 11 installed mega and 7 small-scale (capacity of less than 40 MW) hydroelectric power plants in Ethiopia (Hailu, 2022). The construction of several additional large hydroelectric projects has begun. One of them is the Gilgel Gibe IV (Koysha) hydropower project and the massive Grand Ethiopian Renaissance Dam (GERD), which is being built on Abay/Blue Nile River and will be Africa's largest dam and the sixth largest dam in the world when completed (Hailu, 2022).

Groundwater

When it comes to groundwater, the natural geological environment plays an important role for its occurrence and circulation. "Ethiopia is characterized by complex hydrogeology with high spatial variability due to various complex geological evolutionary processes including tectonic movement and climatic variability" (H. A. Mengistu et al., 2019, pp. 1053–1054). The aquifer recharge rates are very variable across the country, with a variety from nearly 0 to 300 mm/yr. (S. Kebede et al., 2018). Between 25 and 30 % of the aquifers mapped to date are categorized as high yielding and suitable for exploitation (H. A. Mengistu et al., 2019), while an estimated 30 % is unavailable due to high salinity and/or high fluoride (S. Kebede et al., 2018). However, it is important to highlight here, that while much of the distribution of aquifers is now mapped, quantitative information on the characteristics of the aquifer as well as groundwater recharge rates and flow regimes is irregular and information on water quality is generally incomplete (H. A. Mengistu et al., 2019).

Groundwater provides most of the domestic (90 %) and industrial (95 %) water supply in Ethiopia (S. Kebede et al., 2018; H. A. Mengistu et al., 2019). More than 90 % of groundwater is used for households (ca. 80 %) and industrial supply while only a very small proportion (<1 %) is used for irrigation (water for irrigation is mostly surface water) (S. Kebede et al., 2018). Only some larger (commercial) irrigation schemes are starting to use groundwater (S. Kebede et al., 2018). Throughout sub-Sahara Africa and in most rural areas in Ethiopia, the accessibility of groundwater has been through wells and springs, that are mostly hand dug (H. A. Mengistu et al., 2019).

Water Availability

There is a large variety of water availability across the country as there are tropical rain forests as well as arid regions that are often prone to drought (*Chapter 3.2.1.*). In 2020 only

13 % of Ethiopians use safely managed drinking water services (The World Bank, 2023). Major differences in water availability can be observed for households between rural and urban areas. While more than 39 % (2020) of the urban population use safely managed drinking water services, this is only true for 5 % (2020) of the rural population (The World Bank, 2023). However, 50 % of people use at least basic drinking water services in 2020 (84 % of urban population; 40 % of rural population) (The World Bank, 2023). “The human right to water is recognized in international treaties to which Ethiopia is a party and under the Ethiopian Constitution where it is expressly mentioned as a social objective. Ethiopia is also committed to ensuring safe drinking water and sanitation for all by 2030 (SDG 6)” (EHRC, 2022). The implementation of ensuring safe drinking water and sanitation for all proves to be difficult. Despite large water resources, there is water scarcity in many regions and degraded quality of water has led to chronic food insecurity. This is amplified by increasing climatic extremes and variability of rainfall patterns and distributions (UNICEF, 2022a). Subsequent flooding “[…] is a significant problem, exacerbated by shortage of climate-proofed water infrastructure” (UNICEF, 2022a) and droughts. In the semi-desert regions in southern Ethiopia, the frequent occurring water shortage is the main cause of nomadic conflicts, due to lack of water for livestock and desirable access to grasslands (H. A. Mengistu et al., 2019).

Water Management

The Ministry of Water, Irrigation and Energy is responsible for policy making, financing, planning, and providing base information. Exploration and mapping are carried out by the Geological Survey of Ethiopia. Shallow groundwater mapping and management policy, which is particularly important for farmers, is performed by the Agricultural Transformation Agency. Other important institutions for water management are the Ministry of Forestry and Environment (reviewing possible impacts on groundwater quality and quantity of national investments; strategic environmental assessments), Regional Water Bureaus (regulatory, policy, financing, planning), River Basin Organizations (allocation and supplies), and Water User Associations (local regulation and allocation; formal and informal) (S. Kebede et al., 2018). The monitoring of groundwater level or quality is to date only sparsely performed by research institutes. There are no regional or national programs and there is little formal registration of boreholes and other water extraction points (S. Kebede et al., 2018).

3.2.6. Climate Change impacts and scenarios

In general, sub-Saharan Africa is susceptible to climatic changes and is considered one of the most vulnerable regions to CCV and its subsequent effects on the population (Conway et al., 2015; IPCC, 2022). Factors for this are vast semi-arid areas, the high reliability on rainfed agriculture, and low adaptive capacity (Borderon et al., 2019). Among African countries (and in general), Ethiopia is extremely vulnerable to CCV (Etana et al., 2022; Gezie, 2019). Therefore, climatic changes and their consequences in Ethiopia receive a lot of attention in research (Auci et al., 2018; Bogale & Erena, 2022; Etana et al., 2022; Gelete et al., 2020;

Gezie, 2019; Hermans & McLeman, 2021; Negera et al., 2022; Teklewold et al., 2017). Since the majority of the population is dependent on rainfed agriculture the amount, regularity, and predictability of precipitation is of very large interest for the country (Etana et al., 2022; Fazzini et al., 2015). It is evident that anthropogenic climate change has impacts on climate parameters in Ethiopia. Anomalies of temperatures and precipitation trendlines measured throughout the last century "[…] cannot be associated with ordinary cyclic oscillations of these parameters" (Fazzini et al., 2015, p. 83). For the time period from 1981-2010, an average temperature increase of 1.1 °C (0.04 °C per year) has been recorded in all meteorological stations (Fazzini et al., 2015). Although, changes of precipitation are more difficult to evaluate due to data gaps in different time series of 3-5 years, an overall decrease in the amount of rainfall throughout the last century emerges (Fazzini et al., 2015).

Drought

Drought is becoming an increasing important topic in sub-Sahara Africa, as the reliability on periodic rainfall decreases and occurrence as well as intensity of heavy rainfall events increase (Teshome & Zhang, 2019). There is an increase of precipitation extremes (both excess and deficient precipitation) in most of sub-Sahara Africa, including Ethiopia (Teshome & Zhang, 2019). When drought conditions and extreme precipitation occur simultaneously or shortly after another, impacts can be increased erosion, decreasing groundwater levels, flash flooding, crop destruction, loss of life, and infrastructure damage (Teshome & Zhang, 2019). Dry soil has a limited capacity to absorb precipitation sufficiently which is the reason for increased surface runoff that potentially increases soil erosion, landslides, and flooding (Dikau et al., 2019). These consequential effects of droughts are some of the most impactful consequences for the environment and the population (Teshome & Zhang, 2019).

The rural highlands of northern Ethiopia experience particularly frequent and severe drought conditions (Zeleke et al., 2017) and count as a "[…] global hotspot of increasing rainfall variability, crop yield reduction, and ecosystem change" (Hermans & Garbe, 2019, p. 1102). In the southern and southwestern regions the frequency and intensity of drought conditions have increased particularly since ~ 1997 (Zeleke et al., 2017).

Overall, droughts are expected to become more frequent and intense in the future (Etana et al., 2022; Hermans & McLeman, 2021). With the current course of greenhouse gas (GHG) emissions, "[…] spatial expansion of drylands (typically defined as areas that are hyper-arid, arid, semi-arid, and/or dry sub-humid), and generally greater aridity at a global scale" (Hermans & McLeman, 2021, p. 237) is to be expected. Gidey et al. (2018) conducted a study in Raya in northern Ethiopia predicting future meteorological drought hazards (2016-2070) under the representative concentration path (RCP) 4.5 climate change scenario. According to this study, the recurrence of droughts will be every 1.8-2.3 years. Moreover, droughts are predicted to have higher magnitude and frequency (for the study period 2016-2070) than the last three decades (Gidey et al., 2018). It can be assumed that the situation is similar in other parts of the country (Etana et al., 2022).

The highly resource-dependent subsistence farmers and rural populations of Ethiopia in general are especially affected by drought (Etana et al., 2022; Hermans & Garbe, 2019). This poses a major risk as it potentially undermines livelihoods and wellbeing due to shortage of drinking water for humans and livestock as well as land degradation and subsequent damage of crops (Hermans & Garbe, 2019; Hermans & McLeman, 2021). In this context, migration represents one coping strategy to adapt to climate change, of which increasing droughts are a consequence (Hermans & Garbe, 2019). Irrigation can also be an adaptation strategy, in order to cope with (future) precipitation irregularities. However, the fundamental condition for irrigation is the basic availability of water.

3.3. Socio-economic Environment

Ethiopia's population is growing rapidly (UNSD, 2023) and although, urbanization is increasing, most people live in rural areas. Most people are involved in agricultural activities and practice subsistence farming (Dorosh & Schmidt, 2010). It is one of the most vulnerable countries to CCV in sub-Sahara Africa, which is mainly due to the dependency on climate-sensitive agriculture (Etana et al., 2021).

In this chapter, the socio-economic situation and development is elaborated, and an overview of the agricultural sector is given, as it plays a particularly important role in this thesis.

3.3.1. Population Dynamics and Development

According to the United Nations Statistics Division (UNSD) (2023), the population of Ethiopia is rapidly growing with an average annual growth rate of 2.6 % in 2021. The population increased from 21.74 million in 1960 to 120.28 million in 2021 (The World Bank, 2023). However, the growth rate has been decreasing over the last two decades (3.0 % in 2000; 2.8 % in 2010) (UNSD, 2023). The Ethiopian population is a young population with 39.6 % of the population age 0-14 and only 5.3 % above 60 years (UNSD, 2023). The average life expectancy at birth (2021) is 67.9 years for women and 64.1 years for men (UNSD, 2023). The gender distribution is even, with slightly fewer women (49.7 % of total population) than men (The World Bank, 2023). At present, around 20 % of the total population live in urban areas while the remaining 80 % are rural population (UNSD, 2023). Although the majority of the population still lives in rural regions, this proportion has been steadily reduced from 94 % in 1960 (The World Bank, 2023).

Most people in rural areas are involved in agricultural activities (*Chapter 3.3.4.*). Despite growing share of urban population, Ethiopia remains one of the least urbanized countries in the world (Dorosh & Schmidt, 2010). Migration does not contribute significantly to an expansion of Ethiopia's urban areas (Dorosh & Schmidt, 2010).

Beside the permanently residing persons in Ethiopia, in 2022, there were around 868.000 refugees (under United Nations High Commissioner for Refugees (UNHCR) mandate) and almost 2.250 asylum seekers. Additionally, 4.500.000 internally displaced people (IDP) (of concern to UNHCR) are located in Ethiopia (UNHCR, 2023).

EXCURSUS 2: PASTORALISM

"Pastoralism refers to a range of subsistence modes based on specialized herding of domestic animals on free range, and to forms of social life culturally dominated by values associated with the management of livestock wealth (Dahl, 2001, p. 11108). It is a fundamental way of subsistence living that dates back over 10.000 years (Little, 2015) and a way of life in ASAL regions of the world (Mohamed, 2019; Tofu et al., 2023). According to Mohamed (2019) 41.7 % of the worlds estimated 120 million pastoralists reside in sub-Sahara Africa. They live in remote areas, that are often "[…] conflict prone, food insecure, and associated with high levels of vulnerability" (Mohamed, 2019, p. 1).

In **Ethiopia**, there are 12 to 15 million pastoralists (UNICEF, 2019) and around 60 to 65 % of the total land mass is inhabited by pastoralist and agro-pastoralist communities (Mohamed, 2019; UNICEF, 2019) of which 97 % are located in the low land areas of Afar, Somali, Oromia, and SNNPR (southern and western part of Ethiopia) (Mohamed, 2019).

Resilience to Climate Change and Vulnerability (CCV): As pastoralist and agro-pastoralist communities rely on grazing land for their livestock and are dependent on available land and water resources their livelihood systems are particularly vulnerable to CCV (Behnke & Kerven, 2011; Headey, Taffesse, & You, 2014; Tofu et al., 2023). Recurrent droughts are the most common climatic risk for income and livelihood systems of pastoralists (Tofu et al., 2023). Droughts often decimate both, herd size and crops simultaneously (Headey, Taffesse, & You, 2014). Subsequently, the adaptive capacity of pastoralist households is further reduced due to "extreme shortages of animal feed or pasture, scarcity of water, the decline in household income, and outbreaks of livestock and crop diseases and pests [that result] in livestock loss and crop failure" (Tofu et al., 2023, p. 12) which can ultimately lead to starvation of people. As droughts are becoming more frequent, the resilience of pastoralists to climatic stress and shocks is heavily stressed (Headey, Taffesse, & You, 2014). Dam constructions and large-scale irrigation development projects also often negatively affect pastoralist communities. A famine that occurred in the region in 1972/73 and mainly affected pastoralists, was caused by loss of grazing land, water resources and environmental degradation due to large-scale irrigation projects and additional absence of rain (Behnke & Kerven, 2011).

Religion plays a major role in Ethiopian society. The country has a long historical and cultural connection to both Christianity and Islam. Around two thirds of the population identify as Christian, one third as Muslim. However, people in Ethiopia have a high tolerance towards other religions and respect of religious diversity. Mosques and churches are not seldom situated within close proximity and relationships between people of different religions are peaceful (Evason, 2018).

3.3.2. Political Development

Ethiopia as known today exists with similar borders for over 2000 years, which makes it one of the oldest countries in the world (S. Kebede et al., 2018). The political development in Ethiopia went through different stages in history. Ethiopia is known for being the country on the African continent with the longest history of independence with around 2000 years (CIA Factbook, 2023). It is the only African country that was never colonized (Fransen & Kuschminder, 2009). For most of this time its government was an independent monarchy (S. Kebede et al., 2018). Until 1974 the Emperor Haile Selassie was ruling the monarchy, this was when a committee of armed forces (also called the military Derg government) arrested him (Clapham, 2015; S. Kebede et al., 2018). This committee was ruling the country until 1991. Starting from 1991 the Ethiopian People´s Revolutionary Democratic Front (EPRDF) took over the power (Prunier, 2015). Since then, democracy has prevailed, but it is quite unstable and has experienced several contested elections (S. Kebede et al., 2018). Today, Ethiopia is a federal democratic parliamentary republic, led by the prime minister as the head of the government and the president as the head of state who has minor political powers (CIA Factbook, 2023). The current constitution was implemented in 1995 and is still in practice today (CIA Factbook, 2023). The Ethiopian political system is based on three pillars:

- <u>Executive</u>: Represented by the government consisting of the Prime Minister and the Council of Ministers
- <u>Legislative</u>: Represented by the government and the House of Federation as well as the House of Peoples´ Representatives which together constitute the parliament
- <u>Judicative</u>: Represented by the federal state courts

The country is federally organized in 11 regional states which are ethnically based and two charted cities (CIA Factbook, 2023). Further administrative categories within the regional states are Zones, that are further divided in Woredas and further to Kebeles. A Kebele "[…] is the smallest administrative unit in Ethiopia and comprises several villages" (Bantider et al., 2011, p. 43). According to the US Embassy of Ethiopia (2019) there are 62 Zones and 523 Woredas. However, the exact number of zones is not clear, as their names and the number of zones varies in literature and official documents.

3.3.3. Economic Development and GDP

Ethiopia's economy depends largely on smallholder rainfed agriculture, which is vulnerable to climatic changes (Liou & Mulualem, 2019). Ethiopia is classified by the African Development Bank as non-resource intensive and as one of Africa's low income countries (AFDB, 2023). Yet, it is one of the fastest growing economies in Africa (AFDB, 2023; Degefu et al., 2015) and over the past 15 years one of the 10 fastest-growing economies in the world (AFDB, 2023). Especially in the years from 1998 to 2016 the country has seen unprecedented economic growth with an average economic growth rate of 10 % and a rapid urbanization from 6 % to 20 % of the total population living in urban areas (H. A. Mengistu et al., 2019). The growth rate stabilized in 2004 (see *Figure 7*). However, this economic growth has dropped significantly as a result of the COVID-19 pandemic and of internal violent conflict (AFDB, 2023; BMZ, 2023).

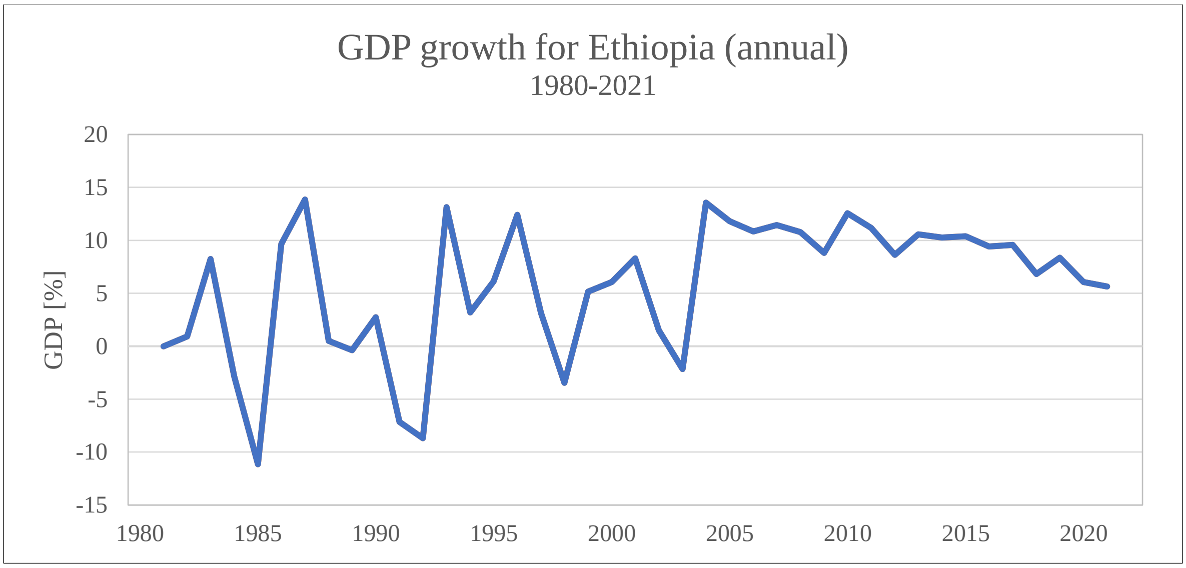

Figure 7: Annual GDP growth of Ethiopia. Data Source: The World Bank, 2023

Despite the economic growth of the last decades, Ethiopia still counts as one of the world's least developed countries, which is reflected in the Human Development Index (HDI), where Ethiopia ranks 175th out of 191 countries (BMZ, 2023). The current inflation is hitting Ethiopia particularly hard. At 24.1 % (outlook for 2023) it has one of the highest inflation rates in Africa compared to the previous year (AFDB, 2023). When it comes to foreign direct investment (FDI), Ethiopia is among the five major FDI destinations in Africa. In 2021, 4.3 billion US-Dollar in FDI's were recorded, which is 79 % higher than the previous year. The largest share of it went into renewable energy projects (AFDB, 2023).

The Labour Force Participation Rate (LFPR) is at national level at about 64.7 % (IOM & CSA, 2021). The most popular sector for employment is the agricultural sector with 65 % of the employed population (IOM & CSA, 2021). Here, are also rural and urban variations. While the agricultural sector is especially popular among rural employed persons (77.3 %), in urban areas the service sector is more popular (73.4 %) (IOM & CSA, 2021).

The extractive industry is not yet widely developed and does not contribute much to the country's growth. However, Ethiopia has geological potential for the discovery of new considerable oil, gas, and mineral deposits (The World Bank, 2015). Gold is the main contributor in this sector, which makes almost 100 % of mining exports (The World Bank, 2015). There is one large gold mine in operation and a growing number of mining projects are under development (The World Bank, 2015).

Generally, Ethiopia's economy is strongly dependent on agriculture, with the majority of people living in rural areas and many of them supporting or sustaining their livelihoods with subsistence farming (Auci & Coromaldi, 2021). Throughout the period from 1990 to 2021, the agricultural sector contributed between 31 % and 64 % to the total GDP. Since almost two decades, the service sector has caught up with the agricultural sector (see *Figure 8*).

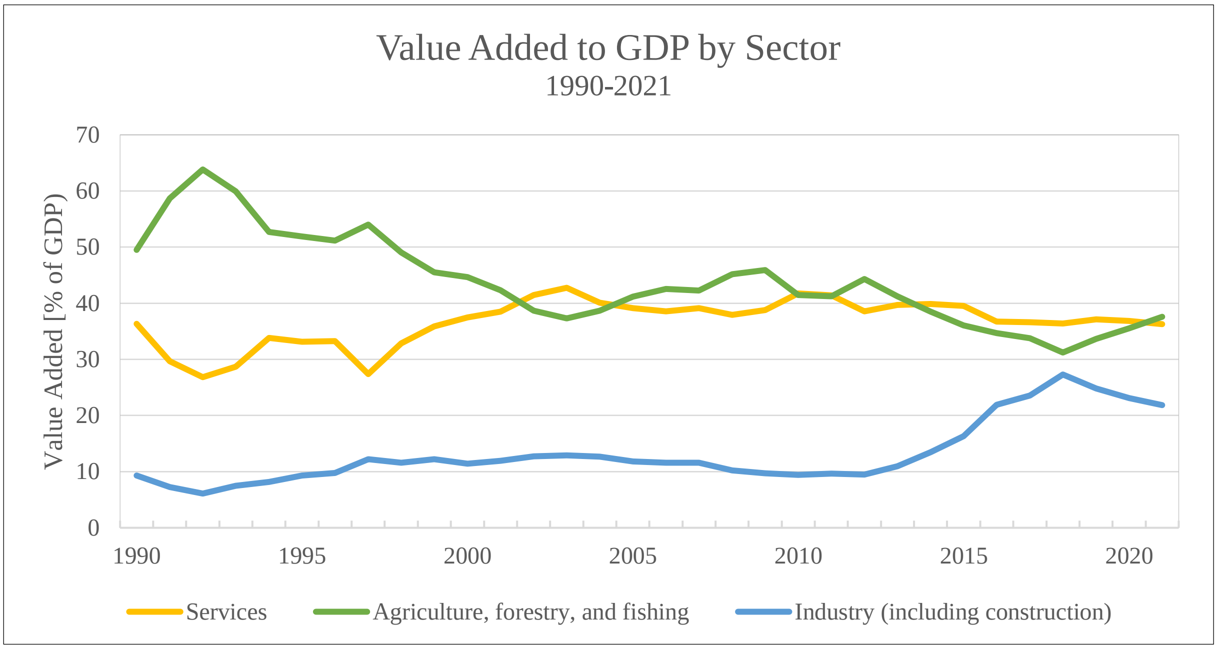

Figure 8: Value Added to annual GDP by Sector. Data Source: The World Bank, 2023.

Moreover, the agricultural sector has a major influence on wealth improvement. It is the growth in the agricultural sector, that drives poverty reduction, which is why "[…] resources should be allocated where they will obtain the highest returns, for instance to the small commercial farmers, to commodities with high growth potential and favourable markets, and to regions with high potential." (Dorosh & Mellor, 2013, p. 436).

Chronic food insecurity due to recurrent drought, degradation of natural resources, and population growth is a critical concern in Ethiopia (Fransen & Kuschminder, 2009). It is estimated, that even in a 'good year' with sufficient rainfall and yield, around five million people still depend on food aid (Fransen & Kuschminder, 2009).

3.3.4. Agricultural Sector

The agricultural sector also plays a central role in Ethiopia's economic and social life (Auci & Coromaldi, 2021). The sector is dominated by small-scale farmers who practice rainfed mixed farming, mostly using traditional technology (Auci & Coromaldi, 2021; Berhe et al., 2022; S. Kebede et al., 2018). The sector is dominated by the production of cereals and keeping livestock which each account for about one third of the agricultural GDP (Dorosh & Mellor, 2013). Throughout the past 30 years, the share of the agricultural sector in Ethiopia's GDP was always between 1 and 2 thirds (see *Figure 8*). More than 80 % of Ethiopians are engaged in the agricultural sector, most of them as small-scale farmers (Adem et al., 2018; Auci & Coromaldi, 2021). Nevertheless, the cash-crop sector is the one that contributes most to the very profitable export economy (S. Kebede et al., 2018). Generally, crops account for about 60 % of the agricultural GDP and livestock and related products for about 20 % (Auci & Coromaldi, 2021). According to the latest data (2021) of the FAO (2023a) cereals, maize (corn), and wheat are the main crops harvested (by area) in Ethiopia in that order (Coffee ranks 6) and are also the crops with the highest production quantity. Ethiopia’s most important cash-crop is coffee. The plantations are mostly located in the southwestern part. The country is the largest coffee exporter worldwide (S. Kebede et al., 2018).

Despite the important role of agriculture for Ethiopia and the high employment rate in the sector, a large part of the population cannot be supplied with food from domestic production (Adem et al., 2018).

Given the fact, that 95 % of the population depends on rainfed agriculture (Auci et al., 2018) and most of the population is employed in food production, effects of climate change will not only have serious economic consequences for the largest part of the population but also negatively impact food security and welfare in the country (Auci et al., 2018). Additionally, water shortages can cause nomadic tribal conflicts and in many regions with sedentary farming communities, soil degradation is an increasing challenge resulting from poor farming practices, overgrazing, and drought (H. A. Mengistu et al., 2019) .

The application of climate smart agricultural practices represents an innovative way to cope with negative climate change impacts. These practices can include, integrated soil fertility management, drought tolerant high yielding crop variety, integrated disease, pest, and weed management and small-scale irrigation. The implementation of climate smart agricultural practices has shown to be a successful strategy, however, it is rarely applied by smallholder farmers in developing countries such as Ethiopia (Negera et al., 2022).

4. State of the Art

A lot of literature deals with the introduction and implementation of irrigation projects and their challenges and potentials (Berhe et al., 2022; Desulie & Abebe, 2017; Gebul, 2021; G. G. Haile & Kasa, 2015; Kassie, 2020; Meja et al., 2020) as well as with migration in Ethiopia (Asfaw et al., 2010; Groth et al., 2021; Hermans & Garbe, 2019; Yalew et al., 2018). But so far, there is little literature on the linkage between the two topics. However, both, migration and irrigation in Ethiopia are mentioned in the same publications dealing with different topics such as climate change mitigation and adaption, sustainability or diversifying of livelihoods, dam projects and their impacts, or agricultural topics. There is no study, particularly on the impacts the implementation of irrigation projects on different scales has on migration and how migration affects irrigated agriculture and more general on the key mechanisms between the two topics.

4.1. General Aspects of Irrigation and Migration

To get an overview of the situation, concerning the two main topics (irrigation and migration) of this thesis, the following two chapters outline general aspects that were found to be important for placing the issue in the overall context.

4.1.1. Irrigation

According to the FAO an estimated 60 % of extra food is needed to satisfy the world's population in 2050 of estimated nine billion (FAO, 2023b). To achieve this, various measures must be taken. Therein, "Irrigation can lead to major changes in agricultural economies in developing countries" (Minten et al., 2020, p. 1410). Particularly because it can offset higher temperatures on yields and can reduce the effects and therefore also the dependency on precipitation (Benonnier et al., 2019). They found that the reduction of yields due to a temperature increase of 1° C is up to 33 % lower in countries with a higher level of irrigation (for methodological details see Benonnier et al., 2019).

"Irrigation is the artificial application of water to land to assist in the growing of crops and pastures. It is carried out by spraying water under pressure or by pumping water onto the land" (OECD, 2001) or simply put it, is "[…] the controlled application of appropriate quantities of water to crops in a timely manner" (Adams, 1989, p. 21). Irrigation plays a key role in agricultural production since the beginning of crop cultivation (FAO, 2023b) and is an important key mechanism in increasing agricultural productivity and production (Bahiru et al., 2023). Through the controlled supply of water, the water demand of different crops can be optimized, which ultimately leads to a significant increase in production and thus economic profit (FAO & Earthscan, 2013). This is of great importance, as food security is a critical issue in developing countries like Ethiopia (Bahiru et al., 2023). In addition, the world population is continuing to grow, which requires an increasing amount of food. Irrigation is used to reduce crop drought stress during low precipitation periods and can thus contribute to a more reliable and predictable agricultural cultivation. It enables to grow an additional crop in the dry season in many regions (S. Siebert et al., 2015). Hence, irrigation also “[…] has a substantial and positive impact on household food security” (Bahiru et al., 2023, p. 10) for small-scale farmers as the agricultural yield can be increased and is more predictable and reliable (Gebregziabher et al., 2012). Irrigation is a very effective tool to increase crop yield which intensifies land use and to improve resilience to climate shocks (AGRA, 2019; S. Siebert et al., 2015).

Around 36 % (2020) of the global land area is agricultural land, and around 7 % is equipped for irrigation (FAOSTAT, 2023). About 40 % of the global crop production takes place on irrigated areas, which account for only 20 % of the global farmland (FAOSTAT, 2023; Nagaraj et al., 2021). This shows the efficiency of irrigated agriculture in comparison to rainfed agriculture. However, a distinction must be made here between regions, as there are many regions with climates, that do not require additional water, or dryer regions, where undemanding crops, that do not require much water are cultivated. *Figure 9* shows the global irrigated areas in 2018, marked in green.

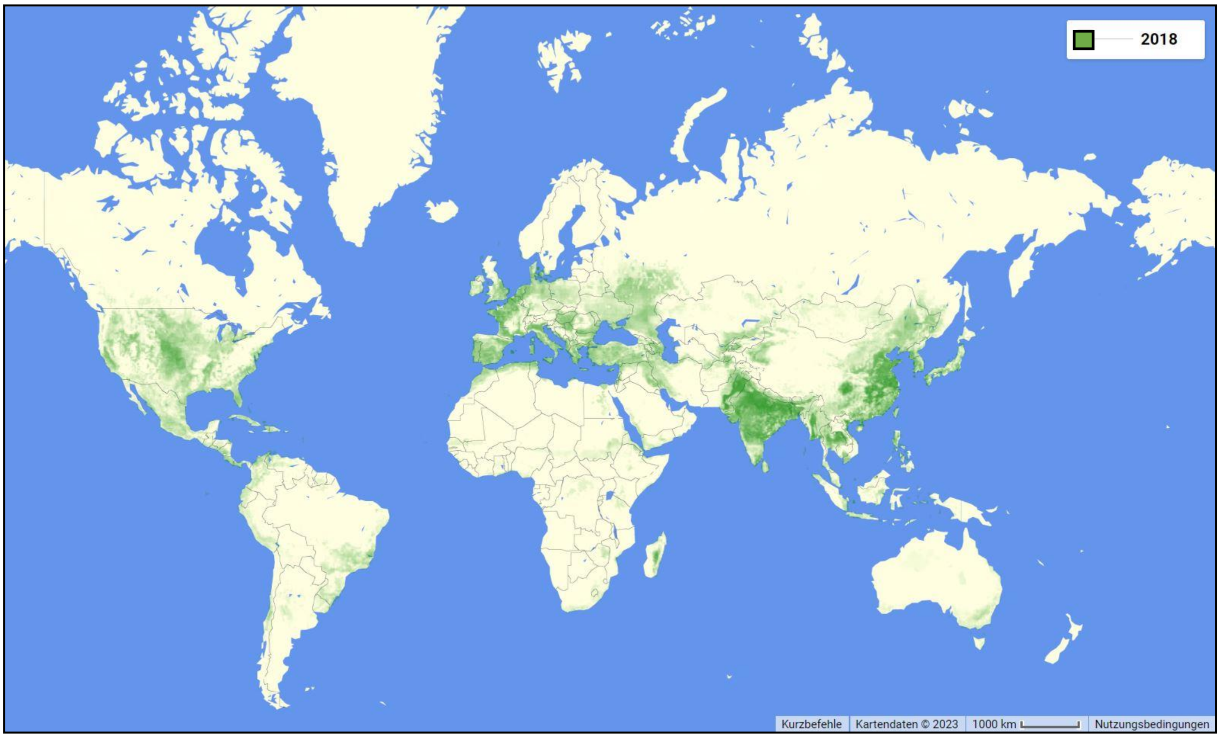

Figure 9: Irrigated cropland in 2018 (Global Irrigation Map, 2020).

Asia (in particular China and India) has the largest irrigated areas, followed by North America and Europe. In Africa, most farmers rely on rainfed agriculture (AGRA, 2019; Gelete et al., 2020), which can also be seen on the map above. In global comparison, Africa has the least amount of irrigated land (Nagaraj et al., 2021). Only 6 % of the cultivated area in Africa is irrigated, compared to 37 % in Asia (AGRA, 2019; You et al., 2010). In sub-Sahara Africa, there is vast potential to scale up irrigation, which, if implemented, could boost its agricultural production by at least 50 % (AGRA, 2019).

Irrigation has increased in most areas of the world in the last two decades. *Figure 10* shows where irrigation was increased between 2000 and 2018 (red) and where irrigated croplands decreased (green) in the same period.

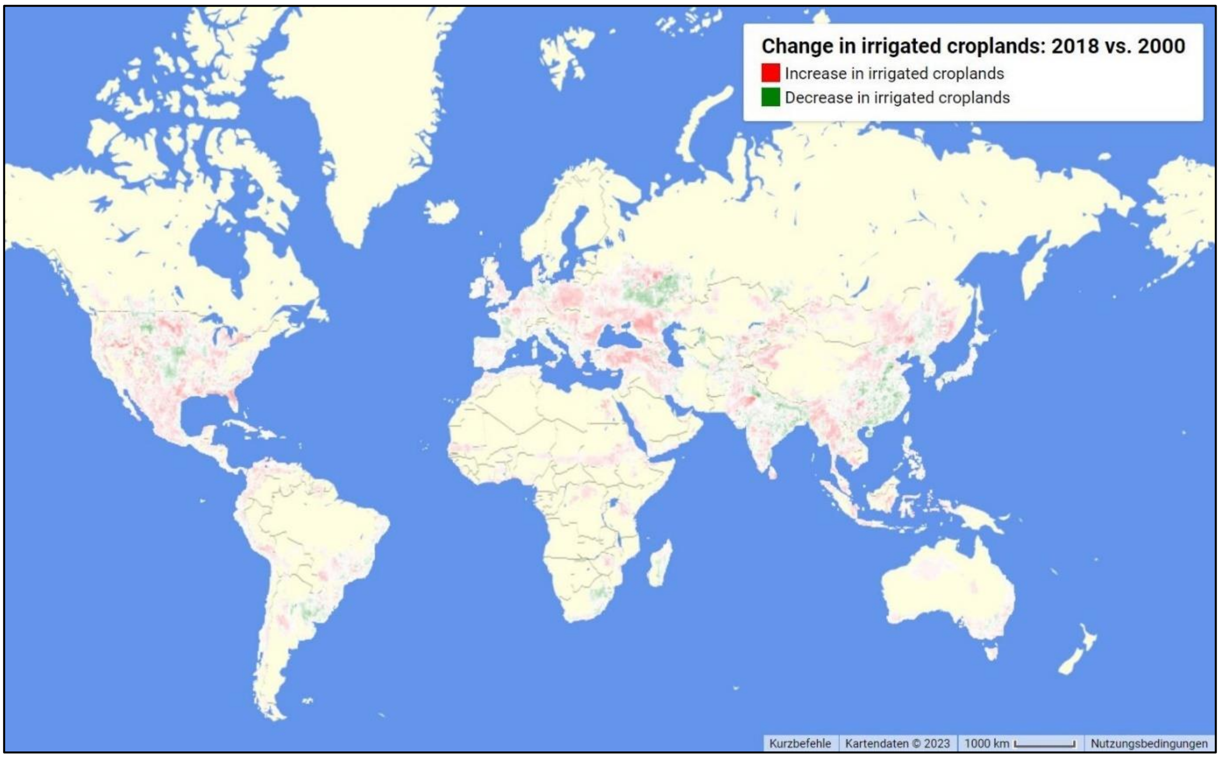

Figure 10: Change in irrigated cropland from 2000 to 2018 (Global Irrigation Map, 2020).

Agriculture is the largest water user, as well as the sector with the lowest gross value added (GVA) aggregate. Around 70 % of global freshwater is being used in the agricultural sector (FAO, 2021). The majority of it is associated with irrigation (Nagaraj et al., 2021). Water is the essence of all life and the core of the agri-food system, which makes it a highly precious commodity (FAO, 2021). Hence, reducing the amount of water used for irrigation plays an important role for the overall water use efficiency for a country (FAO, 2021). As a result, the agricultural sector is caught between water use efficiency on the one and food security on the other hand (FAO, 2021). Over time, numerous different irrigation systems have been developed to best meet the needs of the respective crops and their cultivation in the various regions of the world (Bjorneberg, 2013).

All irrigation methods have their advantages and disadvantages. Which irrigation method is best is according to Brouwer (1988) mainly depending on the following factors:

- Natural conditions (soil type, slope, climate, water availability, water quality, …)
- Crop type
- Type of technology

- Previous experience with irrigation methods
- Required labour input
- Costs and benefits

There is no uniform subdivision of the various irrigation systems. Basically, a distinction can be made according to the direction, i.e., from the surface or from the ground. Surface irrigation is the dominant method worldwide and accounts for more than 90 % of irrigated land (Deng et al., 2017). The following is a broad overview of the most common irrigation methods.

Types of Irrigation

Surface irrigation consists of a broad variety of irrigation methods. In surface irrigation, water flows over the ground by gravity and is transported from the water source to the field through canals, pipes, or ditches. However, in some locations, the water must be pumped from the water source to an area of the field that is higher (from the water source) (Bjorneberg, 2013). Types of surface irrigation can be:

- <u>Furrow irrigation:</u> suitable for fields on slopes. Evenly spaced furrows are created, through which the water flows (Bjorneberg, 2013).
- <u>Basin and border irrigation:</u> Water is applied to a nearly level field (Bjorneberg, 2013).
- <u>Sprinkler irrigation</u>: Water is applied by spraying or sprinkling it through the air on to the fields. Several different types such as Solid-set sprinkler system, Set-move sprinkler system, or moving sprinkler system (Bjorneberg, 2013).

Micro irrigation**:** water is delivered to the plants or soil in many small doses by dripping, trickling or spraying; these methods typically wet only a portion of the soil surface in the field and therefore have a high water use efficiency (Bjorneberg, 2013).

Subsurface irrigation: A less common irrigation method, in which the groundwater table is raised or maintained near the plant root zone using ditches or subsurface drains to provide water (Bjorneberg, 2013)

Possible Negative Impacts of Irrigation

Despite the many positive effects, irrigation also has its negative impacts. It modifies "[…] the global water cycle by enhancing evapotranspiration and reducing surface and groundwater runoff. In many regions of the world irrigation contributes to streamflow and groundwater depletion, soil salinization, cooler microclimate conditions, and altered land-atmosphere interactions." (Nagaraj et al., 2021, p. 1). In addition, irrigation can have effects on water and energy balances which can modify microclimatic conditions in irrigated areas (S. Siebert et al., 2015).

However, one of the supposedly simplest measures to gain maximum benefit from available water is to adapt the respective crops to the location and season, and to expand agriculturally to suitable regions where rainfed agriculture can be practiced, which not only saves water but also alleviates water stress (Pfister et al., 2011). Irrigation is not the one best solution for the future global food system. However, it can be particularly helpful in those regions where there is little water left for farming at all and where it is becoming increasingly difficult to sustain a livelihood (Pfister et al., 2011).

4.1.2. Migration

According to the International Organization for Migration (IOM, 2023) migration is, when "[…] a person moves away from his or her place of usual residence, whether within a country or across an international border, temporarily or permanently, and for a variety of reasons". *Other basic terminology regarding migration, used in this thesis, are compiled in excursus 3 (see below).*

Over the past five decades, the estimated number of **international migrants** has increased in all United Nations (UN) regions, especially in Europe and Asia (IOM, 2021). However, most people remain living where they were born. Only one in 30 persons (globally) are migrants (IOM, 2021). In 2020, an estimated total of 281 million people (3.6 % of the global population) live in a country other than their country of birth. In 1990, it was just about half of this number (128 million people) (IOM, 2021). Generally, the largest migration corridors tend to be from developing countries with weaker economies to countries with stronger economies. Since 1970, the main country of destination on a global scale has been the United States of America (IOM, 2021). According to the IPCC (2022), the future numbers of migrants and displacements of people could further be increased due to CCV, in the form of increased temperatures and increasing frequency and magnitude of extreme (weather) events.

Hence, a much larger number is estimated for **internal migration** (740 million people in 2009), as most people do not migrate across borders. The proportion of internal migration varies widely from country to country. In some countries, such as the United Arab Emirates, the share of internal migrants in the total population is 88 % (IOM, 2021).

In developing countries, the most common type of migration is rural-to-urban migration. Most migrants move from the agricultural sector (rural) to non-agricultural sectors (urban) or from poor to rich countries (F. Eshetu et al., 2023).

Excursus 3: Definition of Key Migration Terms

The following definitions were developed and published by the International Organization of Migration (IOM) and are used throughout this thesis. Unless otherwise noted, all definitions are taken verbatim from the IOM (2023) website.

Climate migration: The movement of a person or groups of persons who, predominantly for reasons of sudden or progressive change in the environment due to climate change, are obliged to leave their habitual place of residence, or choose to do so, either temporarily or permanently, within a State or across an international border. Climate migration is a subcategory of environmental migration; it defines a singular type of environmental migration, where the change in the environment is due to climate change. Migration in this context can be associated with greater vulnerability of affected people, particularly if it is forced. Yet, migration can also be a form of adaptation to environmental stressors, helping to build resilience of affected individuals and communities.

Displacement: The movement of persons who have been forced or obliged to flee or to leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters.

Environmental migrant: A person or group(s) of persons who, predominantly for reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are forced to leave their places of habitual residence, or choose to do so, either temporarily or permanently, and who move within or outside their country of origin or habitual residence.
Note: There is no international agreement on a term to be used to describe persons or groups of persons that move for environment related reasons. It is a working definition aimed at describing all the various situations in which people move in the context of environmental factors.

Forced resettlement/relocation: Involuntary transfer of individuals or groups within the jurisdiction of a State away from their normal residence as part of a government policy.

Internal migration: The movement of people within a State involving the establishment of a new temporary or permanent residence.

International migration/migrant: The movement of persons away from their place of usual residence and across an international border to a country of which they are not nationals.

Labour migration: Movement of persons from one State to another, or within their own country of residence, for the purpose of employment.

Migration/Migrant: When […] a person moves away from his or her place of usual residence, whether within a country or across an international border, temporarily or permanently, and for a variety of reasons.
Note: […] the above definition is meant to cover both internal and cross-border displacement.

Push-pull factors: Migration is often analysed in terms of the “push-pull model”, which looks at the push factors, which drive people to leave their country (such as economic, social, or political problems) and the pull factors attracting them to the country of destination (IOM, 2011).

Re-Emigration: The movement of a person who, after having returned to his or her country of origin, again emigrates (IOM, 2011).

Reintegration: A process which enables individuals to re-establish the economic, social and psychosocial relationships needed to maintain life, livelihood and dignity and inclusion in civic life.

Remittances (migrant): Monies earned or acquired by non-nationals that are transferred back to their country of origin (IOM, 2011). They are private international monetary transfers that migrants make, individually or collectively.
Note: Remittances are primarily sent to people in countries of origin with whom migrants maintain close links, although, in some cases, they are also sent to relatives in other countries of destination. Increasingly, the terms "social remittances" or "social capital transfer" are used in the context of transfers of non-monetary value as a result of migration, such as transfer of knowledge, know-how, networking and skills

Labour Migration and Remittances

Around 169 million people migrated (globally) for reasons of work (labour migrants) in 2019 (IOM, 2023). Migrant workers account for nearly 5 % of the global labour force and are therefore an important component of the global economy (ILO, 2021).

Migrants can be a valuable asset in countries with aging populations, as they can help to fill labour shortages, boost the labour force, and support social security systems. The remittances sent back to their countries of origin can increase national savings, encourage investment, and enhance overall economic prosperity (Abdelmoneim & Litchfield, 2016; ILO, 2021). Remittances account for over three times the amount of official development assistance (ODA) an foreign direct investment (FDI) (DESA, 2023). Therefore it is not surprising, that according to Benmamoun and Lehnert (2013), international remittances have a greater impact on the economic growth rate of low income countries than ODA and FDI combined (result of analysis of panel data from 1990-2006). Yet, all three are positively and significantly associated with the economic growth rate (Benmamoun & Lehnert, 2013). On an individual level, the move of (a) family member(s) can result in a higher standard of living and provide financial support to their families through money transfers. On average, migration has a positive impact on the welfare of rural households and/or families that receive remittances and generally on consumption expenditure (Abdelmoneim & Litchfield, 2016). Globally, about one billion people are involved with remittances, either by sending or by receiving them. It often is a major part of the total income for households receiving remittances. Around one in nine people globally are supported by remittances (DESA, 2023). The sharing of knowledge and skills between countries through diaspora and returning migrants can also lead to higher global productivity and output (ILO, 2021).

Remittances have increased from 126 billion US-Dollar in 2000 to 702 billion US-Dollar in 2020 (IOM, 2021). Remittances are of high importance for developing countries and the share of total remittances directed to developing counties increased from 57 % to 97 % in the same time period (IOM, 2021).

However, it must be noted, that compiling accurate data on remittances is difficult and the actual magnitude of global remittances is likely to be larger than the named estimates, due to unrecorded cash flows through formal or informal channels (IOM, 2021). The main source of remittances are usually high income countries like the United States, the United Arab Emirates, Saudi Arabia, Switzerland, and Germany (Top 5 in 2020, decreasing in that order) (IOM, 2021).

Effects of Climate Change and Variability on Migration

Environmental changes indirectly affect migration by influencing other drivers of migration of socio-demographic, economic, and political types (Borderon et al., 2019). Generally, the direction and extent of the influence of environmental changes depend on a variety of factors, including the socio-economic and geographical context, demographic characteristics, as well as the type and duration of migration (Borderon et al., 2019).

As CCV progresses, **climate migration** will be of increasing importance (Warner et al., 2010). The impacts of climate change on environmental degradation and socio-economic systems that are dependent on environmental factors, will potentially cause substantial population mobilities and displacements (Warner et al., 2010). Particularly increased rainfall variability and droughts, that are significant drivers of soil degradation have substantial effects on agricultural systems and hence, the resource-dependent rural populations (Groth et al., 2021; Hermans & McLeman, 2021; Warner et al., 2010). This can potentially lead to livelihood losses and subsequently enhance migration in the respective areas (Hermans & McLeman, 2021). Groth et al. (2021) conclude, "[…] that environmental changes increase migration, either through high migration needs due to low agricultural production and/or through increased non-farm activities, which increases the necessary financial means to enable migration" (Groth et al., 2021, p. 128).

Migration is also highly connected to the availability of financial resources. In the world's poorest countries "[…] higher temperatures are associated with a decrease in emigration rates […] whereas no such effect is found […]" (Benonnier et al., 2019, p. 18) in countries with higher GDP (Benonnier et al., 2019). This is particularly important in view of CCV as it stresses the inequal impact of associated effects.

Food insecurity, which is being exacerbated by environmental changes, as it arises due to factors such as poverty, environmental degradation, climate shocks, and ethnic conflict, is one of the key drivers for migration (Asefawu, 2022; IOM, 2021). In growing economies in Africa (like Ethiopia), food insecurity is one of the main factors for seasonal rural-to-urban migration (Asefawu, 2022). In sub-Sahara Africa, Asia and Latin America, future internal migration flows will be majorly impacted by climatic changes (Borderon et al., 2019).

Limitations of Migration

The availability of options for migration varies largely by the national passport of the potential migrant. The Henley Passport Index is "[…] a global ranking of countries according to the entry freedom of their citizens […] reveals that an individual's ability to enter a country with relative ease is in many respects determined by nationality" (IOM, 2021). Generally speaking, a countries status and relations within the international community, its stability and safety compared to other countries is broadly reflected by visa access of the respective passport (IOM, 2021). Additionally, migration generally requires enough money for basic travel expenses. In particular international migration is usually only accessible for middle- or high-income households/persons (Benonnier et al., 2019).

4.2. Irrigation in Ethiopia

Ethiopia's rainfed-based smallholder farming systems would not be able to meet the requirements necessary to ensure food security for the country (Zerssa et al., 2021). "Irrigation development in Ethiopia is embraced as a possible solution to maximize agricultural production to satisfy the food demands of the ever-increasing population and improve the income of smallholder farmers" (Berhe et al., 2022, pp. 1–2). Applying appropriate technologies like climate smart agricultural practices, of which the implementation of efficient and/or improved irrigation is part of, can help to counteract the spatial and temporal rainfall variability and ensure a more stable food system in Ethiopia (Zerssa et al., 2021). One main trigger for crop failure in Ethiopia's rainfed farming system, is soil moisture stress. It is the result of lack of water availability due to long dry periods, combined with shorter rainy seasons or even the complete absence of rain (Berhe et al., 2022).

In 2020, 42 % of Ethiopia's land area are accounted for as arable land. Around 34 % (in 2020) of the country's total area is cultivated and only 2.23 % (in 2020) of the total agricultural land is equipped for irrigation (FAOSTAT, 2023). For poorer households this percentage is even lower, which emphasizes the importance of irrigation for the development of Ethiopia, as it can help to provide more security in terms of food security and livelihoods (Auci et al., 2018) and is generally seen as a tool that helps to mitigate climate change effects (Berhe et al., 2022).

According to the Ministry of Water Resources of Ethiopia (MWR, 2002) irrigation schemes are organized in four different ways as displayed in *Table 3*.

The small-scale irrigation category accounts for approximately 46% of the proposed irrigation developments (Makombe et al., 2011). Often, large-scale irrigation schemes do not achieve the hoped-for performance, which also explains the popularity of small-scale irrigation (Aberra, 2004).

Table 3: Organization of irrigation schemes in Ethiopia. Modified from MWR (2002)

Irrigation scheme	Size	Organization	Comment
Small-scale schemes: traditional communities	Up to 100 ha	• Managed in user's associations or committees. • Built and operated by farmers in local communities. Technical and material support by the government.	Average farm size: 0.25 ha Average Scheme size: 70 to 90 ha
Small- to medium-scale: modern communal schemes	20 to 200 ha	• Built by Government agencies with farmer participation. • Farmers operate and maintain them through user's associations with (in some regions) on-farm support from zonal departments of agriculture. • Irrigation commissions or authorities provide technical support	• Developed after catastrophic drought of 1973 to improve food security. • Based on run-of river diversion of streams • May involve micro-dams for storage
Medium- to large-scale: modern private schemes	Up to 2.000 ha	Owned and operated by private investors individually, in partnership, or as corporations	• 1950's and 1969's: Pioneered in the Upper Awash region by Private estates • Mid-1970's: unexpectedly nationalized • 1990's: some private schemes re-emerged
Large-scale: public schemes	Over 3.000 ha	Owned and operated by public enterprises, as state farms	• Late 1970's: public involvement started • Most large-scale schemes have been suspended because public involvement was withdrawn as a result of government changes.

Research on small-scale irrigation potential concerning pastoralists in Ethiopia concluded, that their areas had around 60 % (2.2 million hectares) of Ethiopia's total potential (Headey, Taffesse, & You, 2014). According to Headey, Taffesse, and You (2014) the surface water potential is underestimated due to the incomplete consideration of the potential for small-scale irrigation and the underground water potential could provide another 540.000 hectares of irrigated agriculture. They also emphasize, that "these numbers give the impression of immense potential, but economic potential is likely to be constrained by high implementation costs, and limited benefits that are largely related to poor market access" (Headey, Taffesse, & You, 2014, p. 206).

S. Kebede et al. (2018) state, that the majority of irrigation water is groundwater, while G. G. Haile and Kasa (2015) state, that most traditional irrigated areas are supplied by surface water and groundwater is so far only used in some marginal areas. Precise statements about water usage of irrigation cannot be made here. Kasye and Adibar (2022) conducted a review on the water resource potential and irrigation agriculture practice in Ethiopia. Their conclusion confirms the unclear information situation about surface and groundwater potential in Ethiopia. Further investigation is needed to allow clear statements.

4.2.1. History and Development

The exact date when irrigation initially started in Ethiopia is unknown. It is assumed, that irrigation had already taken place in ancient times (G. G. Haile & Kasa, 2015). However, it was likely not of great significance for initiation of ancient civilization in the country (G. G. Haile & Kasa, 2015). Smallholder famers have used irrigation for centuries to counteract water stress and thus, secure their livelihood (G. G. Haile & Kasa, 2015).

Modern irrigation systems were introduced by a bilateral agreement since 1950's in Ethiopia at sugarcane plantations. This agreement was between the dutch company HVA-Ethiopia (De Handelsvereiniging Amsterdam Ethiopia) and the Ethiopian government (G. G. Haile & Kasa, 2015). The first larger irrigation schemes were implemented in the Rift Valley Basin, where commercial crops are produced (G. G. Haile & Kasa, 2015).

To address food security in the country, the Ethiopian government has developed multiple irrigation projects of different scales across the country (Berhe et al., 2022; Kasye & Adibar, 2022; H. A. Mengistu et al., 2019). In this context, the government is also targeting the expansion of small-scale community irrigation schemes (Berhe et al., 2022; G. G. Haile & Kasa, 2015). There is an increasing focus on the use of groundwater in Ethiopia, which additionally reinforces the development of irrigation schemes (Kasye & Adibar, 2022; H. A. Mengistu et al., 2019).

4.2.2. Governance of Irrigation

The Ethiopian economy grew in the past decades, with the EPRDF shaping the socio-economic development, e.g., with a large development plan the so-called Growth and Transformation plan I (2000-2015) and II (2015-2020) (Vaughan, 2015). From which the Growth and Transformation plan II indicated to expand the famer-led irrigated area from 2.3 million hectares to 4.1 million hectares (Kafle et al., 2020). The general interest of governments in actively supporting irrigation practices are manifold (Kafle et al., 2020). These include, reducing poverty, increasing food security, and increasing productivity (see

(Kafle et al., 2020) and the references therein). In Ethiopia the government supported the implementation of irrigation practices as “primary avenue for economic growth” (Kafle et al., 2020, p. 2).

Currently, the Ministry of Water and Energy of Ethiopia is a federal organization which is responsible for large and medium scale irrigation (Ministry of Water and Energy, 2023). The Ministry “[…] is a regulatory body which involves the planning, development and management of resources, preparation and implementation of guidelines, strategies, polices programs, and sectoral laws and regulations.” (Ministry of Water and Energy, 2023).

4.2.3. Types of Irrigation used in Ethiopia

According to the Ministry of Agriculture (MoA) in Ethiopia, a variety of contemporary water storage and management systems have been established for irrigation purposes. These encompass water diversion schemes, water storage dams, micro-irrigation systems, rainwater harvesting, and shallow groundwater harvesting techniques. These systems utilize different irrigation technologies for water extraction, conveyance, and application. Notable examples include night water storage facilities, treadle pumps for water lifting, smallholder drip systems, and micro-sprinklers for irrigation application, among other methods which are compiled below (Ministry of Agriculture, 2011):

Spate irrigation (stream/spring diversion) is a traditional and long used irrigation method, especially in northern Ethiopia and some semi-arid regions in Oromia (mid-western Ethiopia) (G. G. Haile & Kasa, 2015). Flood water is being diverted form rivers, originating from mountain catchments, and distributed over large areas (UN Water, 2013). However, the water can only be discharged if sufficient quantities are available, which is dependent on the poorly predictable occurrence of floods. This, and in addition the frequently changing course of the rivers makes this method very risk-prone and again, dependent on precipitation (UN Water, 2013). The water-efficiency of this most common type of irrigation in Ethiopia is often very low and transmission losses are high (Aberra, 2004). However, the very common traditional stream/spring diversion irrigation schemes are so successful due to their time flexibility. Even if they are not used for a longer period of time, they can be operated again any time (Aberra, 2004).

Modern **pressurized sprinkler irrigation** is used at some private farms in the Rift Valley and in Eastern Amhara and Southern Tigray regions. The Rift Valley, particularly in the Awash River Basin, is recognized as the starting point for modern irrigation practices in Ethiopia, particularly the adoption of pump-irrigation (G. G. Haile & Kasa, 2015).

Cotton and wheat production primarily utilize **furrow irrigation** methods, while **basin irrigation** techniques are predominantly employed for the cultivation of commercial fruits like bananas (G. G. Haile & Kasa, 2015).

Traditional irrigation systems like the long-practiced spate irrigation, are managed by water user's associations. "They are generally well organized and effectively operated by farmers who know each other and are committed to cooperating closely to achieve common goals" (MWR, 2002, p. 50). One association typically consists of up to 200 users sharing one main canal or side-canal. Some are divided into groups of 20-30 farmers (MWR, 2002). "Such associations handle construction, water allocation, operation, and maintenance functions" (MWR, 2002, p. 50).

4.2.4. Current State

The current status of the performance of small-scale irrigation schemes is below the expectations, which results in large areas remaining unirrigated (Berhe et al., 2022). Reasons for the low level of success are "[…] design failure, poor water and agronomic management practices, weak local institutions, and excessive siltation problems" (Berhe et al., 2022, p. 2). Another issue in Ethiopia is the degradation of watersheds, the lack of sustainable funding for operation and maintenance, poor extension services or failure of hydraulic structures (Berhe et al., 2022). It is estimated, that less than 50 % of initially planned irrigation users have ultimately benefited from the developed schemes.

Generally, in proportion to rainfed agriculture, the importance of irrigation is still minor and localized (Minten et al., 2020). During the recent years the government and development agencies have stressed the importance of irrigation more. Accordingly, an increase in irrigation can be observed (Minten et al., 2020). However, as higher crop productivity is essential for food security in Ethiopia, the implementation of (enhanced) irrigation is on the development agenda in most Regions (Nyssen et al., 2022).

4.3. Migration in Ethiopia

According to a survey report by the International Organization for Migration (IOM) and Ethiopia's Central Statistical Agency (CSA) 17.1 % of Ethiopia's population (not including Tigray region) are migrants (IOM & CSA, 2021). Generally, people tend to "move from limited resources and job scarce areas to regions with better resources, employment prospects and public goods" (IOM & CSA, 2021, p. 14).

The ongoing CCV is a major factor for the decision to migrate (Hermans & McLeman, 2021). In a survey conducted by Hermans and Garbe (2019), more than one in four non-migratory farmers in Ethiopia said, they would move somewhere else, if climatic extremes like droughts will not improve. This emphasizes the overall conclusion of the study, that "[…] migration is a key strategy to secure livelihoods in rural Ethiopia within the context of climate stress" (Hermans & Garbe, 2019).

The consequences or effects of migration are also evident in Ethiopia's economy. Remittances play an important role in the economy of the country as they contribute significantly to the national GDP (Zegeye et al., 2022). However, as a high level of inflows (up to 78 %) are informal, an exact share of the GDP cannot be stated (Zegeye et al., 2022). Although, the number of migrating people is constantly increasing, "[…] it has not been well managed to fully harness the added value of migration for economic development" (IOM & CSA, 2021, p. 12).

4.3.1. History and Development

Over the course of Ethiopia's history, the country experienced political instability, war, famine, and economic plight (Fransen & Kuschminder, 2009) (*Chapter 3.3.2.*) that all contributed to many types of migration, international and internal migrant flows. As these issues are also characteristic for the Horn of Africa, not only Ethiopians migrate to other countries, but the country was and is also a destination for voluntary or involuntary migrants as well as a transit country (Fransen & Kuschminder, 2009). Even though, there were migratory flows throughout Ethiopia's history, "[…] the movement of Ethiopian civilians became substantially greater in the late 1960s and 1970s" (Fransen & Kuschminder, 2009, p. 10). Most of the migrants were refugees in the course of the revolution in 1974, that fled from political conflict, famine, and persecution. Most Ethiopians migrated to neighbouring countries (Fransen & Kuschminder, 2009).

The main reasons for migration changed over time. Due to frequent changes in the political regime during most of the last half century, political violence is mostly prioritized as primary driver of migration within Ethiopia and across its borders during this time (Schewel & Asmamaw, 2022). Other key factors for population movements are famine, environmental degradation, poverty, resettlement projects, and other displacements for reasons of development (Schewel & Asmamaw, 2022). However, there is also a "[…] relatively recent and rising trend in formal and informal international labour migration [that] is one important manifestation of a more complex shift in Ethiopia's mobility complex, taking place over the course of the last century and accelerating since the 2000s" (Schewel & Asmamaw, 2022, p. 1697). Today, reasons for migration in Ethiopia are often economic and less often due to conflict or (other) political reasons (Fransen & Kuschminder, 2009). However, it can often be difficult to pin down one reason, as many key reasons for migration are related to each other and/or are mutually dependent. Ecological and/or environmental degradation for instance often conditions the economic situation of households due to poor living conditions and low opportunities. Therefore, out-migration due to degradation of resources, drought, or other major environmental factors is often classified as a form of household income diversification (Fransen & Kuschminder, 2009). The same can be the case for political unstable situations. "To conclude, the major factors driving Ethiopian migrants over the years were economic, political, and environmental, factors that were all heavily interlinked and intertwined with regional issues" (Fransen & Kuschminder, 2009, p. 12)

Rural-to-rural migration has been the dominant type of migration within Ethiopia over the last century. Reasons to migrate were for instance employment, land, or marriage. In the late 1990's and early 2000's, the most common type of out-migration was seasonal and agricultural migration (Schewel & Asmamaw, 2022). A few years later, by the 2010's, migration to urban areas and international labour migration (mainly to the Gulf States, Sudan, and South Africa) have become more dominant. Since the 2000's, rural-to-urban migration has steadily increased and it has been a significant factor for urban growth in the last decades up until today (Schewel & Asmamaw, 2022).

4.3.2. Governance of Migration

The management of migration in Ethiopia is mainly based on "proclamations, declarations and other legal and policy documents [...]." (Andersson, 2022, p. 3) and does not have a comprehensive strategy. So far, migration policies have been focusing on the protection of migrants, e.g., mistreatment of Ethiopian migrants in Middle East countries and restricting irregular migration. In order to actively support migrant diaspora groups in Ethiopia, the Ethiopian Diaspora Agency was founded in 2019 (Andersson, 2022). Recently, an initiative was launched dealing with internally displaced persons and how to create sustainable livelihoods for them. One option which is discussed is the creation of industrial parks in different zones of the country (Andersson, 2022). For working in Ethiopia, foreigners need a working permit, employers who want to hire foreigners need to prove that no Ethiopian is eligible for the job (Andersson, 2022). Ethiopia represents a transit point for migrants of the Horn of Africa, however, there is currently no policy concerning transit migration. The country accepted a large number of refugees in recent years who are, according to the Ethiopian Refugee Response Plan, allowed to work. However, salaries are mostly very low (Andersson, 2022).

The so called National Migration Policy is been developed by the government together with stakeholders, such as non-governmental institutions and international organizations (Government of Ethiopia, 2021). The main goal of this policy is to bring more coherence and a clear mandate to issues related to migration in Ethiopia. For instance, there has been training of planning department heads of different governmental agencies on how to incorporate migration issues into their development plans (Government of Ethiopia, 2021).

4.3.3. Types of Migration, Current State, and Trend

According to the survey conducted by the IOM and CSA, of the four types of internal migration, about one third (32.2 %) of internal migration is from **rural to urban** areas, 25.9 % from **urban to urban** areas, and 23.4 % from **rural to rural** areas. The lowest form of migration is from **urban to rural** areas (13.7 %) (IOM & CSA, 2021). However, migration does not contribute much to the expansion of Ethiopia's urban areas (Dorosh & Schmidt, 2010). The survey also indicates that women tend to migrate more often than men (19.1 % of females; 15.1 % of males) and that most migrants (two thirds) are in the productive age group (aged 15-39) (IOM & CSA, 2021).

At the time of the Survey (2021) more than 800.000 Ethiopians (excluding the Tigray region) migrated to other countries (**international migration**) in search for labour (46 % female; 54 % male) (IOM & CSA, 2021). A significant number of migrating women, are low skilled and mostly uneducated (not able to read and/or write) (ILO, 2017). Remittances sent due to international migration account for 25 % of the foreign exchange earnings of Ethiopia's economy (Zegeye et al., 2022).

The survey also covered **return migration**, whereby here no number of migrants is mentioned. Most (8 out of 10) of returnees are young (aged 20 to 39) and around 77 % return from Middle Eastern countries, only 13 % from other African countries. Almost half 47 % of all return migrants came from Saudi Arabia (IOM & CSA, 2021). More of half (6 out of 10) of the return migrants completed primary education. Around 25 % of returnees plan to re-migrate (IOM & CSA, 2021).

According to Schewel and Asmamaw (2022) there is a recent **trend** in formal and informal international migration. They identify "[…] three core shifts that together constitute an emerging mobility transition: the sedentarization of traditional forms of seasonal mobility, the urbanization of internal migration, and the diversification of international migration" (Schewel & Asmamaw, 2022, p. 1697).

5. Results

The content presented below, is the result of the conducted literature review (explained in *Chapter 2.4.*). Here, the results are structured in three sections: the focus is on the challenges and impacts of irrigation (*Chapter 5.1.*) and migration (*Chapter 5.2.*) as well as the mechanisms between them (*Chapter 5.3.*).

In order to display the spatial distribution of the reviewed literature, the respective zones which contain the study areas of the publications (*Table 1*) are shown in *Figure 11*.

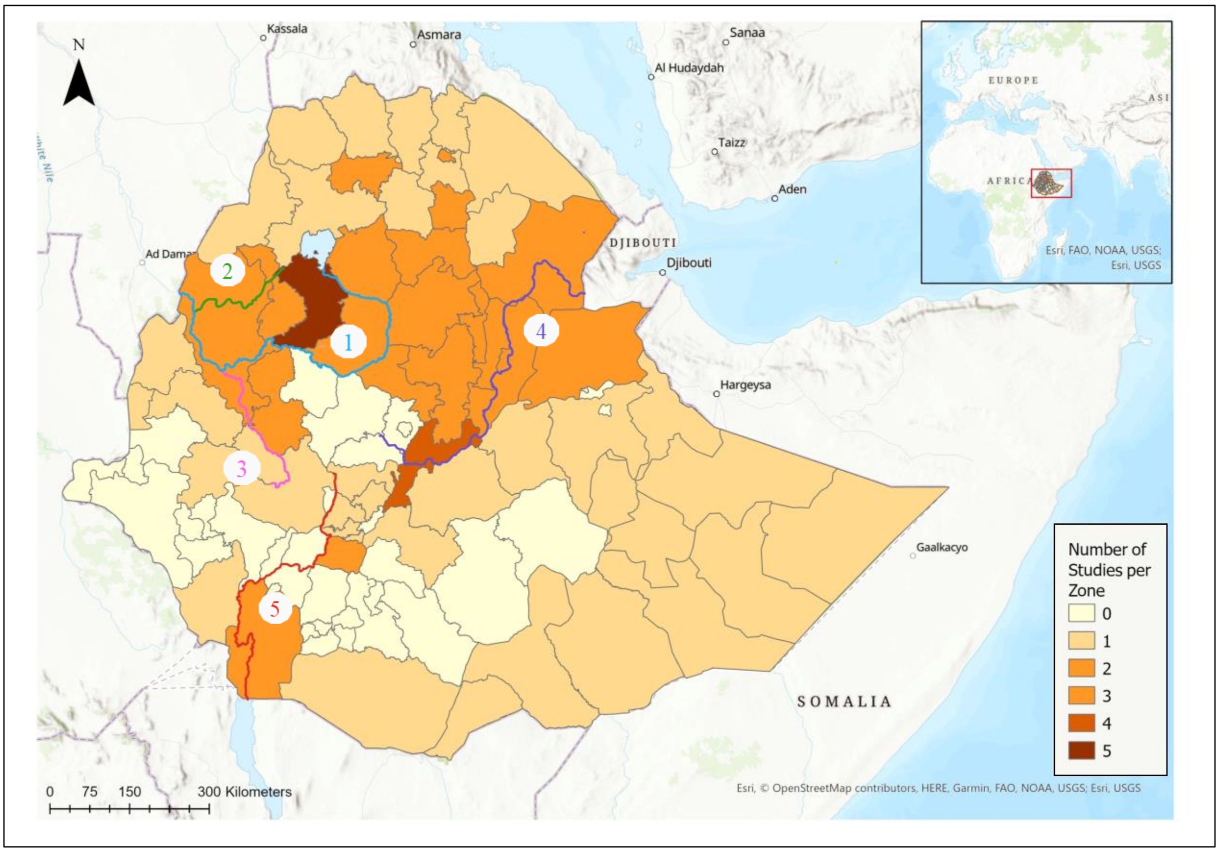

Figure 11: Study areas of the reviewed literature (Data source, ArcGIS Pro (ESRI, 2023); 1) Blue Nile River; 2) Beles River; 3) Dedessa River; 4) Awash River; 5) Omo River).)

The above figure shows, that most research which was analysed in this thesis, containing both, irrigation and migration, was conducted in the areas where the large river systems of Ethiopia are located. Particularly obvious and worth mentioning here is the Blue Nile River Basin (1) with associated tributaries such as the Beles River (2) and the Dedessa River (3), the Awash River Basin (4), and the Omo River Basin (5).

5.1. Irrigation

Only a small percentage of Ethiopia's area that is suitable for irrigation is actually irrigated (Cochrane & Thornton, 2021), even though "[…] evidence suggests that rainfed farming is a low return and economically inefficient activity in ASAL [Arid and Semi-Arid Lands] areas" (Headey, Taffesse, & You, 2014, p. 205) and that irrigated farming is economically more promising. Beyond the last decade, the Ethiopian government has emphasized the development and implementation of irrigation projects (Headey, Taffesse, & You, 2014). Particularly, in the lowlands, is a large potential for the profitable increase of irrigated areas (Headey, Taffesse, & You, 2014). Most systems of water management in Ethiopia are rather roughly-built and wasteful on water (Aberra, 2004). In general, stream diversion is the most common irrigation method in Ethiopia, which requires comparatively little costs. The implementation of rainwater harvesting techniques are often not successful (Aberra, 2004).

First the collected reasons for implementation of irrigation are presented (*5.1.1.*) to understand the motives and situations from which decisions to implement irrigation are made. Then the challenges and socio-economic impacts that can arise from these implementations are elaborated and classified (*5.1.2.*) to get a more complete picture of the situation of affected people.

5.1.1. Reasons for Implementation of Irrigation

Irrigation is often mentioned in the reviewed literature as one of the most important or the most important **climate change adaption strategy** (Cochrane & Thornton, 2021; Gebeyehu et al., 2021; Kidane et al., 2022; N. A. Mengistu, 2022). It counts as a measure to facilitate the transition to sustainable, resilient communities and a targeted, long-term strategy (Gebeyehu et al., 2021) that can strongly reduce the risk to livelihood vulnerability (Cochrane & Thornton, 2021; N. A. Mengistu, 2022).

In a study conducted in Wolaita administrative zone (Great Rift Valley) Bedeke et al. (2018) found that the perception of climate change has an impact on the decisions of farmers, regarding the implication of climate change adaption strategies. More than 40 % of farmers started rainwater harvesting due to their perception of increased temperatures, decreased rainfall, and/or an increase in extreme weather conditions (Bedeke et al., 2018). Additional influencing components are socio-economic factors such as level of education and farm experience (Bedeke et al., 2018). In most cases, farmers consider climatic and non-climatic reasons equally to decide on whether to use irrigation as an on-farm adaption measure (Kidane et al., 2022). The majority of farmers (87 %) in the Raya Azebo district (Tigray) who implemented irrigation as an on-farm adaption strategy did so in response to erratic rains (Kidane et al., 2022). More than half of the farmers (64 %) named the desire to increase agricultural profits and for 60 % of farmers the financial support by the government for the implementation of irrigation was a large contributing factor for implementation (Kidane et al., 2022).

According to Gebeyehu et al. (2021) the "[…] likelihood of households adopting CC [climate change] adaption strategies – rather than not adopting strategies at all – is negatively related to crop production and age of household head ($p < 0.01$ in both cases) and positively related to livestock ownership and access to climate information ($p < 0.05$ in both cases)" (Gebeyehu et al., 2021, p. 6).

The **location** factor can impact the implementation of irrigation in several ways. The geographical location as well as the proximity to markets for example, to sell products or the access to off-farm labour are of major importance (Cochrane & Thornton, 2021; Nyssen et al., 2022). This can be exemplified at the community of Buge (Wolaita administrative zone, Great Rift Valley), where the geographical setting and a series of external factors led to the successful implementation of an irrigation system (Cochrane & Thornton, 2021). The relief of the area is well suited for a gravity-fed irrigation system, which is a favourable serendipity that also helped the successful implementation of irrigation (Cochrane & Thornton, 2021). Due to these favourable conditions a foreign donor, supported the project in addition to the governmental support through the SNNPR (Southern Nations, Nationalities, and Peoples' Region) regional state.

In the case of a study conducted by Nyssen et al. (2022) in May Gabat around Mekelle in Tigray (northern Ethiopia) which was an active warzone during the study period, the irrigated area was expanded by 39 % from 2019/2020-2021. Due to Mekelle being a warzone, the market as source of supplies and selling and buying products as well as the impossibility to work anywhere near Mekelle in any non-agricultural employment has stimulated farmers to maximize the implementation of irrigation. This way, they were able to stay at their farms in relative safety due to distance from the main roads (Nyssen et al., 2022).

According to Nyssen et al. (2018) there is a shift towards small-scale pump or river diversion irrigation and commercial agriculture in many dam impacted areas where the traditional rainfed farming system is and was predominant. Dam constructions for the utilization of hydropower and large-scale irrigated commercial farms often benefit farmers in implementing irrigation as they can often connect to the constructed irrigation scheme, due to the diversion of waterways (Nyssen et al., 2018).

5.1.2. Challenges and (Socio-Economic) Consequences of Irrigation

Benefits

Improved infrastructure in general has a direct impact on people's livelihoods and brings many benefits. Access to irrigation infrastructure has a great transformative potential and can contribute greatly to the socio-economic situation of a household (Cochrane & Thornton, 2021; S. Eshetu et al., 2010; Etana et al., 2021; N. A. Mengistu, 2022; Teweldebrihan et al., 2020). All studies that mention the socio-economic impact of irrigation for farmers state that levels of income are higher for households with irrigation than for households with rainfed agriculture, and that the implementation of irrigation decreases the livelihood vulnerability of a household (Adem et al., 2018; Ayele & Degefa, 2020; Bantider et al., 2011; Bedeke et al., 2018; Cochrane & Thornton, 2021; S. Eshetu et al., 2010; Etana et al., 2021; N. A. Mengistu, 2022; Teweldebrihan et al., 2020).

N. A. Mengistu (2022) found that (improved) access to irrigation, decreases the household livelihood vulnerability by 23.1 %. For farmers, the application of irrigation enables a more consistent and higher income through the possibility for a wider variety of crops, more than one yield per year, and higher value produce (such as fruit trees) that can be sold at markets (Cochrane & Thornton, 2021). This increased net return can in turn enable more investments in livestock, which are less vulnerable to price shocks (Cochrane & Thornton, 2021; S. Eshetu et al., 2010) and again improve crop varieties and quality of fertilizers (Bedeke & Tebeje, 2022). Furthermore, households with consistent higher income are able to have more of their children attending school (Cochrane & Thornton, 2021). The livelihood sustainability index (LSI) of farmers using irrigation was about 21 % higher, than the LSI of farmers without using irrigation (Etana et al., 2021). Based on self-reported perception of the socio-economic status of households in a study by Cochrane and Thornton (2021), significant positive changes were much higher (23 % of households) in a community that gained irrigation access in a time period of 10 years, compared to a more remote and poorly connected community where the significant negative changes (36 % of households) were much higher.

Headey, Taffesse, and You (2014) assume, that a family of six persons would need irrigated land of 0.5 hectares (optimistic) or 1 hectare to maintain a livelihood. According to their estimates, improved and further irrigation could have substantial impacts on the creation of extra livelihoods, substituting pastoralism. With the optimistic scenario of 0.5 hectares of irrigated land per household (of six persons), further irrigation projects could enable livelihoods of an extra 8.2-11.4 % of the population in ASAL regions (Headey, Taffesse, & You, 2014).

Teweldebrihan et al. (2020) conducted a study in the Dedessa River Basin, where migrants who were settled around the area of the dam were forced to relocate elsewhere. Despite also negative impacts of the dam project on the environment such as deforestation or increase in floods for downstream users or resettlement, diverting the river and harnessing the water for irrigation led to a more sustainable agricultural productivity of the farmers. They were able to grow fruit and vegetables that enabled them to generate additional income and subsequently improved their overall livelihoods and did not want to return to their place of origin (Teweldebrihan et al., 2020). Also, in the community of Buge (Wolaita administrative Zone, Great Rift Valley) families were able to overcome situations of poverty and decrease their vulnerability through the successful implementation of irrigation in the community. Even though not all villagers have received access to irrigation, their situation has not worsened either (Cochrane & Thornton, 2021).

Due to predictable, calculable, and adjustable water supply irrigation positively impacts **agricultural production**. Due to a rapidly increasing demand from growing urban areas, the commercial cluster in the Central Rift Valley has become the most important area for commercial vegetable production (Minten et al., 2020). Through the implementation of irrigation, investments of richer tenant farmers, and modern inputs, farmers were able to increase vegetable production which was led by the private sector (Minten et al., 2020). Minten et al. (2020) have found, that there was a major increase in vegetable production in areas, where irrigation systems were implemented.

However, benefits through the irrigation potential are often overestimated because water experts assume that the hydrological potential of an area equates the economic potential that can be drawn from it (Aberra, 2004; Headey, Taffesse, & You, 2014). The costs of large-scale irrigation projects are higher in developing regions in Africa because materials, devices and expertise are often times imported, which creates a high level of external dependency (Aberra, 2004). Generally, irrigation requires financial investment, that many smallholder farmers in Ethiopia cannot afford (Cochrane & Thornton, 2021; Kidane et al., 2022). Without external support most smallholder farmers are unlikely to adopt irrigation on their own (Kidane et al., 2022). Therefore, government support can be a major factor for the feasibility and impetus for implementing irrigation (Kidane et al., 2022). Due to many economically beneficial aspects of irrigation it is also used as a poverty reduction intervention (Cochrane & Thornton, 2021; Kidane et al., 2022).

With regard to **adaptation to climate change**, irrigation is repeatedly mentioned as a decisive factor (Bantider et al., 2011; Bedeke & Tebeje, 2022; Bedeke et al., 2018; Etana et al., 2021; Kidane et al., 2022). Using irrigation as climate change adaption strategy helps to alleviate water stress and increases the possibilities for changing cropping dates and varieties (Bedeke et al., 2018). Through irrigation farmers can counteract erratic seasonal rainfall patterns and drought stress (Bedeke et al., 2018).

Other climate change adaption strategies mentioned in the reviewed literature are:

- Crop rotation, (Bantider et al., 2011)
- Adjusting planting periods (Kidane et al., 2022)
- Diversifying crops (Etana et al., 2021; Kidane et al., 2022)
- Use of drought resistant crops (N. A. Mengistu, 2022)
- Soil and water conservation (Bantider et al., 2011)
- Use of industrial fertilizer, (Bantider et al., 2011; Bedeke et al., 2018; Minten et al., 2020).
- Switching crop type (Etana et al., 2021; Kidane et al., 2022)
- Use of improved seeds (Etana et al., 2021; Minten et al., 2020)
- Various land management activities (Etana et al., 2021)
- Livelihood diversification (N. A. Mengistu, 2022)

Etana et al. (2021) found, that the amount of enhancing strategies used, plays an important role. When using more than four adaption strategies, livelihoods were more sustainable than using fewer strategies. This underlines the effect adaption strategies have on livelihood improvement (Etana et al., 2021).

Challenges

As mentioned above, Ethiopia's irrigation potential is far from exhausted. Even though, the benefits of irrigation can be manyfold, there are also many challenges that hinder or complicate the implementation of irrigation. Most reasons for failures of irrigation schemes are related to financial resources, cultural factors, policy environment, political situation/stability, institutional difficulties, design issues, and environmental problems (Aberra, 2004).

For small-scale irrigation systems, reasons for failure are often related to financial and technical resources as well as the availability of water, engineering, policy or community issues (Aberra, 2004). In their study on perception of and response to climate change by smallholders, Bedeke et al. (2018) found, that "[…] farmers reported four main challenges: (1) financial constraints to purchase water pumps; (2) increased water evaporation rates due to increased temperature; (3) poor quality of pond construction materials, leading to high water infiltration rate; and (4) high price of polythene plastic to collect and conserve rainwater during the rainy seasons" (Bedeke et al., 2018, p. 11). In the following, selected factors are explored more in depth.

According to S. Eshetu et al. (2010), the **financial benefits** of irrigation are very unevenly distributed. Households in three sites in East Hararghe Zone (Oromia Regional State) that are financially "[…] better off, had benefited more from irrigation, because they had more land and labour, compared to poor and female-headed households for whom these are significant constraints" (S. Eshetu et al., 2010, p. 10). For many poorer households, the cost of water is unaffordable. Members of poorer households therefore face additional challenges. This is especially the case during water shortages as alternative approaches that can be obtained by better-off households, such as pumps, are not accessible (S. Eshetu et al., 2010). Further, the income generated from irrigation also differs according to wealth group. Reasons named are "different amounts of water received for irrigation; different levels of knowledge about improved agricultural practices; and different amounts of effort put into farming" (S. Eshetu et al., 2010, p. 10).

Inequities also occur at the **cultural level**. The economic value that can be created from large-scale irrigated cultivation is (with current designs) often produced at the expense of livelihoods of indigenous communities (Hodbod et al., 2019; Nyssen et al., 2018). Indigenous groups and systems are mostly marginalized in decision-making procedures and not considered well enough while also receiving few of the benefits (Aberra, 2004; Nyssen et al., 2018). However, they bear most of the costs also due to environmental damages. Labour migrants working on the respective farms and dam construction sites, government workers, new settlers, or investors in commercial agriculture are the main beneficiaries of large-scale irrigation projects (Hodbod et al., 2019; Nyssen et al., 2018).

Especially through large-scale irrigation schemes, **pastoralist communities** are often negatively affected. Their access to key water resources as well as grazing land is often restricted (Headey, Taffesse, & You, 2014). It is often additionally challenging, when implementing irrigation to agro-pastoralists, who are often precluded from benefiting and in turn cause out-right harm by restricting access to, or damaging land and water resources (Headey, Taffesse, & You, 2014).

Inequities between farms/plantations are often related to **location.** Downstream users often get less access to water or lack sufficient amounts because of excessive abstraction of upstream users (Aberra, 2004; Grasham et al., 2022). Inequities in water distribution due to the location of farms (as well as mismanagement of irrigation committees) are a general problem that prevent many households from obtaining the expected gains of irrigation (S. Eshetu et al., 2010). During the drought in 2015, downstream users in Wenji (Central Ethiopia) were more severely affected due to insufficient to no availability of irrigation water during the drought period (Grasham et al., 2022). In other cases, communities lose the access to irrigation water they had for decades because the land along the river was leased to investors, so that the communities are forced to depend on rainfed and pond cultivation (Gebeyehu et al., 2021). The number of irrigation water points of irrigation schemes is mostly limited, which is why often not all farmers benefit (Kidane et al., 2022).

Another example for location based inequities farmers can be faced with in development projects focusing on the implementation of irrigation is elaborated in a case study by Eguavoen and Tesfai (2012) on the social impact and impoverishment risks of the Koga irrigation scheme in the Blue Nile Basin. The construction of dams and associated reservoirs, always affects people living in the respective area. Usually, households are entitled to adequate compensation that should equal the cost of the damages caused by the respective project as it was the case in the Koga project (northern Ethiopia) (Eguavoen & Tesfai, 2012). The compensations were based on assessments, carried out prior to the time of construction. People were compensated for their losses during the time of construction attributed to the three-year waiting period people had to endure for new land plots in the Koga scheme (Eguavoen & Tesfai, 2012). The losses contained the land use rights or assets (houses, trees, etc.) and especially the capabilities for agricultural production (Eguavoen & Tesfai, 2012). However, they find that farmers that were faced with displacement in some way (displaced, expecting displacement, part of host communities) due to the dam construction and farmers cultivating plots upstream of the dam, were not part of the land reallocation accompanying the project. In this case, those farmers were faced with an increase in poverty instead of being part of the ‘target population’ that benefited from the implementation of the irrigation scheme (Eguavoen & Tesfai, 2012). Additionally, the households that were entitled to reimbursements, also faced several challenges. The compensations were not fully paid. Of the initially estimated 8.000 ETB, only 3.000 to 5.000 ETB were actually paid. The amount paid is not nearly enough to build a new house. Many households were paid months after they lost their assets, when the construction of the dam had already begun. Therefore, there was violent resistance by the farmers when Chinese workers came to demolish their houses. Eventually the conflict was settled peacefully through negotiations (Eguavoen & Tesfai, 2012). The construction of the project was delayed, and for many relocated households farming was first possible again five years after the losses of land and assets (Eguavoen & Tesfai, 2012).

In other cases, where farms have been relocated due to the implementation and its accompanying construction of irrigation schemes, farmers had difficulties reaching their farm plots. Some could not afford the transport fares and/or were lacking the work force of oxen on the field due to the new distance to their farmland (Eguavoen & Tesfai, 2012).

The location of farms is also important when it comes to water security. In water scarce areas with rainfed farms, water security is highly connected to rainfall. On the other hand, in flood prone areas where farmers practice irrigated agriculture on the banks of a river all year round, food security, farming output, and income is increased. However, they were dependent on the water level of the river. The main water risk is unanticipated flooding, that regularly destroyed the irrigated crops (Grasham et al., 2022).

The potential for inequity is particularly high in the distribution of **water allocation** as shown in the following example. The Awash River Basin is industrially and agriculturally well developed and therefore has a high significance to the national economy (Grasham et al., 2022). The river flows through five of Ethiopia’s regional states, which additionally complicates administrative management (Grasham et al., 2022). When it comes to the allocation of water for irrigation Grasham et al. (2022) found that (in the Awash Basin) the state-owned sugarcane farms are in the focus of the allocation planning. “The logic behind this is intuitive—sugarcane farms are ‘large water users’ and domestic water users are ‘small water users’—therefore, it is more important to manage large quantities of water rather than small quantities” (Grasham et al., 2022, p. 13). This is contradicting as the national water policy sets the priority on drinking water. The end result is that groups with less power or influence do not have secure access to drinking water (Grasham et al., 2022).

Abstraction of water for the use of irrigation can also cause substantial effects on water resources and distribution of water. The construction of dams, directly affects the availability of the quantity as well as the quality of water to regions located downstream of the dam (Hodbod et al., 2019). According to Hodbod et al. (2019) it is expected that the abstraction of water for irrigation will cause a further decline in the water level of Lake Turkana (northern Kenia) (see *Figure 12*), which is fed by the Omo River. The water level has already been reduced by the filling of the Gibe III Reservoir (Ethiopia) and the regulation of the river flow of the Omo River (connects Lake Turkana and Gibe III) in 2015 (Hodbod et al., 2019).

Expected declines in the water level of the lake depend greatly on the amount of water extracted and the management applied at the plantations (Hodbod et al., 2019). The worst-case scenario is the complete drying of the lake. Though, the further decline of the lake level would already result in a complete drying of Ferguson's Gulf (located in the centre part of Lake Turkana, which stretches in North-South direction) (Hodbod et al., 2019). A positive effect is the high interest from domestic and foreign investors due to the possibility of large-scale irrigation through the Gibe III and the favourable investment conditions (Hodbod et al., 2019).

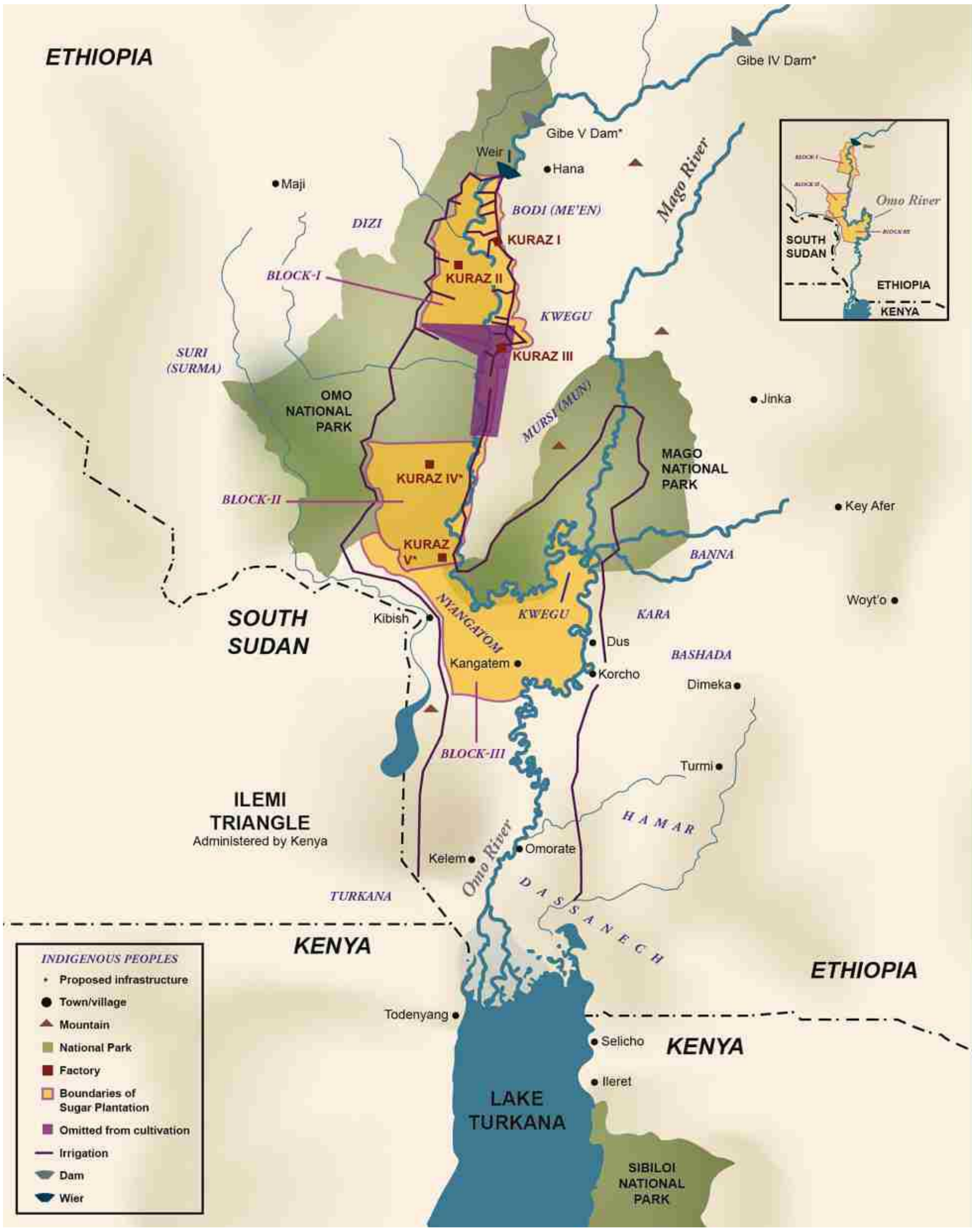

Figure 12: Lower Omo Valley in Ethiopia and the northern part of Lake Turkana in Kenya. Flow direction of the Omo river is from North to South (Hodbod et al., 2019, p. 1101)

The abstraction of water for irrigation can also affect the production of energy through hydropower plants, as Nyssen et al. (2018) explain for the GERD (Grand Ethiopian

Renaissance Dam) as follows. The water flowing from the Tana-Beles project (located at Lake Tana) to the GERD, has an estimated planned command area of 115.000 ha. The required irrigation water in the area around the Tana-Beles project would be abstracted from the discharge entering the GERD. This “missing” discharge accounts for about 3.3 % of the average annual flow. Even though, this number seems low, considering the size of the GERD, using such an amount of water for irrigation may negatively impact the hydropower production of the GERD (Nyssen et al., 2018). As the extraction of water for irrigation affects downstream users as well as the production of energy through hydropower plants, sustainable water resources use and improvement in water management can counteract some of these issues. The major constraint in this regard is the missing know-how such as different water balance terms (runoff, river discharge, evapotranspiration, etc.) or concerning agricultural practices like tractor cultivation (Nyssen et al., 2018). The latter, for example, leads to 50 % higher peak discharges due to increased soil compaction, which prevents the water from seeping into the soil (Nyssen et al., 2018).

Due to the additional discharge of Lake Tana to the Beles River because of the Tana-Beles project, it has become difficult to impossible to cross the river in many places. Many are unable to reach their relatives or their agricultural land across the river (Nyssen et al., 2018). Downstream of dams, increased unanticipated flooding can occur, especially during the rainy season, that often destroys large parts of the crops (Grasham et al., 2022; Teweldebrihan et al., 2020). Water risks are an issue that can come with irrigation (Grasham et al., 2022). After the start of the hydropower operation of the Tana-Beles project, more than 250 people were killed by floods (Nyssen et al., 2018).

Further **environmental impacts** of water extraction in the Beles Basin are increased sediment production as well as siltation of the GERD Reservoir and deforestation (Nyssen et al., 2018). Deforestation is a common side-effect of dam projects (Nyssen et al., 2018; Teweldebrihan et al., 2020). Through a migration and resettlement program, the impacts of drought and famine on the population living in the Dedessa River Basin have been reduced, however, through the deforestation of native forests for the benefit of agricultural land, hydrological and environmental conditions of the basin are highly likely to be altered negatively (such as flooding downstream of the dam, heat due to lack of vegetation, etc.) (Teweldebrihan et al., 2020). The implementation of irrigation schemes can destroy valuable ecosystems, as it was the case in Fincha (west of Addis Abeba). Here, also the increased migration due to high employment opportunities increased the pressure on the ecosystem (Ruffeis et al., 2008).

The implementation of large-scale irrigation projects often creates **jobs** and substantial income (Headey, Taffesse, & You, 2014; Nyssen et al., 2018; Ruffeis et al., 2008). A major aspect concerning socio-economical aspects is, that the planned positive effect on the local employment is often not met. Large-scale irrigation schemes do often not create many permanent jobs. Instead, most workforce is needed seasonally and the income as well as the jobs are often unequally distributed. The seasonal jobs are not taken by the local population but are filled with labour migrants, who benefit most from the additional employment opportunities (Headey, Taffesse, & You, 2014). Former pastoralists who are settled due to irrigation projects (Headey, Taffesse, & You, 2014) or indigenous groups (Nyssen et al., 2018) often do not benefit much from these projects, neither through employment nor through income, even though the projects generate high revenues (Headey, Taffesse, & You, 2014). Most of the money is transferred to government workers, new settlers (often from the highlands), or to investors in commercial agriculture (Nyssen et al., 2018).

Of the many jobs created, only a few provide permanent employment (Headey, Taffesse, & You, 2014). The Afar region, which is a very arid area, has the highest levels of investment in irrigated agriculture (Headey, Taffesse, & You, 2014). However, according to Headey, Taffesse, and You (2014) there is only one permanent job per 34 hectares (in total around 4.800) of irrigated agricultural land. The number of temporary jobs such as seasonal employment is with around 70.000 positions much larger. However, most of these positions are taken by seasonal migrants from the highlands instead of the local Afar population (Headey, Taffesse, & You, 2014). Headey, Taffesse, and You (2014) explain the low permanent job creation with the emphasis on cotton production, which is only seasonally labour intensive and difficult access to markets, which hinders returns from horticultural crops (which therefore are not grown). Another factor is the higher possibility of mechanization of large farm investments in irrigated projects, that do not require as much labour anymore (Headey, Taffesse, & You, 2014).

In vegetable production in the Central Rift Valley, which is the major economic vegetable producing area, medium-scale tenant farmers cultivate about 60 % of the irrigated area in the region (Minten et al., 2020). On average, a farmer cultivates about 5 hectares of irrigated land, which is relatively little in international comparison, but large for local standards. These farmers rely on the short-time rental contracts (Minten et al., 2020). There is an inflow of labour migrants to the area, primarily from the poorer South of the country, who enter these contracts, where the employment conditions are poor. They usually get daily, monthly, or piecemeal contracts and most often no healthcare or other benefits beyond their salaries (Minten et al., 2020). Only 3 to 4 % of daily workers get supported for healthcare by their employers (Minten et al., 2020). Most of them are hired from daily labour markets in the centre of the woredas. Even though women make up a large part of the work force (one third of the daily laborers), they rarely get employed under long-term contracts (Minten et al., 2020). Long-term contractors often get housing provided by their employer, but general contract conditions are usually poor. As also work equipment such as clothing or gloves is typically not provided by employers, most workers do not wear protective equipment (Minten et al., 2020).

In many cases and projects, where irrigation is to be established, the problem is not irrigation per se, but poor **implementation**, **planning**, and **maintenance** work from involved entities (Headey, Taffesse, & You, 2014). The implementation of rainwater harvesting program by the Ministry of Agriculture has failed "[…] because of myopic project planning, inadequate engineering studies, unsound designs, too short a time for implementation, and lack of full farmer involvement at different levels of project planning and implementation" (Aberra, 2004, p. 226). Problems also occur due to a lack of experience in the process of planning and designing irrigation systems or due to collapse of irrigation canals in which the diverted water is transported to the fields. These canals are mostly weak structures, made of small stones loosely cemented by mud, which entails high erosion rates and makes them very susceptible to floods. They are additionally damaged by human and animal traffic. At least once a year, the canals have to be rebuilt (Aberra, 2004).

Delays in construction work on canal systems are an issue, farmers often face when being involved in irrigation projects. As in the case of the construction of the Koga Reservoir, where the "[…] temporal extension of the project led to a much longer economic dependency on land loss compensation payments, as the time for the allocation of new arable plots shifted to an uncertain date in the future" (Eguavoen & Tesfai, 2012, p. 46). Hodbod et al. (2019) also refer to two projects (Gibe III and Kuraz sugar development) that are behind schedule. Further, these projects are faced with major limiting factors for irrigated cultivation (land suitability and quality of soil) of sugarcane and other cash crops (Hodbod et al., 2019). In the 1980s a large irrigation project was initiated for the Beles River and a diversion dam was built. Hence, the irrigation scheme was never officially implemented because the tunnel that was planned to connect Lake Tana (water source) with the irrigation scheme was never built (Nyssen et al., 2018). Nevertheless, the area is irrigated locally with the help of pumps. Eventually, another water tunnel was constructed, that opened in 2010 (Nyssen et al., 2018). Since then, 55 % of the outflow of Lake Tana is diverted directly through the Beles River instead of following the Blue Nile (Nyssen et al., 2018).

Irrigation systems – especially the large scale systems – need maintenance which is often omitted due to lack of practical maintenance skills and attitudes of national employees (Aberra, 2004). When it comes to development interventions like the implementation of irrigation, the importance of the know-how of the people involved is not to be underestimated. Introducing new technologies to farmers who have no experience with them has a lot of potential to fail. Instead, development interventions that concentrate on improvements to existing (traditional) practices have been observed to be more successful (Aberra, 2004).

Other issues that complicate the implementation of irrigation can be **policy** related, such as the distribution of responsibilities in different departments, e.g., issues concerning water in one department, and issues concerning agriculture in another department. A low level of farmer participation often further complicates an implementation process (Aberra, 2004).

The benefits of (successfully implemented) irrigation schemes are mostly not only unevenly distributed but the profitability for farmers is also severely limited by cost considerations, problems with their implementation, and poor access to markets to sell the created surplus in yields (Headey, Taffesse, & You, 2014). According to Headey, Taffesse, and You (2014), only 10 % of the total irrigable area in Ethiopia's ASAL is actually profitable. They conclude that improved roads and more efficient implementation processes could raise this ratio (Headey, Taffesse, & You, 2014).

Summarizing, the subsequent resulting benefits of the implementation of irrigation can be:

- More variable yields per year (Cochrane & Thornton, 2021; Etana et al., 2021; Minten et al., 2020)
- Increased yield per hectare (Etana et al., 2021)
- Wider variety of crops (Bedeke et al., 2018; Cochrane & Thornton, 2021)
- Increased resilience against (climate) shocks and (climate) stresses (F. Eshetu et al., 2023)
- Increased food security (reduced risk of crop failure) (Etana et al., 2021)
- Production of higher value produce (such as fruit and vegetables) (Teweldebrihan et al., 2020)
- Higher value produce can be sold in markets (Cochrane & Thornton, 2021)
- Additional income (Bedeke et al., 2018; Etana et al., 2021; Teweldebrihan et al., 2020) which can enable the following investments:
    - Increased expenditure on fertilizer and pesticides (Bedeke et al., 2018; S. Eshetu et al., 2010)
    - Invest in livestock (S. Eshetu et al., 2010)
    - Enable education for children (S. Eshetu et al., 2010)
    - Buy new equipment (S. Eshetu et al., 2010)

As was shown in the previous sections, irrigation is one of the significant variables, that contribute to farm income (Adem et al., 2018; Ayele & Degefa, 2020; Bantider et al., 2011; Bedeke et al., 2018; Cochrane & Thornton, 2021; S. Eshetu et al., 2010; Etana et al., 2021; N. A. Mengistu, 2022). The second variable that was analysed in the reviewed literature is migration. Information obtained from the literature regarding migration are described in the following chapter.

5.2. Migration

Migration is one of the adaption options available to many households who are no longer able to sustain their livelihoods at their place of residence (Etana et al., 2022). It remains one of the central components of livelihood strategies in developing countries like Ethiopia (Asfaw et al., 2010). According to Asfaw et al. (2010) the migration-livelihood framework approach argues that migration, in particular seasonal migration, "[…] is one of the most durable components of the livelihood strategies of people living in rural areas" (Asfaw et al., 2010, p. 60). This approach stresses a multidisciplinary perspective that focuses on the individual and acknowledges that livelihoods are diverse and not restricted to one specific economic sector (Asfaw et al., 2010).

Rural-based livelihoods are often diversified with and supported by seasonal migration as well as wage labour or off-farm activities (Asfaw et al., 2010; Bantider et al., 2011; Bedeke & Tebeje, 2022; Cochrane & Thornton, 2021; Etana et al., 2022; Headey, Taffesse, & You, 2014). These measures are intentional, although their origin can be attributed to necessity and/or vulnerability rather than being solely driven by opportunity (Cochrane & Thornton, 2021).

5.2.1. Reasons for (non-) Migration

The reasons for why people change their place of residence are manyfold. In most cases of voluntary migration, it is aimed to improve the living environment (Asfaw et al., 2010). CCV is a known global threat that eventually affects everyone. However, it particularly concerns the agriculture-dependent farmers as it affects crop production and food security (Etana et al., 2022). It is important to note that the factors for the decision whether to migrate are complex and not mere economic reasons. There are also social, cultural, and political aspects of a person's life that affect this decision (Asfaw et al., 2010). Additionally, knowledge and skills to improve agricultural productivity and livelihood resilience can be obtained when one or more members of a household work elsewhere for a period of time (Etana et al., 2022).

The **changing climate** and its subsequent consequences make in increasingly difficult to make a living. As Teweldebrihan et al. (2020) state, studies show an increase in migration due to climate change and related environmental changes. Smallholder farmers tend to feel the effects even more and are most vulnerable to impacts of climate change (Etana et al., 2022). They often live from hand to mouth, have no or only few reserves and little adaptive capacity due to limited access to technologies and other valuable farm investments. Additionally, they are often poorly integrated into the market and farm in risk-prone environments (Etana et al., 2022; Kidane et al., 2022). Therefore, migration is a popular CCV adaption strategy. When yields are little or crops fail, households may send one (or more) member(s) to search for employment elsewhere (Etana et al., 2022; Kidane et al., 2022). In a household survey by Kidane et al. (2022) the majority of smallholders that use migration as an adaption strategy, indicate climate-related factors, especially drought, as justification.

Migration can also function as source of livelihood diversification to counteract the impacts of climate change (Bedeke & Tebeje, 2022). In a study by Bedeke and Tebeje (2022) on the impact that local cognition of climate change by farmers has on their adaption to it, almost half of the interviewed farmers stated that they try to migrate to urban areas for labour for about one to two months per year. Some others migrate for three to five months to work on large-scale sugarcane farms. The farmers do so during the dry season to increase their livelihood resilience through additional income (Bedeke & Tebeje, 2022).

Migration can be a delayed reaction to the occurrence of climate risks. Most farmers first apply adaption measures undertaken at their place of residence, also called in-situ adaption strategies (Etana et al., 2022). If the living requirements can be met, or at least if the benefits obtained from the implementation of these in-situ strategies prevail the effort and expense of migration, migration is not necessary. It becomes viable or in many cases inevitable if available adaption strategies fail or when in-situ adaption is not enough to protect livelihoods from climate or other risks (Etana et al., 2022). According to Kidane et al. (2022), temporary migration was the most common non-farm or off-farm climate change adaption strategy, used by over half (65.3 %) of the households in rural Ethiopia.

The climate has a direct impact on the decision to migrate, especially when temperature and rainfall are concerned (Etana et al., 2022; Teweldebrihan et al., 2020). Through the effect of rainfall variability on food security, it has a profound influence on migration decisions (Etana et al., 2021).

According to Kidane et al. (2022) in addition to responding to climatic and non-climatic challenges, smallholder farmers also respond to opportunities. During droughts, when farming is not profitable and does not bring required yields, households took the opportunity to send (at least) one person to cities to pursue education (Kidane et al., 2022).

Study findings of Teweldebrihan et al. (2021) show that an increasing number of farmers are migrating to and cultivating crops in the Dedessa River Basin due to their adaptation strategies, such as prioritizing Teff (lower sensitivity of prices to rainfall) cultivation over other crops in response to rainfall variability and price expectations. Thereby, they are enhancing climate resilience, facilitating further immigration and cultivation within the basin, and preventing migration of farmers of the basin to destinations further away.

Migration is a strategy for **vulnerable households** to sustain their livelihoods and move out of **poverty** as a high proportion of migrants live below the poverty line (Etana et al., 2021). In Ethiopia it is mainly a survival-oriented strategy to counteract climate related problems or a lack of farmland and a popular strategy in the highland and midland areas (Etana et al., 2021). It is less common in the lowland areas "[…] due partly to expansion of irrigation infrastructure in the adjacent areas, creating opportunities for non-farm activities" (Etana et al., 2021, p. 15).

Land scarcity or landlessness are two of the main motivations for the decision to migrate. The lack of employment opportunities, as well as family-related reasons such as better education options for children are also common reasons for migration to urban areas (Kidane et al., 2022).

The **infrastructure** is also an important factor for migration decisions. The construction of roads, agricultural investments, and the establishment of towns often lead to immigration due to enhanced work opportunities and overall conveniences (Nyssen et al., 2018).

In short, **Push factors** for migration can be:

- Frequent drought (Teweldebrihan et al., 2020; Tizazu et al., 2021)
- Unreliability of rainfall (Teweldebrihan et al., 2020)
- Crop failure or risk of yield reduction (Etana et al., 2022)
- Population pressure (Asfaw et al., 2010)
- Low living standards (Asfaw et al., 2010)
- Lack of economic opportunities (Asfaw et al., 2010; Kidane et al., 2022)
- Political discomfort (Asfaw et al., 2010)
- Land scarcity (Kidane et al., 2022)

Factors (particularly) for seasonal migration

- Shortage of farmland (Asfaw et al., 2010)
- Rainfall variability (Etana et al., 2022)
- Lack of sufficient means of subsistence (Asfaw et al., 2010)
- Supplementation of income from agricultural work (Asfaw et al., 2010)

Pull factors of migration can be:

- Availability of job opportunities (Asfaw et al., 2010; Nyssen et al., 2018)
- Obtain knowledge and skills (Etana et al., 2022)
- Health services (Asfaw et al., 2010)
- Political freedom (Asfaw et al., 2010)
- Construction of roads (Nyssen et al., 2018)
- Agricultural investments (Nyssen et al., 2018)
- Available area for crop production (Teweldebrihan et al., 2021)
- Opportunities of non-climate-sensitive employment (Etana et al., 2022)
- Expected higher income in urban areas (Etana et al., 2022)
- Education options for children (Kidane et al., 2022)

The decision to migrate is also affected by and dependent on social networks and access to information (Asfaw et al., 2010). Ayele and Degefa (2020) argue, that in the essence of the sustainable livelihood approach (SLA) there are five components to livelihood assets. These components are:

- <u>Natural capital</u>: land size; soil fertility; availability and quality of water; forest,
- <u>Human capital</u>: size of households; gender, age, education, and health of household members,
- <u>Financial capital</u>: income; savings; credit; financial transfers

- Physical capital: livestock; building; farm equipment
- Social capital: network; membership in social organizations capitals.

The livelihood strategies a household can pursue are determined by these components. They affect the decision to migrate as well as the type of employment or activities migrants are able to obtain (Ayele & Degefa, 2020).

The gender dimension in a household has an impact on the probability of migration. The presence of a male adult in a household doubles the likelihood of migration compared to a female household member (Ayele & Degefa, 2020). This increased probability is on the one hand associated with the tedious agricultural work, which is a more attractive field of employment for men than for women. On the other hand, women are often less likely to be encouraged to seek employment elsewhere and are much more involved in and made responsible for domestic works (Ayele & Degefa, 2020). *Figure 13* illustrates clearly and in summary, which reasons contribute to the decision of whether to migrate.

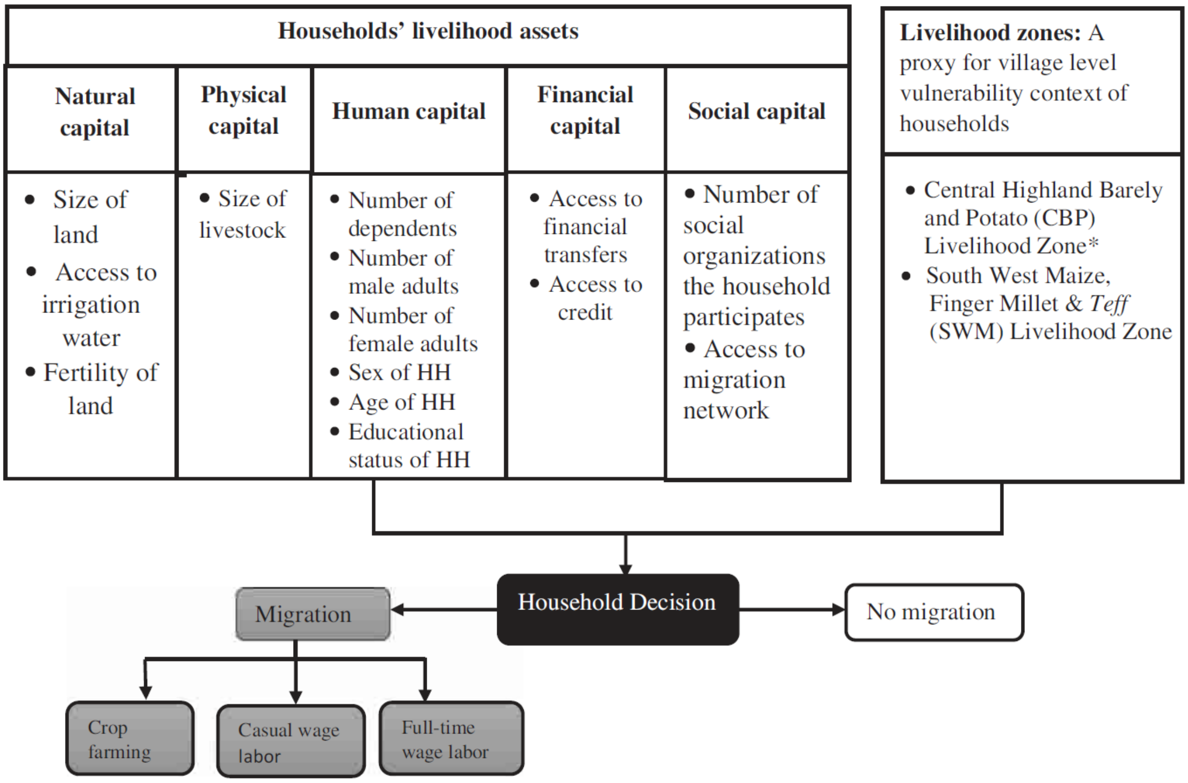

Figure 13: Conceptual framework for their study, developed based on literature reviewed by the Authors Ayele and Degefa (2020, p. 383)

The number of children in a household, still dependent on care of an adult person decreases the likelihood of migration for crop farming and full-time wage labour (Ayele & Degefa, 2020). It requires adult household members to provide care to the dependents (children). Accordingly, the likelihood of this type of labour migration increases with the increasing number of adult members (male and female) of a household. The reason could be, that labour migration for crop farming and full-time wage requires migrants to remain longer at the place of destination. This means, that additional labour in the household enables migration (of one or more members of the household) as a livelihood diversification strategy (Ayele & Degefa, 2020). The access to migrant networks increases the likelihood of migration, while owning livestock, is another key asset, that decreases the likelihood of migration (Ayele & Degefa, 2020).

Teweldebrihan et al. (2021) conclude in their analysis of secondary and primary data over a period of 20 years, "[…] that irrespective of rainfall variability, more farmers are moving in the basin because the area under crop cultivation, as well as the number of households practicing it, has grown over the years" (Teweldebrihan et al., 2021, p. 9).

The rainfall conditions and variability are also an important factor for farmers in their decision whether to migrate. The onset of rainfall in rainy seasons is an indicator for the productivity of crop production. If rainfall starts early, the conditions for a surplus production are favourable (Etana et al., 2022). An increase in rainfall during the short rainy season (March to May) and a late onset of rainfall in rainy seasons in general, reduces migration, while increased rainfall during the longer rainy season (June to September) as well as early onset of rain in both seasons increases migration (Etana et al., 2022). The dependency on agriculture, water scarcity, drought, and the general unreliability of rainfall are major reasons for migration (Teweldebrihan et al., 2020).

According to Bantider et al. (2011) migration is a response of farming communities, "[…] when there is stress in rural areas due to environmental degradation, decline in landholdings, or landlessness" (Bantider et al., 2011, p. 51). In their study in eastern Wollo (northern Ethiopia) according to observations as well as verified focus groups, the land tenure policy was the primary factor for the decision not to migrate, even though, the benefits of both options (migrating and not migrating) were considered. The land tenure policy requires families to remain in rural areas if they want to keep their current farm plots. It is not possible for a whole family to migrate in search of labour and keep owning their land at the same time (Bantider et al., 2011). Additionally, there were already many unemployed people in urban areas, which was another factor that hindered migration for work reasons (Bantider et al., 2011).

Income diversification is often difficult for poor people living in rural areas, due to lack of assets such as livestock, cropland, or education (Headey, Taffesse, & You, 2014). In rural areas, the potential of non-farm activities for livelihood diversification is limited and there is less potential for profitable diversification than for migration to urban areas. Therefore, the cost-benefit of cities is the more obvious choice for many poor people as they can also get education and health services. Additionally, urban livelihoods are less vulnerable to environmental impacts such as drought (Headey, Taffesse, & You, 2014).

Generally, the livelihoods of **pastoralist communities** have diversified. The pure nomadic form of pastoralism, which is based on seasonal migration within an area has been replaced by a partly sedentary form, where a part of the household (mostly women, children and some animals) lives in a permanent or semi-permanent setting, and others (mostly men and more robust animals) migrate to other areas (Headey, Taffesse, & You, 2014). Nevertheless, the further increasing temperatures and unpredictable rainfall patters (high variabilities in the onset and end of rainy seasons), led to a shorter plant growth period, which affects the overall land productivity (Gebeyehu et al., 2021). Due to subsequent shortages in fodder and water, "pastoralists are forced to migrate over extended periods and longer distances to meet their demand for dry season fodder and water" (Gebeyehu et al., 2021, p. 2). Increased mobility can in turn lead to new problems, such as animal health or conflicts with neighbouring communities (Gebeyehu et al., 2021). Pastoralists have also adapted to the increase of droughts by temporal migration as well as herd diversification and livestock mobility (practiced by 87 % of pastoralists interviewed in the Lower Omo Valley). Temporary migration to urban centres for wage labour is also considered by a few (9 %), although it is the less preferred option (Gebeyehu et al., 2021). Members of agro-pastoralist groups in the Awash River Basin also seasonally migrate to a tributary of the Awash River during the dry season. This way, they have a reliable and free water source for themselves and their livestock as well as grazing land (Grasham et al., 2022; Hodbod et al., 2019). Children and older people remain in the village so that children's education can be ensured (Grasham et al., 2022). Alongside this type of migration, there are villagization programs that aim to settle the pastoralists in the region, and resettlements of people living in more densely populated areas of southern Ethiopia, planned by the government (Hodbod et al., 2019).

When it comes to CCV, there is also involuntary **non-migration** i.e., people who are willing to migrate, but unable to do so. The most common reason for involuntary non-migration are financial means, as migration involves costs that many families cannot afford (Etana et al., 2022). Another reason can be the lack of skill, that makes it difficult to find work aside from agriculture (Etana et al., 2022). In an example given in Etana et al. (2022) the reason for non-migration was due to social dependence of the family on the person potentially migrating. Other household members were not eligible. Another reason, why people cannot fall back on migration can be (political) conflicts. During wartime for example, the opportunities people have, are extremely limited. In the Tigray region in 2021 for example, out-migration and off-farm income were no options due to a blockade (Nyssen et al., 2022).

5.2.2. Challenges and (Socio-Economic) Consequences of Migration

Challenges

Population movements can have a high potential for **conflict**. Conflicts can occur due to various reasons. Conflicts can for example arise between members of different groups (e.g. due to unequal treatment by government officials, allocation of land, cultural differences, or uneven distribution of benefits) (Hodbod et al., 2019; Teweldebrihan et al., 2020), between indigenous groups or other population entities and the government or other institutions (Hodbod et al., 2019), or within (re-) settled groups due to inequalities for example (Hodbod et al., 2019). Another reason for conflict can be resentment from the local population towards new measures that come with development projects such as larger roads with more traffic and noise (Hodbod et al., 2019). Many generally feel disturbed by the new changes which can lead to conflict between local people and migrants or new settlers (Hodbod et al., 2019).

Especially (re-)settlement projects often face several challenges. New settlements can have negative impacts on the host community and lead to tensions between the native population and migrants (Nyssen et al., 2018). In the South Omo Valley, the government planned to resettle all agro-pastoralists in the area, simultaneously with the expansion of commercial farms (Hodbod et al., 2019). However, the attempted implementation of villagization proves to be difficult. In parts of the region, there was a strong resistance against the project from the local population as well as the pastoralist groups. So far, only the area around a sugarcane development project in Kuraz has been addressed (Hodbod et al., 2019). The local population was informed of the plan and pastoralists moved into new villages. Pastoralist communities that were subject to the villagization, were allocated irrigated fields of 0.25-0.5 ha. However, settlers trying to grow crops on these fields were not very successful with it and largely remained dependent on food aid (Hodbod et al., 2019). Eventually, the villages were abandoned due to conflicts between other settled groups along with the cancelation of food aid (Hodbod et al., 2019).

When migrating from rural to urban areas, many families struggle with **cultural differences** between rural and urban living, such as gender specific distribution of labour and/or a not welcoming atmosphere from the host community (Eguavoen & Tesfai, 2012). The typical rural farm economies with men as the breadwinner of the family, are difficult to apply to the urban context. Additionally, the former farmers were faced with prejudices and earned spotlight for their different clothes and behaviour. This can and often does bring additional problems such as alcoholism, increased in prostitution and subsequent increased vulnerability to HN/AIDS or social disruption, as it was the case in Merawi (close to the Koga project) (Eguavoen & Tesfai, 2012). Another issue was the legalization of land exchange between farmers, that some farmers had arranged, as not all relocated families received plots from the committee. In cases of unregistered land exchange, farmers had to fear for their new houses to be torn town (Eguavoen & Tesfai, 2012).

The dependency on labour migrants of irrigation applications also showed effects during the **COVID-19** crisis. “A large share of the vegetable farmers complained about more difficult access to modern inputs, higher prices for these inputs, lack of access to laborers, and reduced yields since the crisis began” (Minten et al., 2020, p. 1426). This seems to affect particularly the medium-scale tenant farmers, that rely more on labour markets and less on family labour.

They are often more involved in vegetable production which is more risky than other crops. On the other hand, they also benefit more from increases of prices in output markets (Minten et al., 2020).

Increased migration and resettlement programs can cause **environmental challenges** such as the destruction of valuable ecosystems. This applies in particular to labour migration for agricultural employment (Ruffeis et al., 2008; Teweldebrihan et al., 2020). Due to increased agricultural activity in an area, forests are being cleared in favour of fields, which can cause droughts, increased erosion and other long-term consequences (Teweldebrihan et al., 2020).

When migrating from a rural area to an urban area, people face a series of changes such as the "[…] dependency on food and labour markets, an urban lifestyle, new income resources, change in gender relations and social networks" (Eguavoen & Tesfai, 2012, p. 48). It is often hard for people from rural areas to find **employment** in urban areas due to their lower level of education. This often results in stress and frustration (Eguavoen & Tesfai, 2012). Migration to urban areas is often increased, if the productivity in the agricultural sector is low which induces unemployment in this sector. Urban areas have opportunities of non-climate-sensitive employment. Even though, finding employment in urban areas is often not assured and its chances may get overestimated, the expected higher earnings still drive migration from rural to urban areas (Etana et al., 2022).

There also **gender differences** in migration. Many women (especially in rural areas) change their place of residence at least once in their lifetime. Women typically marry early, particularly in rural areas. After marriage, they move to their husband's homestead, which is often quite far as they are not allowed to marry within the same clan. There they have to adapt to a new environment at a very young age (Nyssen et al., 2018).

In pastoralist communities, women often have a more sedentary lifestyle where they engage in dairy production, collection of firewood, or trade, while men manage the main livestock herd with which they often migrate in the area (Headey, Taffesse, & You, 2014).

In their paper on individual and institutional drivers of inequality in rural agricultural contexts in Ethiopia, Cochrane and Thornton (2021) concluded that "[…] in many cases, development interventions result in opportunities that come at the expense of a minority. These inequalities are expressed at the micro- and meso-levels, and are a product of macro-structures and systems" (Cochrane & Thornton, 2021, p. 38). To change this system, there must be major changes at individual and community levels. In this context they stress the importance of changing norms about gendered inheritance as one of the key points to understand pathways out of and into poverty and for whom and why they exist (Cochrane & Thornton, 2021).

Socio-economic Consequences

Non-farm employment and migration of household members can significantly **increase livelihood sustainability** of households through increase and diversification of income

(Asfaw et al., 2010; Bedeke et al., 2018; Etana et al., 2021; N. A. Mengistu, 2022). According to interviews conducted by Asfaw et al. (2010) in two woredas located at Lake Tana (northern Ethiopia), individuals that migrated for work were eventually able to start their own small business in their home village from the money earned from migration. Others teamed up and bought a mill together (Asfaw et al., 2010). Families are able to invest the income gained from labour migration (through remittances from their children) in developing their livelihoods and increasing overall wealth and wellbeing by being able to pay their depts, purchase grain, and cover all other household costs (Asfaw et al., 2010).

The socio-economic consequences of migration are versatile. They may be for example:

- Increase general livelihood sustainability (Asfaw et al., 2010; Etana et al., 2021)
- Increase household income (Bedeke et al., 2018; Etana et al., 2021)
- Enables people to buy cattle (Asfaw et al., 2010)
- Enables investments in agriculture (Etana et al., 2021)
- Cover payments for land rent (Asfaw et al., 2010)
- Construct houses (also with higher quality roofs) (Asfaw et al., 2010)
- Enable education for their children (Asfaw et al., 2010)
- Enables food security (Etana et al., 2021)
- Cover medical expenditure (Asfaw et al., 2010)
- Start a small business (Asfaw et al., 2010)
- Enables people to repay loans (Asfaw et al., 2010)
- Change in gender relations and social networks (Eguavoen & Tesfai, 2012)

Around half of the smallholder farmers interviewed for the study by Bedeke et al. (2018) in Wolaita Zone (Great Rift Valley) have indicated, that they **seasonally migrate** (especially during the dry season) to nearby urban areas in search for labour or some even further away to work on large-scale sugarcane farms (Bedeke et al., 2018). The additional income gained through migration allows better adaption to uncertain rainfall variability or improved crop varieties (Bedeke et al., 2018).

According to (F. Eshetu et al., 2023), households of which one member is an **international migrant** "[…] have a lower incidence, dept, and severity of poverty." (F. Eshetu et al., 2023, p. 1)

However, for a **critical view,** Cochrane and Thornton (2021) say that according to a large-scale randomized control trial "[…] unskilled work opportunities are more precarious and no more financially rewarding than small-scale agriculture" (Cochrane & Thornton, 2021, p. 37). They argue that the outcome of temporary, seasonal, or long-term work opportunities for unskilled and low-paying work appears to be "[…] less transformational than might be assumed" (Cochrane & Thornton, 2021, p. 37). The need to migrate for these unskilled and low-paying job is often due to severe short term challenges such as food insecurity, poverty, and other vulnerabilities (Cochrane & Thornton, 2021).

Additionally, the beneficial consequences of migration also depend on a household's initial socio-economic situation. According to Etana et al. (2021) it might not be a viable option for households that are able to sustain their livelihoods through available local adaption options. Members of wealthier households and households owning larger areas of agricultural land are less likely to migrate. "For better-off households, migration may reduce labour force availability, consequently undermining farming and other productive activities, leading to reduction in livelihood sustainability" (Etana et al., 2021, p. 15). High costs of living in urban areas and low-paying jobs may not compensate the farm income generated through agricultural work by the same person (Etana et al., 2021). Etana et al. (2021) also point out, that some studies show an increase in household income through migration without constraints in agriculture. They argue that this "[…] only true under the two-fold conditions of enough labour resources in the households and the high earning potential of the migrant" (Etana et al., 2021, p. 15).

5.3. Irrigation and Migration

The reviewed literature suggests that there are various connections between irrigation and migration, which are presented in the following.

Access to water is the basic requirement for irrigation and according to Ayele and Degefa (2020) it also has an effect on migration. 43 % of non-migrant households in Ethiopia have access to irrigation water, while this only applies to 30 % of migrant households. This indicates that with the availability of irrigation water, the likelihood of migration tends to decrease (Ayele & Degefa, 2020). "Access to irrigation water is a strong negative predictor for all forms of migration" (Ayele & Degefa, 2020, p. 390). The likelihood of migration is reduced by 12 % if access to irrigation is given. Ayele and Degefa (2020) argue that this could result from the fact that more non-migrant households live in areas with less land scarce and degraded areas and in areas with better access to market and road networks.

Fried and Lagakos (2021) conclude, that electrifying a village leads to an increase in agricultural productivity, which is likely achieved through irrigation. In the same study they found, that "electrified villages experienced substantial decrease in out-migration, relative to non-electrified villages, and modest increase in in-migration" (Fried & Lagakos, 2021, p. 12). This suggests that agricultural production increase through irrigation directly affects migration behaviour, both in-migration (increase) and out-migration (decrease).

The **impact of irrigation on migration** seems to be manifold. In a study by Etana et al. (2022) "[…] migration is conceptualized as a decision made when in-situ adaption fails" (Etana et al., 2022, p. 739). Irrigation is an in-situ adaption strategy, meaning climate change adaption strategies, undertaken at the place of residence. If those strategies are not sufficient, migration becomes inevitable. (Etana et al., 2022). This in turn also means, that the successful implementation of irrigation can prevent destress out-migration. According to F. Eshetu et al. (2023, p. 2) “promoting access to land, capital, farm and non-farm employment, irrigation, family planning, and basic public services would improve rural household welfare and reduce the current wave of rural out-migration in southern Ethiopia.” (F. Eshetu et al., 2023, p. 2)

There are different **types of migration associated with irrigation**. The following sections elaborate the types of migration and associated challenges and consequences identified in the reviewed literature.

A common form of migration for livelihood diversification is **rural-to-urban** migration. In their study Eguavoen and Tesfai (2012) conclude, that due to the increase in household earnings form irrigation, 98 % of their interviewees said they would built a house in the city, so their children can have better access to education. Seemingly contradicting to this, F. Eshetu et al. (2023) conclude, that families or households that use irrigation are less likely for rural out-migration due to their increased farm income. But F. Eshetu et al. (2023) also add, that the decision to migrate is also associated with family size and size of livestock and does not solely depend on a household’s income. In addition to this, Cochrane and Thornton (2021) found, that households that achieve a higher and more consistent income through the implementation of irrigation are enabled to reduce distress migration and improve opportunities for skilled labour migration. However, these possibilities also depend on the given infrastructure. Another indirect factor of (non-) irrigation can occur when farmers are not able to cultivate their fields due to droughts, as it would be unviable. According to Kidane et al. (2022) households then often decide to send (at least) one member to cities to pursue education, as they do not need as many helping hands on the farm (Kidane et al., 2022). But if irrigation projects are successful and household incomes increase, in the case study of Eguavoen and Tesfai (2012), an increase in rural-to-urban migration can be expected.

The availability of irrigation infrastructure can be a major reason for migration from **rural to rural** areas, especially when combined with generally better agricultural performance (Etana et al., 2022). In the course of a program by the Ethiopian government to fight drought and famine, the sites for resettlement were also chosen due to their suitability for irrigation (Teweldebrihan et al., 2020).

In their publication on the role of agriculture in poverty reduction Dorosh and Mellor (2013) state that around half of the farmers live in the moisture-reliable highlands and around 20 % live in the more drought prone areas. Due to lack of irrigation or improved land and water management systems, the moisture-reliable highlands experience population pressure which subsequently has diminished farm sizes in the area. In the area, **out-migration** therefore has become a major pathway out of poverty (Dorosh & Mellor, 2013). Many people migrate to areas with large-scale irrigation projects (Nyssen et al., 2018).

Income diversification, that is the widening of a household's base of income through the adoption of different economic activities, is an efficient strategy in view of climate change and associated shocks, stresses, extreme events, or simply an increase in temperature and decrease in rainfall (S. Eshetu et al., 2010). Irrigation is a useful tool to increase income due to reduced dependence on rainfall. If crops fail, "[…] members of poor farming households are forced to migrate in search of wage labour or sell assets […]" (S. Eshetu et al., 2010, p. 4).

Labour migration is a major type of migration associated with irrigation as many large-scale irrigation projects create numerous jobs. In a study from Headey, Taffesse, and You (2014) in the Afar region (North-East) it is said that most large irrigation projects are allocated to sugarcane production. This sector also creates many jobs (around 80.000) which are, however, often taken up by migrants from the highlands instead of the local Afar population (Headey, Taffesse, & You, 2014). The profitable sugarcane estates often attract thousands of migrant workers, as it is also the case in the Lower Omo Valley, where many people migrated from Ethiopia's southern highlands (Hodbod et al., 2019). Generally, it was found that many people from the Ethiopian highlands migrate to areas with profitable large-scale irrigation projects like also the Beles Valley bottom (Nyssen et al., 2018), Awash Valley (Behnke & Kerven, 2011), or Afar region (Headey, Taffesse, & You, 2014). Also the resettlement of highland communities is specifically associated with water and land resources (Nyssen et al., 2018).

However, the dependency of large-scale irrigated farms on migrant workers (even from not far) can also have a negative impact on investments from investors e.g., during times of political instability as there is no guarantee, that the labour migrants can be present at the farms (Nyssen et al., 2022).

Displacement, Resettlement, or **Settlement** (of pastoralists) is another form of migration that often comes with irrigation or associated dam projects. Despite the potential benefits of implementing a nationwide initiative to construct large-scale irrigated agriculture, such as providing employment opportunities for numerous unemployed youth, its execution would pose various challenges at the local level (Gebresenbet & Kefale, 2012). In their study on traditional coping mechanisms for climate change of pastoralists in South Omo, Gebresenbet and Kefale (2012) point out, that the included forcible settlement of pastoralists in the Omo area would undermine their traditional expertise in pastoralism and their ability and knowledge of coping with climate change which would ultimately exacerbate the vulnerability to climate change.

In the case of an irrigation project in the Beles River (mentioned under *5.1.2.*) numerous numbered villages were built, parallel to the works for the irrigation scheme. The area has a high potential for irrigated agriculture for an estimated 115.000 ha. As this area was planned to be irrigated, additional farmers to cultivate the area and laborers for construction and agriculture were needed (Nyssen et al., 2018).

There are several reasons for the displacement of people. A particular type is **dam-induced displacement and migration**, as one factor particularly connected to irrigation is the construction of dams for the extension of irrigated agriculture and hydropower (Eguavoen & Tesfai, 2012). Some households have to move their houses some meters due to construction of canals or streets, others have to move entirely if their place of residence is located in the area affected by the construction of the dam and the planned inundation of the reservoir (Eguavoen & Tesfai, 2012). Most households relocate to areas that are familiar to them or where they have relatives (Eguavoen & Tesfai, 2012).

Usually, affected farmers are compensated with a plot of land as it was the case in the Koga irrigation project in northern Ethiopia. But these plots were further away from their place of residence than their old plots, which posed new challenges for farmers who often do not have the financial means for the required transport (Eguavoen & Tesfai, 2012). Due to the construction of the Koga project, many farmers had to give up their land use rights and assets. Despite reimbursements, many also had to give up their livestock-related occupations like the sale and production of dairy products. A few former farmers are now involved in trade, others built houses in nearby Merawi (although they continue to live in rural areas) which they rent out to relocated families (or other people). The money earned from the rent, is often their main income (Eguavoen & Tesfai, 2012). In the context of the project, 831 households were relocated. Another 5.075 households lost land and agricultural assets and many more were affected by the construction of infrastructure for the project. In order to keep their communities as good as possible, people tried to move as neighbourhood groups (Eguavoen & Tesfai, 2012). The relocated households had to develop alternative strategies to sustain their livelihoods. “The main shift in occupation was from subsistence to marker-based provision of household goods and services with the consequences of an increased dependency on money in the household economy additional to the compensation money received by relocated households“ (Eguavoen & Tesfai, 2012, p. 51). Many members of relocated households who typically made their living through agriculture, found it difficult to find work in urban areas, due to their lower level of education. This often results in stress and frustration (Eguavoen & Tesfai, 2012). Most men worked at the construction site of the dam or consider labour migration, even though the salary is very low (Eguavoen & Tesfai, 2012).

Another example is a study by Teweldebrihan et al. (2020), dealing with the migration and resettlement of farmers in the Dedessa River Basin. Through government initiatives prior to the dam development, the majority of the population living alongside the Arjo-Dedessa Reservoir (western Ethiopia) has migrated from other regions (Teweldebrihan et al., 2020). The majority (73 %) of these migrant farmers was able to increase their crop production compared to their place of origin. Because the migrant farmers received land from the government and were able to properly use the available water resources, they were better off than the indigenous groups in the area (Teweldebrihan et al., 2020). This illustrates the value of migration facilitated by the government and the support and often the advantage such migrants have contrary to the native population (Teweldebrihan et al., 2020). However, in this case, the large-scale dam construction and a sugarcane irrigation project have forced the migrant farmers to relocate elsewhere. The farmers stated that the project will most likely have negative impacts on their livelihood as well as their emotional wellbeing due to loss of land and assets, despite of probably positive impacts on the regional economy in a long run (Teweldebrihan et al., 2020). The relocation of farmers to nearby villages is heavily contested by local inhabitants. This could destabilize local economies, which became increasingly stable due to the planned migrations into the basin prior to the dam project (Teweldebrihan et al., 2020).

In connection with the construction of the Gibe III dam in the Lower Omo Valley, a general increase in mobility took place. People migrated to nearby regions due to food insecurity and changes in availability of natural resources (Hodbod et al., 2019). Additionally, there were villagization programs aimed at pastoralists, an increase in immigrants from the southern highlands due to an increase in job opportunities in the area, as well as resettlement of people from more densely populated areas planned by the government (Hodbod et al., 2019).

In a case of **community displacement** by a state-owned (irrigated) sugarcane farm, the rural population perceived their life quality poorer compared to prior to the displacement. People reported a lack of provision of basic services after the displacement (Grasham et al., 2022). Pastoralist communities are often affected by displacements. They rarely have a say in decision making processes. Hence, their values are often put at risk (Grasham et al., 2022).

Returnees often struggle with lack of ownership of productive agricultural land. In a study by Tizazu et al. (2021) on the **reintegration process of returnees** in rural areas conducted in North Wollo (northern Ethiopia), the importance of access to irrigation is emphasized in context of successful reintegration. In this case, many of the returnees were too young to receive land ownership during the land redistribution in Amhara region (1997), which was subsequently the primary reason for emigration. As drought is an incisive problem in many parts of Ethiopia the returnees stress the coverage of areas by irrigation projects as only those areas are reliable and produce enough for them to be able to sustain their livelihood. Many returnees see themselves forced to remigrate if they do not get access to irrigated land. Without irrigation, the incisive droughts would extremely limit the possibility of yields (Tizazu et al., 2021). Returnees "[…] to rural Ethiopia that consider themselves economically reintegrated are those who have their own house and sufficient income from agricultural productivity or a self-owned business" (Tizazu et al., 2021, p. 215). Land productivity and income sufficiency are therefore key elements for successful reintegration (Tizazu et al., 2021).

Migration can also serve to **cover financial investments in irrigation systems**. Irrigation, in particular its acquisition, can be costly, especially for smallholder farmers in proportion to their regular income gained from agriculture. Migration can therefore also be a strategy for smallholder farmers to cover the costs for irrigation and other adaptive strategies they try to implement. In the Ethiopian Highlands, "[…] farmers migrate to nearby towns to gain financial capital to cover costs of agricultural inputs such as fertilizer and irrigation" (Bedeke et al., 2018, p. 11).

In their study F. Eshetu et al. (2023) found that the use of irrigation is negatively and significantly related to rural-to-urban as well as international migration, while family size and household savings are positively associated with both types of migration. As mentioned from Headey, Taffesse, and You (2014), in ASAL regions pastoralists are generally better off than farmers without access to irrigation.

Migration can also **influence irrigation**. The seasonal migration for work of one or more members of a household has various positive impacts. The socio-economic benefits were addressed in *Chapter 5.2.2.* Additionally, from the extra income, families are able to buy water pumps for irrigation which improves a households food security through the reduced necessity to buy food at markets (Asfaw et al., 2010).

According to Headey, Dereje, and Taffesse (2014) the substantial irrigation potential in the regional states Somali (South and East) and Afar (northeast) is difficult to exploit, due to inter-regional migration restrictions and poor infrastructure (Headey, Dereje, & Taffesse, 2014).

6. Discussion

Both, irrigation and migration represent important adaption strategies to environmental changes. Understanding the mechanisms between both can be of valuable information, particularly considering the accelerating climate change. The results of this thesis are discussed in this chapter. Firstly, methodological considerations are discussed to point out possible inaccuracies but also highlight the strengths of this type of research (*Chapter 6.1.*). The presented results are linked to the research questions (*Chapter 1.2.*) and embedded in an overall context to explore the mechanisms between irrigation and migration (*Chapter 6.2.*). In this way, the main research question as well as the sub-questions are answered.

6.1. Methodological considerations

As every methodological approach, the one chosen for this thesis also has advantages and disadvantages.

Conducting a SLR is a rigorous and valuable research methodology. but it also has its **limitations**. For this thesis, literature identified and selected via specific criteria (explained in *Chapter 2.3.1.*) was reviewed. Therefore, only statements found in these publications (*Table 1*) were considered. Adjusted search criteria may provide a different selection of literature and therefore may lead to a different spectrum of results. Due to the selective identification process, the results of this thesis have no claim to completeness within the general or overall context of the field of research concerning each, irrigation and migration, individually in Ethiopia. Here, only publications dealing specifically with both topics were considered.

As the results are based on published literature, they are limited to studies that have been conducted and published up to the date of literature identification (February 2023) for this thesis. Further, as the review only includes publications written in English language, studies conducted in other languages, potentially widening the result spectrum, are excluded.

Another challenge is that this review is susceptible to publication bias, where studies with positive or significant results are more likely to be published, as studies with negative or marginal results may remain unpublished. This bias can affect the comprehensiveness and accuracy of conclusions of this thesis.

Further, a limitation of this approach is due to the content analysis (explained in *Chapter 2.4.*). There is inherent subjectivity since it is a matter of deciding whether a segment is to be coded or not and, if coded, in which category a statement or text passage fits best. Further, the quality of this thesis, in particular the SLR, is dependent on the expertise of the person conducting it. Biases and errors may occur during the literature selection, data extraction, and data synthesis stages.

The synthesis of information extracted from the literature can also pose limitations, as comparing and interpreting data from different studies can be complex, especially of those using different methodologies, outcome measures, or statistical approaches as it is the case for the studies reviewed in this thesis.

The focus of the research question are the mechanisms between irrigation and migration. A broader perspective could have been obtained, by also specifically looking at the dam construction sector. Hence, the sector was only considered if mentioned in the selected literature. However, it was not integrated in the process of literature identification (*Chapter 2.3.1.*) in the key words or the search string, as this would have exceeded the scope of this thesis.

Despite the above-mentioned limitations, SLR’s have many **strengths** and are an essential feature of academic research. As written in *Chapter 2.1.* “to push the knowledge frontier, we must know where the frontier is” (Xiao & Watson, 2019, p. 93). SLR’s do exactly that. They analyse the stages of research in a particular field and can thereby identify and highlight the current stage of research. Gaps in the existing research can be identified and areas where further investigation is needed can be pointed out, thus providing directions for future research.

The methodology of this SLR is particularly comprehensive and transparent as it follows a rigorous and systematic process to identify and include all relevant studies, minimizing the risk of bias (which however still exists) and ensuring a comprehensive overview of the available evidence. The entire process is well defined, clearly outlined, and transparent, allowing others to replicate the review process and verify its findings. As all reviewed publications are listed, replication and validation of the study's findings by other researchers are facilitated and therefore the reliability, credibility, and trustworthiness of the results strengthened.

Additionally, this review allows generalizability, by analysing a broad range of studies. Findings across different populations, settings, and contexts can be generalized as similar results in different contexts as well as patterns that are identified in different settings or conditions, allow more general statements. Also, a clear and accessible way is provided for people not familiar with the subject matter to get a good overview of the situation.

Consequently, the applied methodology appears to be appropriate to investigate the mechanisms between migration and irrigation in Ethiopia and to answer the research questions.

6.2. Mechanisms between Irrigation and Migration

This master thesis aims to provide a comprehensive synthesis of existing research, explore the mechanisms between irrigation and migration in Ethiopia and identify gaps and opportunities for future research. By examining and discussing the results of existing research, this chapter seeks to shed light on the implications of irrigation practices on migration patterns in Ethiopia, place them into the broader (research) context, and highlight potential avenues for further exploration in this field. First, the sub-questions (*Chapter 1.2.*) are dealt with to finally address the main research question of this thesis.

All reviewed studies, dealing with **the socio-economic consequences of the implementation of irrigation in Ethiopia** (***sub-question a***) state, that the use of irrigation decreases the livelihood vulnerability of a household, enables a higher income compared to households without irrigation, and increases the general socio-economic situation of a household (Adem et al., 2018; Ayele & Degefa, 2020; Bantider et al., 2011; Bedeke et al., 2018; Cochrane & Thornton, 2021; S. Eshetu et al., 2010; Etana et al., 2021; N. A. Mengistu, 2022; Teweldebrihan et al., 2020). On a household level it is likely that the successful implementation of irrigation leads to a more sustainable and efficient agricultural productivity which in turn can create additional income (Teweldebrihan et al., 2020). If implemented successfully, situations of poverty can be overcome and general livelihood vulnerabilities are most likely decreased (Cochrane & Thornton, 2021). Due to a reduced dependency on precipitation and the possibility of a wider variety of crops and more than one yield per year farmers can have a more consistent and reliable income. This enables them to reinvest in higher value crops and fertilizers as well as in livestock and/or equipment (Bedeke & Tebeje, 2022; Cochrane & Thornton, 2021; S. Eshetu et al., 2010). Further, children of those households are more likely to be able to attend school (Cochrane & Thornton, 2021). The socio-economic impacts that successful introduction of irrigation can have, particularly the increased security and reduced vulnerability, are also confirmed by the study from Tizazu et al. (2021). Here, the coverage of areas by irrigation is stressed in the context of a successful reintegration of returnees, as these areas are reliable and enable a (also economically) successful reintegration into communities.

The main take that can be drawn from literature regarding the socio-economic consequences of irrigation for a household is, that <u>successfully implemented</u> irrigation can play a fundamental role. It can improve the overall living conditions and lower the susceptibility to CCV by providing less dependence on amounts and variability of rainfall, leading to better predictability and higher amounts of yield. This is in accordance with the findings of Benonnier et al. (2019) that show on a more general scale, that the access to irrigation offsets negative impacts of higher temperatures. They also find that "[…] higher irrigation reduces the effect of precipitation" (Benonnier et al., 2019, p. 17). Therefore, the positive impacts of irrigation, particularly considering CCV are not only limited to Ethiopia but seem to be a useful, efficient, and sustainable tool to counteract future challenges of smallholder households in other areas as well. Additionally, through the analysed data it appears that irrigation practices are needed to increase productivity to ensure food security for the increasing population in urban areas, which is partly also due to migration.

The construction of dams, which is mostly (also) associated with irrigation, also affects the socio-economic situations of people as many get displaced or relocated, some receive reimbursements in form of other plots of land or compensation payments. The living conditions of some farmers improve if they get access to the irrigation scheme (Eguavoen & Tesfai, 2012; Teweldebrihan et al., 2020), others are compensated with plots of land that are a less accessible and/or desirable, have to sell livestock, or receive compensation payments years later or not at all (Eguavoen & Tesfai, 2012). Some people built houses in urban areas from the compensation payments, which they rent out as main household income (Eguavoen & Tesfai, 2012). Often the livelihoods of dam-induced displaced or relocated people drastically change as many are less or no more involved in agricultural activities for subsistence due to an increased dependency on money. Their main occupation shifts to market-based provision of household goods and services (Eguavoen & Tesfai, 2012). However, it can be difficult to find secure and permanent employment, so many work at the construction sites of the dam and associated infrastructure for low wages (Eguavoen & Tesfai, 2012). However, in a study conducted in Turkey, Kuslu (2008) found, that despite the positive effects of irrigation projects on rural development and increases in agricultural activity, many people living in rural areas preferred to migrate to urban areas. They argued that urban centres are more attractive due to better chances of education, non-farm employment, and housing. Despite these study findings being interesting for the subject in general, comparisons with the situation in Ethiopia are difficult, due to the importance of subsistence in Ethiopia and due to the high percentage of the population involved in the agricultural sector. The agricultural situation of countries, especially countries in different regions of the world, varies greatly, which is why direct comparisons of single factors are not useful, without taking the overall situation (agricultural sector, irrigation projects, water availability, employment opportunities, demography, wealth, etc.) into account.

The results also show that the role of the government is important in large-scale irrigation/dam projects. Households that are entitled to another plot of land and/or other reimbursements are often well-off, unlike households that do not receive reimbursements but are still affected by the project (water shortages during and after construction, in-migration, and subsequent population pressure, etc.). Migration facilitated by the government and the subsequent support can play a vital role in the livelihoods of farmers living near the project, as most of those famers are affected by the project in some way. However, first it is crucial how well organized the entire process of the project is by the government and second, it seems of great importance, if a household benefits in some way, such as access to the irrigation scheme, an appropriate amount of compensation payments, or a new plot of land that is at least as usable as the original plot. It is essential to acknowledge that in most cases the main beneficiaries of large-scale irrigation projects are labour migrants, government workers, new settlers, or investors (Hodbod et al., 2019; Nyssen et al., 2018). Therefore, the distributional impacts of irrigation projects should be considered to ensure equitable socio-economic outcomes for all members of affected communities.

Despite immense benefits of successful irrigation that mostly improve the livelihoods of many households, there are also various **challenges associated with (the implementation of) irrigation** (***sub-question b***). In Ethiopia the main reasons that challenge irrigation or its implementation found in the reviewed literature are related to financial resources, cultural factors, water allocation and dams, design, planning and maintenance, policy environment, environmental impacts, location, and employment.

An important factor for irrigation are **financial resources**. Many smallholders often cannot afford irrigation systems without external support (Cochrane & Thornton, 2021; Kidane et al., 2022). Additionally, costs for introducing irrigation are higher in African regions then elsewhere, as materials, devices, and expertise often have to be imported, which also creates a high degree of dependency (Aberra, 2004). Furthermore, missing reimbursements or lack of other financial compensation due to dam projects can subsequently lead to an increase in poverty (Eguavoen & Tesfai, 2012). Moreover, there are differences in the financial benefits farmers can obtain from irrigation. Better-off households tend to benefit more, due to more land and better access to resources and higher quality materials (S. Eshetu et al., 2010). Poorer households often cannot afford the cost of water and the acquisition of pumps and they often have less knowledge of improved agricultural practices, all leading to a lower income (than better-off households) (S. Eshetu et al., 2010). In this context, the government's (financial) support seems to play a key role as it can support households in sustainably improving existing livelihoods or in creating a new livelihood, either in urban areas (rural-to urban migration) or in rural areas with a different plot of land (rural-to-rural migration). Also, the (financial) benefits of irrigation are often overestimated as the economic potential is assumed to equate the hydrological potential, which is often not the case (Aberra, 2004). Specialized experts as well as higher quality research and assessments could be helpful here but may not always be available and/or affordable, especially for smaller projects.

Cultural challenges often arise in the context of irrigation and migration, particularly in the construction of dams and diversion of waterways. With current designs, benefits through irrigation are often created at the expense of indigenous and/or pastoralist communities and they are often not considered well enough in decision-making processes. They highly depend on environmental resources, which makes them more exposed to the environmental damages caused by irrigation- and dam projects (Aberra, 2004; Hodbod et al., 2019; Nyssen et al., 2018). Additionally, they may lose access to their key water resources due to large-scale irrigation schemes (Headey, Taffesse, & You, 2014). Pastoralists are often forcible settled in the course of introduction of large-scale irrigation schemes, which undermines their traditional expertise and knowledge in coping with climate change and subsequently increases their vulnerability to effects of CCV (Gebresenbet & Kefale, 2012). As pastoralists make up an important part of Ethiopia's population (around 10 to 12 % that inhabit around 60 to 65 % of Ethiopia's land mass (UNICEF, 2019)) the importance for the country of their livelihood security should not be underestimated. If their traditional ways of life are undermined in too great extent, so that they are no longer able to independently sustain their livelihood, the country could be confronted with a far-reaching problem of poverty. Accordingly, it can be of great benefit to the country if pastoralists have good conditions for a sustainable and secure livelihood. Not least because they also have a very vast and ancient knowledge, passed down through many generations, of how to deal with environmental influences. Therefore, if pastoralists are better involved in processes and decision-making, this could lead to a better understanding and integrity of this community, which can be beneficial for the rest of the country.

Water allocation and inequities in water distribution due to **dams** pose a main challenge of irrigation. Large-scale irrigated plantations and other large water users often receive most access to water resources as the need to manage large volumes of water is rated more important than to ensure water access for smallholders (Grasham et al., 2022). The lack of sufficient water resources to cover irrigation additionally to the water people need for daily needs, can prevent the possibility of irrigation (Aberra, 2004). Hence, to create a higher incentive for the adoption of irrigation for smallholder farmers, enabling them a more reliable and secure access to water resources could enhance conditions for implementing irrigation is vital. However, water use efficiency is often a factor that limits the area that can be irrigated. Water use efficiency is often challenged by socio-economic factors or policy related issues as well as limitation of technical and human capacity (Eshete et al., 2020). Eshete et al. (2020) have found, that "in most cases where water is saved as a result of the efficient use of technologies, the spare water ends up being used to expand the irrigation area, which results in an increased income for the household" (Eshete et al., 2020, p. 143). This shows that it is important to devote more attention to this topic and to provide access to technological means. However, here the financial constraints are often a crucial limiting factor.

The **location** factor can pose another challenge. Subsequently, they are more affected by water shortages and droughts (Grasham et al., 2022). Regions located downstream of a dam are often affected by water shortages, floods, irregularities in availability, quantity, and quality of water (Aberra, 2004; Hodbod et al., 2019; Nyssen et al., 2018). Unanticipated flooding that regularly destroys yield are another common problem for downstream users (Grasham et al., 2022). If the land along a river is leased to investors, farmers in the area can lose their access to irrigation water (Gebeyehu et al., 2021). Additionally, some areas are simply not suitable for irrigation, due to shortages of water or unfavourable landscape conditions (Cochrane & Thornton, 2021). The lack of knowledge for a more sustainable water management is often a major constraint to counteract these issues (Nyssen et al., 2018). Educating farmers and all other stakeholders involved on how to sustainably manage water resources as well as introducing different irrigation systems with their advantages and disadvantages (particularly for upstream users) could help to counteract these issues. Generally, it seems of great importance to better regulate the access to available water resources for smallholders and ensure a fair distribution of this resource.

Challenges with irrigation systems also arise due to **design, planning, and maintenance**. When implementing irrigation systems common challenges are delays before or during construction (Eguavoen & Tesfai, 2012; Hodbod et al., 2019), lack of experience in planning an irrigation project (large- or small-scale) (Hodbod et al., 2019), unsound constructions of irrigation canals, and/or use of low quality material (Aberra, 2004). Government projects may fail due to inadequate engineering studies, too tight scheduling, flawed designs, and too little or no involvement of farmers in the entire process (Aberra, 2004). The needed maintenance for (especially) large-scale systems is often omitted due to lack of practical maintenance skills and low work attitudes from national employees (Aberra, 2004). Small-scale irrigation systems often fail due to technical issues and lack of financial means and know-how to properly maintain the irrigation system (Aberra, 2004). In this regard, again, the role of the government seems particularly significant both for large- and small-scale irrigation. Well-structured and coordinated processes, as well as financial resources that can be made available for smallholders do not seem to be sufficient.

Adding to this, the **policy environment**, which includes all aspects surrounding policy-making, seems complicated regarding irrigation. Bureaucratic matters are often complicated due to the distribution of responsibilities in different governmental departments that are required for irrigation, such as water governance and agricultural matters (Aberra, 2004). Making irrigation implementation less bureaucratic and easy to register, poses a relatively easy to realize solution to enable the expansion of irrigation in Ethiopia.

Impacts on the environment can hardly be avoided when implementing irrigation, as irrigation per se is an intervention in the natural environment. However, there are great differences in the type of impact and the scale of potential damage that is caused. General negative impacts of irrigation on water resources can be a decreasing quantity and quality of available water. Environmental damages associated with the construction of dams and their reservoirs can be the destruction of valuable ecosystems (Ruffeis et al., 2008), deforestation and subsequent heat and drought, increase in floods, increased sediment production, and siltation (Hodbod et al., 2019; Nyssen et al., 2018). Environmental impacts can also be due to the abstraction of water that can lead to the decline in lake levels or water scarcity downstream of a dam (Nyssen et al., 2018). Poor construction materials of ponds can lead to higher infiltration rates and higher temperatures lead to increased evaporation rates, which subsequently can be an additional major challenge in water scarce areas (Aberra, 2004;

Bedeke et al., 2018). As also Benonnier et al. (2021) mention, the impacts of irrigation on global and regional water supplies needs to be considered. Water overextraction can cause several additional challenges with high potential environmental and social costs (Benonnier et al., 2021). For future steps, not also irrigation per se, but the different types of irrigation methods need to be considered. Drip irrigation counts as the most efficient yet rather costly irrigation method with higher technical requirements than other methods (Martínez & Reca, 2014). Here, the long-term benefits should be in proportion to the negative impact on the environment and should not have long-term negative effects to future generations. However, this is a great challenge, as it is subjective to the perspective who is benefitting what and when and also poses financial challenges.

Employment in irrigation projects, large-scale irrigated farms, or associated dam constructions offer opportunities but also pose several challenges. Large-scale irrigation projects create many jobs and substantial income (Headey, Taffesse, & You, 2014; Nyssen et al., 2018; Ruffeis et al., 2008). However, most of these jobs are short-term seasonal contracts with poor employment conditions, such as missing or low standards of healthcare (Minten et al., 2020) and taken by migrant workers, particularly from the Ethiopian Highlands, instead of the local population (Headey, Taffesse, & You, 2014; Hodbod et al., 2019; Nyssen et al., 2018). The created income mainly goes to government workers or investors in commercial agriculture (Nyssen et al., 2018).

Governmental interventions could improve circumstances of different mentioned challenges. Options may comprise for instance, to avoid unequally distributed financial benefits, overcome inequities in the allocation of land and water resources, improve planning processes with active involvement of the population (farmers, local population living near projects, as well as pastoralists), or reduce negative environmental impacts through guiding policies. The implementation of specific education and trainings on sustainable water management, irrigation practices, maintenance of irrigation systems, and environmental issues could additionally counteract many of the above-mentioned challenges. Also, financial support of smallholders for the acquisition of irrigation systems can contribute to food security and security of livelihoods. Through the analysed literature it seems, that not only governmental support is an important factor in the application of irrigation, but the location also plays an important role concerning the geographical potential (landforms) and natural environment (resource availability).

As the results show, irrigation can have a substantial impact on the socio-economic situation of a household. The **ways in which the introduction of irrigation and its potential socio-economic consequences influence migration behaviour/patterns** (***sub-question c***) are addressed below.

The reviewed documents indicate that the successful implementation of irrigation can prevent distress out-migration due to increased agricultural productivity (Ayele & Degefa, 2020;

Etana et al., 2022; Fried & Lagakos, 2021). The likelihood of out-migration tends to decrease if access to irrigation water is available (Ayele & Degefa, 2020). For farms that have installed irrigation systems, failure of these systems or the inability for irrigation due to longer periods of droughts that would make irrigation unviable, can lead to an increased need for migration to find employment elsewhere (Cochrane & Thornton, 2021; S. Eshetu et al., 2010). Generally, if irrigation and other in-situ adaption strategies fail or are not sufficient, migration as adaption strategy due to economic difficulties becomes inevitable (S. Eshetu et al., 2010). This is also the case for (mostly poorer) households that do not have access to irrigation and are dependent on rainfall who then use migration as income diversification as adaption strategy to counteract food insecurity or general poverty (S. Eshetu et al., 2010). However, the successful implementation of irrigation that is likely to create a higher and more consistent income enables families to provide their children with (better) education in urban areas while there is no or less of a need for the entire household or members of a household for rural (distress) out-migration (Cochrane & Thornton, 2021; F. Eshetu et al., 2023). Additionally, the opportunities for skilled labour to rural areas can be improved (Cochrane & Thornton, 2021). In summary, it can be stated, that the availability and the successful operation of irrigation directly affects migration, either in reducing the need for distress out-migration or in enabling migration for reasons of education or high-skilled labour. This is also confirmed by Benonnier et al. (2019) who find, that the access to irrigation offsets the climate-migration poverty trap effect (meaning, that higher temperatures reduce incomes, blocking the ability of emigration in low-income countries) due to the protective effect of irrigation on crop yields.

These findings are also in accordance with a study from Fishman and Li (2022) about drought induced international migration from Mexico. Here, they underline that the response from farming households to drought shocks is different to those of non-farming households. "Migration by non-farming households does not display statistically significant increases in drought years." (Fishman & Li, 2022, p. 10). Whereas farming households respond to drought shocks in the main agricultural growing season with international migration. However, they conclude that irrigation reduces this effect significantly.

Further, as most workforce at large-scale irrigation schemes is needed seasonally (in Afar: 70.000 temporary positions; 4.800 permanent positions), these positions often attract labour migrants, who only come for certain time periods (Headey, Taffesse, & You, 2014), despite poor employment conditions and low wages (Minten et al., 2020). In contrast to the local population, labour migrants mostly benefit from the additionally employment opportunities (Headey, Taffesse, & You, 2014). However, as the successful implementation of irrigation enables the likelihood of higher yields, additional workforce is needed at the respective farms. Many farmers rely on the short-term contracts and profit from the seasonal migrants as they could not afford to offer permanent employment (Minten et al., 2020). The reviewed literature suggests, that despite poor contract conditions, labour migrants are still among the beneficiaries of irrigated agriculture (Hodbod et al., 2019; Nyssen et al., 2018). However, the largest share of the high profits from large-scale irrigation projects go to investors and project leaders. Also, the government often benefits considerably from irrigation projects, especially if dams are constructed that also produce hydropower (Hodbod et al., 2019). To ensure a safe and fair working environment, improving the contract conditions (such as adding healthcare, increase salary, better equipment) could contribute to an overall fairer system.

As the fourth sub-question of this thesis concerns **the types of migration that are associated with irrigation** (***sub-question d***), its answers are in many ways also linked with the other research questions. Also, some types of migration are difficult to strictly differentiate, as rural-to-rural migration can also imply labour migration for example.

Rural-to-urban migration is a common form of migration for livelihood diversification. As elaborated in the previous sections, reasons can be education or high-skilled labour due to increased income from irrigation. Other kinds of labour as well as resettlements or displacements due to dam projects or investments of the reimbursements of these in urban properties can also be reasons for people to migrate to urban areas.

Further, the availability of irrigation can lead to **rural-to-rural migration** by attracting farming households to migrate to these areas, particularly if combined with enhanced overall agricultural conditions (Etana et al., 2022).

In many regions in the highlands of Ethiopia, **out-migration** has become a major pathway out of poverty. The absence of irrigation and improved land and water management systems has caused population pressures in the moisture-reliable highlands, which led to poverty and subsequent distress out-migration (Dorosh & Mellor, 2013), mainly to areas with large-scale irrigated farms (Dorosh & Mellor, 2013; Nyssen et al., 2018).

Generally, **labour migration** is one key strategy to widen a household’s income base. In Ethiopia, seasonal labour at the profitable, large-scale irrigation projects allocated to sugarcane production is particularly common (Headey, Taffesse, & You, 2014). It was noticeable that four reviewed publications included the migration of people from the highlands to different agricultural areas of Ethiopia (Hodbod et al. (2019), Lower Omo Valley; Nyssen et al. (2018), Beles Valley bottom; Behnke and Kerven (2011), Awash Valley; Headey, Taffesse, and You (2014), Afar region). The dependency on migrant workers can have negative impacts on financial investments from investors, as there is less guarantee, that workers, even if they do not come from far, reliably appear at the workplace.

Further, the introduction of large-scale irrigation projects often comes with forcible **settlement** of pastoralists, that are subsequently often faced with a higher vulnerability to climate change (Gebresenbet & Kefale, 2012). Another factor for resettlement or settlement is the high need for additional farmers to cultivate the area in newly implemented irrigation projects and laborers for construction purposes. In some cases, new villages are built for the additional needed people (Nyssen et al., 2018).

Displacement and **relocation** in development projects aimed at the extension of irrigation and hydropower production have history in Ethiopia (Eguavoen & Tesfai, 2012; K. Kebede, 2009). Several types of migration can be observed due to the construction of dams, also called **dam-induced displacement** (K. Kebede, 2009). This can affect entire communities, villages, or single households. People get displaced because their land is in an area needed for the dam or its associated reservoir, canals, or streets (Eguavoen & Tesfai, 2012). Farming households are affected very differently by these projects, which has been discussed above. Additionally, the relocation can lead to conflict between the displaced people and the local population (Teweldebrihan et al., 2020). Areas often also experience an increase in immigration due to increased job opportunities and change in the availability of natural resources elsewhere due to the dam project (Hodbod et al., 2019).

Another factor regarding migration that can be associated with irrigation is **non-migration**, as the successful implementation of irrigation can prevent distress out-migration. This is often combined with migration of some household members due to reasons of education or high-skilled labour, while the other members of the household can remain at their place of residence.

As was shown, irrigation is linked with many types of migration for various reasons. Generally, the possibilities of migration always depend on the given infrastructures, both at the place of (possible) destination and at the place of origin. However, it seems that a distinction must be made between distress migration due to economic hardship and migration that is enabled due to increased income serves for further education or skilled labour. The latter seem to need less or no governmental support, while people migrating due to situation of crisis often are not able to sustain themselves. Additionally, the more people migrate from rural areas, where they lived on subsistence farming or were involved in agricultural activities in general, to urban areas, the more food needs to be produced for urban areas by the people remaining in the agricultural sector. In their study on the role of irrigation in long-term migration trends and rising temperatures Benonnier et al. (2021) find that, the access to irrigation offsets effects on internal migration, particularly on rural-to-urban migration. However, they fail to find that this is also true for international migration. They argued for a detailed, single-country research to study impacts of alternative adaption strategies on internal and international migration. As this thesis also confirms, access to irrigation impacts rural-to-urban migration, while there was no specific evidence or linkage found in the reviewed literature between the effects on international migration.

Therefore, one goal of governmental actions could be to improve situation in rural areas in a way that agricultural households do not have to leave and that they can (continue to) be largely self-sufficient.

This leads to the **challenges associated with migration connected with irrigation** (***sub-question e***). Generally, migration has a high potential for conflict that can occur due to various reasons. The types of migration associated with irrigation are often confronted with conflicts between migrants and the local population, as they may receive jobs or even plots of land or are generally benefitting more form irrigation projects while the local population often is not (Hodbod et al., 2019; Nyssen et al., 2018). Cultural differences between the local population and migrants especially occur in rural-to-urban migration due to prejudices, different clothes and behaviour, and a non-welcoming atmosphere (Eguavoen & Tesfai, 2012). Additionally, migrants from rural areas often struggle with adaptation of urban lifestyles such as gender specific distributions or the general less precise role distribution of gender (Eguavoen & Tesfai, 2012). They also have to adjust from subsistence to a dependency on food and labour markets and income in general as (Eguavoen & Tesfai, 2012). This can subsequently lead to additional problems such as alcoholism, prostitution, or general social disruption (Eguavoen & Tesfai, 2012). An increase in migration to rural areas due to large-scale irrigation schemes often also negatively affects the natural environment and can lead to the destruction of valuable ecosystems due to deforestation and an increase in needed resources (Teweldebrihan et al., 2020). Another challenge seems to be the successful reintegration of returnees (Tizazu et al., 2021). It is stressed that the access to irrigation can be a decisive factor that can prevent the need for re-emigration, as droughts are an incisive problem in many regions of Ethiopia. Areas equipped with irrigation are more reliable and enable returnees to produce enough to sustain their livelihood (Tizazu et al., 2021). Here, the government can counteract re-emigration, through enabling people a successful reintegration through access to irrigatable land. Further it seems, that the focus needs to be on the support of rural livelihoods as many involuntarily migrate to urban areas because they are no longer able to sustain their rural livelihoods.

The final sub-question to be answered is **the extent, if any, to which migration has an influence on the introduction and implementation of irrigation** (***sub-question f***). Migration, mostly to nearby towns, can enable farmers to cover the costs associated with the introduction of an irrigation system (Bedeke et al., 2018). Further, extra income from the seasonal migration of one member of a household can enable a household to purchase a water pump which subsequently improves food security and generally contributes to secure the livelihood of a household (Asfaw et al., 2010). Additionally, through the migration of one or more members of a household for a period of time, knowledge and skills can be obtained to improve agricultural productivity in a sustainable way which leads to increased resilience of livelihoods (Etana et al., 2022). Inter-regional migration restrictions and general infrastructure can be a key factor for the successful exploitation of the irrigation potential of an area, as it requires additional work force (Headey, Dereje, & Taffesse, 2014). The dependency of large-scale irrigated farms on migrant workers can negatively impact the investments from investors, especially considering times of political instability or war (Nyssen et al., 2022).

Results from Pilarova et al. (2022) about the effect remittances in the context of irrigation in the Republic of Moldova also shows that additional income obtained from migration can enable the acquisition of irrigation systems. However, in their case, the focus was on remittances and pressurised irrigation systems which represent a narrower focus within the nexus of irrigation and migration.

The influence of migration to irrigation governance, particularly from a gender perspective was investigated by Meinzen-Dick et al. (2022) in Nepal. They conclude that women tend to take over more responsibilities in irrigation sites with male out-migration. In the region, women are involved in system operation, maintenance, water allocation and distribution but in sites with higher male migration share, women are more likely to also be involved in supervising water distribution. In the wake of introducing more irrigation systems in Ethiopia, this development could also be possible. This issue represents a valuable research topic to be explored.

Also here, the government is an important actor. Accessibility to and feasibility of migration are important for households that are dependent on income diversification as adaption strategy. On a long run, facilitated migration conditions can contribute to a sustainably implemented, resilient livelihood. This shows that migration can also be a strategy for smallholder farmers to cover the costs and obtain valuable knowledge for (the implementation of) irrigation and other adaptive strategies they try to implement. Therefore, it can be stated that there is indeed a mutual influence between irrigation and migration, which leads back to the main research question of this thesis.

To what extend and with which key mechanisms is agricultural irrigation in Ethiopia linked with the migration behaviour within Ethiopia and across its borders?

The literature shows that irrigation can impact migration and vice versa. Interestingly, in most of the reviewed literature, irrigation and migration were not mentioned as a connected issue. Due to the missing link between irrigation and migration in the literature, this can be identified as a research gap. They were rather mentioned separately as strategies for mitigation to CCV (Bedeke & Tebeje, 2022; Etana et al., 2021; Gebeyehu et al., 2021; Gezie, 2019; Kidane et al., 2022).

There are various key mechanisms to counteract climatic changes and livelihood vulnerabilities such as livelihood diversification, using drought resistant crop varieties or engaging in non-agricultural activities (N. A. Mengistu, 2022). Both migration and irrigation represent two of the most popular chosen strategies. The adaption strategies households choose to manage with vulnerability depend mainly on a household’s level of wealth and the level of difficulties they are faced with. (N. A. Mengistu, 2022). Additionally, farmers also differ in their vulnerability and ability to manage risk, depending on their capabilities and the environmental situation. Hence, different strategies are chosen. The analysis shows that irrigation, in most cases led to an improvement of the economic situation of farmers and were the main or one significant factor for general improvement of the livelihood situation (Cochrane & Thornton, 2021). Migration of one or more members of a household is also a common strategy for the improvement of the economic situation of a family or household (Asfaw et al., 2010; Bedeke et al., 2018; Etana et al., 2021).

When combining all information retrieved from the reviewed literature it can be assumed that the agricultural increase through irrigation directly affects migration behaviour both, in-migration (increase) and out-migration (decrease). Therefore, it can be stated that irrigation and migration are not only two separate adaption strategies to improve living conditions but are also intertwined in several ways. One key mechanism is the mutual financial influence of irrigation and migration. The likelihood of out-migration tends to decrease if access to irrigation water is available (Ayele & Degefa, 2020). In addition, if the implementation of irrigation and other in-situ adaption strategies fail or are not sufficient, migration may become inevitable (S. Eshetu et al., 2010). Migration can in turn provide the financial means and the knowledge needed for the acquisition, implementation, and maintenance of an irrigation system (Asfaw et al., 2010; Etana et al., 2022). If irrigation cannot be implemented successfully, crops may fail and particularly members of poor farming households are then forced to sell assets and/or migrate elsewhere in search for wage labour (S. Eshetu et al., 2010). As Benonnier et al. (2019) state, this is additionally affected by the climate-migration poverty trap effect which means, that the ability of individuals to migrate is inhibited or unavailable due the decrease in incomes for farmers through higher temperatures. This study was carried out on a global scale and Ethiopia is found in the category of poor countries, which means, that the above-mentioned poverty trap effect is applicable for the country. Fishman and Li (2022) also confirm the positive effect of access to irrigation on migration of farmer in their study on irrigation and drought induced international migration from Mexico. Farmers were more vulnerable to droughts as non-farming households. This was shown. As in drought years, emigration rates were higher for farming households than for non-farming households. Additionally, farmers with access to irrigation were less likely to migrate (Fishman & Li, 2022). This confirms the significant effect, irrigation can have on the vulnerability of livelihoods of farming households and the positive economic consequences that ultimately enable secure livelihoods.

However, the related challenges are also manifold. Through the analysis of the literature, it seems that measures planned to improve economic situations of a region or general living conditions mostly tend to also produce negative impacts elsewhere. Or as Cochrane and Thornton (2021) wrote, "[…] in many cases, development interventions result in opportunities that come at the expense of a minority" (Cochrane & Thornton, 2021, p. 38). A good example for this are dam projects which can also be seen as a key mechanism between irrigation and migration. They enable access to irrigation, create many new employment opportunities, produce a large amount of hydropower, and often lead to an overall improvement in the respective area and beyond. But there are several inequalities and negative impacts that are expressed at different levels. The construction of a dam and the associated reservoir as well as an increased in-migration due to increased agricultural conditions (also due to irrigation) and employment opportunities, can have major constraints on the environment. Deforestation and the destruction of valuable ecosystems were mentioned here which can subsequently lead to an additional increase in temperatures and lack or shortage of resources (soil, water, etc.). For indigenous groups and/or pastoralists, these projects usually mean a drastic change in their way of life. They are (forcible) settled or resettled and often have difficult or no access to valuable natural resources anymore. Some of the occurrent challenges and inequalities may be difficult to avoid. However, some issues could possibly be prevented or remedied. It would take changes at individual and community levels but also at the national level. An important factor are financial means that would need to be made available. As shown in all sections above, policies in favour of indigenous people, pastoralists, and smallholders as well as the environment are lacking, and financial support is often insufficient. Additionally, it is suggested to recognize the knowledge and experience on climate change adaption of farmers as well as pastoralists and indigenous people as this could help to develop context-specific, flexible, and efficient adaption strategies to better built resilience capacity.

7. Conclusion

In view of the ongoing and accelerating climate change, effective and accessible adaption strategies are of utmost importance. Food and water security as well as overall livelihoods are additionally increasingly threatened by effects of climate change and variability, particularly in sub-Sahara Africa. Ethiopia represents an interesting study site, due to the availability of considerable amounts of water, which is the basic requirement for irrigation, but water is not used efficiently. Furthermore, migration and displacements have history in the country. Irrigation represents an important tool as most people in Ethiopia work in the agricultural sector. As the agricultural production in Ethiopia is mostly rainfed, there is a high potential for positive impacts following the implementation of irrigation. In this thesis, the connections between irrigation and migration in Ethiopia have been made visible and further the mechanisms between both topics were elaborated.

The conducted systematic literature review shows that in most cases irrigation and migration are seen as separate strategies. As shown in this thesis, both strategies are connected and are often mutually dependent, even if not directly apparent. This review also showed that the nexus between irrigation and migration in Ethiopia is lacking comprehensive studies. The reviewed literature shows that the availability and the access to irrigation influences the decision to migrate. By providing a comprehensive overview of existing evidence, this thesis and systematic literature reviews in general, are valuable resources for evidence-based decision making in various fields, environmental governance, social sciences, research in general, and policymaking.

Irrigation contributes to a more reliable, more predictable, more sustainable, and more profitable agricultural system for smallholders, which in turn secures their livelihoods, food security, and income. Due to this, irrigation can reduce distress migration and enable migration for reasons of education or skilled labour. Supplementary, additional income and knowledge gained through migration of members of a household elsewhere can enable the acquisition, implementation, and maintenance of an irrigation system. Moreover, migration enables the implementation of large-scale irrigation schemes as labour migrants are needed for the construction of dams and for seasonal work on the large-scale irrigated farms.

Irrigation is an in-situ adaption strategy that reduces the dependence on rainfall. Therefore, it can increase a household's income as well as improve livelihood sustainability while decreasing livelihood vulnerability. Migration can help to diversify a household's income, through the adoption of different economic activities elsewhere.

Despite the many positive impacts that irrigation can have, there are also challenges which should not be neglected or underestimated. In general, irrigation is always an intervention in the natural water balance. Depending on the type of irrigation, large quantities of water are required that may consequently be lacking elsewhere. In addition, soil degradation and erosion may be promoted. Further, high costs for acquisition and maintenance as well as required knowledge and skills represent other basic requirements for the successful implementation of irrigation, that are often not sufficiently available/accessible.

For the sustainable and reliable agricultural development in Ethiopia, irrigation is a vital factor that can contribute greatly to meet the growing food demands. The agricultural area needed for one household is reduced if irrigation is applied which could therefore secure several additional livelihoods. As irrigation can help to reduce poverty and distress migration and improve the overall living conditions, particularly of small-scale farming households it is important to promote and provide government support for its expansion. The improved living conditions directly impact migration behaviour in many positive aspects.

As this thesis has shown, the mechanisms between irrigation and migration are manifold and often consequential to each other, both, in negative as well as positive aspects. Since large areas of fertile land and quantities of water will continue to be needed for agriculture in the future as the world's food supply is highly dependent on these resources, it is important to protect them and therefore use them efficiently and sustainably and to promote appropriate measures in this field. Therefore, it can be stated that this thesis contributes and extends the existing literature through a comprehensive view on the linkages between irrigation and migration in Ethiopia and thus being able to highlight areas where action is needed.

To better understand these intertwined and multidimensional mechanisms that depend on a multitude of different factors, further research regarding the linkages and to identify the key driving factors is needed.

8. Perspectives

“Climate change adaption is a complex and context-specific socio-cognitive and -economic process” (Bedeke et al., 2018, p. 13). As this literature review has shown, the role of the government is crucial in all aspects. Better financial support regarding the expansion of irrigation and more consideration of smallholders as well as indigenous groups or pastoralists as well as improved migration conditions seem to be important factors for overall improved living conditions of the population of Ethiopia. Generally, it is not possible to further expand the implementation of irrigation systems, without the farming households that are to work with and maintain these systems. Therefore, development interventions need to meet local knowledge, skills, information, and resources available to or through the persons concerned as well as their needs. Here it is important to mention, that too much control of development processes, that often tend to alienate people instead of seeing and considering individual needs, can have opposite effects of the desired outcome in the worst case. Therefore, a policy environment that encourages self-initiative and enables self-reliance (particularly for smallholders, pastoralists, and indigenous groups) can be a much higher motivation and key factor for successful implementation of development interventions. Further, a higher value of and greater trust in the knowledge of pastoralists on how to use natural resources sustainably could benefit further development projects.

To ensure a more reliable and secure access to water resources is one of the key factors, that needs to be addressed, to make the process and/or the outcome of irrigation more attractive, predictable, and reliable for smallholders. Water security in general, is one of the greatest challenges of the 21st century that needs to be addressed (FAO & Earthscan, 2013). “In a context of global population growth, urbanisation and climate change, increasingly challenging trade-offs in water security will have to be made. Without explicit consideration of equity, risk and values in these trade-offs, the poor will continue to be marginalised and water security outcomes will remain unacceptably unequal” (Grasham et al., 2022, p. 14). Inequities were striking in all mechanisms found between irrigation and migration. Many may not be inevitable but further research and policies to counteract these inequalities need to be addressed.

Eshete et al. (2020) have found, that “in most cases where water is saved as a result of the efficient use of technologies, the spare water ends up being used to expand the irrigation area, which results in an increased income for the household” (Eshete et al., 2020, p. 143). This shows that it is important to devote more attention not just to the expansion of irrigation, but also and above all to provide access to technological means of water efficient irrigation systems. However, here the financial constraints are often a crucial limiting factor.

Education seems to be another key factor that needs to be addressed more in order to educate people on possible adaption strategies such as introduction and maintenance of an irrigation system or sustainable agricultural practices in general.

Further, promoting access to land, employment (farm and non-farm), irrigation and basic public services such as healthcare and improved infrastructure can help to improve the living conditions of rural communities and subsequently prevent rural out-migration.

The complex and multidimensional mechanisms between irrigation systems and migration does not provide easy answers. Further research needs to be carried out in order to develop implementable strategies to counteract the effects of climate change and variability now and in the future. In further research, it would be interesting to include more of the nexus of food security, irrigation, and migration. Further, as in the study conducted by Meinzen-Dick et al. (2022), the gender dimension of the mechanisms between irrigation and migration can have important societal implications, which need to be explored in the future.

Besides very few studies in other countries or a more general approach by Benonnier et al. (2021) and Benonnier et al. (2019), there is little existing research focusing on the nexus between irrigation and migration. However, as shown in this thesis, this field seems to have great potential in view of accelerating climate change and variability and subsequent increasing difficult living conditions, particularly for smallholders in Ethiopia and potentially beyond. All other literature found regarding this topic, supported the findings of this thesis.

With this thesis, a multidisciplinary perspective showed to have potential to sustainably develop effective strategies to counteract climate change and variability in the future, as useful connections and interactions can be elaborated. Future migration research should therefore aim to integrate a greater variety of other adaption strategies into analysis of climate change migration.

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