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AGRICULTURAL RESILIENCE BUILDING AT THE FARM LEVEL IN MALAWI:

THE RELEVANCE OF INDIGENOUS KNOWLEDGE

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ABSTRACT

Anthropogenic climate change poses new challenges to smallholder farmers in the Global South. At the farm level, science-based adaptation measures, as well as farmers' autonomous responses based on indigenous knowledge, are simultaneously in use. This thesis investigates their linkages by assessing the role of indigenous knowledge for the development of modern climate change adaptation strategies in the form of a case study on the agricultural sector of Malawi. Existing literature in the field is therefore interpreted through the lenses of the capability approach and appropriate technology development. By means of qualitative content analysis, the findings are evaluated with regard to the dichotomy between indigenous and modern scientific perspectives on agricultural resilience building. The results of the study suggest that indigenous knowledge holds the potential to complement modern scientific knowledge on climate change adaptation in terms of providing locally accepted and site-specific inputs and enabling the self-determination and empowerment of farming communities in Malawi. While indigenous knowledge is identified as a resource that augments Malawian farmers' capabilities to assess climate change and climate variability, to perform weather forecasting, and to modify agricultural practices, climate change and poverty undermine the foundations of their capabilities. With climate change threatening the utility of indigenous knowledge, the development of appropriate technologies through indigenous and scientific knowledge co-production, can potentially help Malawian farmers to face the rapid pace of climate change.

Keywords: *climate change adaptation, agriculture, indigenous knowledge, resilience building, Malawi.*

Word count: 17992

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LIST OF ABBREVIATIONS

AHT	Appropriate Hard Technology
AST	Appropriate Soft Technology
AT	Appropriate Technology
CA	Capability Approach
ENSO	El Niño Southern Oscillation
HDI	Human Development Index
IKS	Indigenous Knowledge Systems
ITCZ	Intertropical Convergence Zone
MSKS	Modern Scientific Knowledge Systems
SGH	Skipped-generation Households
SSA	Sub-Saharan Africa
UN	United Nations

1. INTRODUCTION

While Malawi is still recovering from the devastating consequences cyclone Idai has brought about its people and environment in March 2019, discussions on climate change and its impact on the Global South have reached their peak (World Food Programme, 2020; UN 2020b). Cyclone Idai is thereby showcased as a tragic example of what can take place in similarly situated risk areas in low- and middle-income countries all over the world. In Malawi and its neighboring countries Mozambique and Zimbabwe, the cyclone resulted in the loss of over 1000 human lives, the displacement of numerous families as well as the destruction of infrastructure, nature, and livelihoods on an unprecedented scale (Oxfam International, 2020). Critical voices, including scientists, politicians, and activists, increasingly draw attention to the fact that those people who least contribute to anthropogenic climate change, are the ones worst affected (UN, 2020b; Schlosberg, 2012). Even though climatic disasters such as cyclones have always occurred in Malawi, a series of other extreme weather events, aggravated by human-induced global warming, have intensified the effects of cyclone Idai. Persistent drought across Southern Africa had previously rendered the area susceptible to strong winds and intensive flooding (Oxfam International, 2020). Whilst all parts of the Malawian society and economy felt the severe effects of cyclone Idai, it is particularly the rural smallholder farmers and the agricultural sector which suffer essential damage in the medium- and long-term. With fields and livestock being washed away by the heavy rains, markets inaccessible, seed stocks destroyed, pests augmented and weather unpredictable, climatic disasters along with climate change put food security at risk. Despite successful food support from less affected regions within Malawi, large-scale international emergency relief operations, and national attempts to build up adaptive capacity in the smallholder sector, Malawian farmers neither passively rely on external assistance nor resign themselves to the increasing occurrence of climate variability. Knowingly and unknowingly, smallholders across Sub-Saharan Africa have developed a wide repertoire of diverse adaptation practices and technologies at the farm level. The formulation of proactive adaptation strategies for Malawi’s agriculture, based on locally appropriate compositions of indigenous and modern features, is a key element to enable sustainable development and livelihood security for the population at large (Magombo et al., 2012; Zulu, 2017; Baulch, 2019). Under the new realities of climate change and the associated uncertainties for farmers in developing countries, the notorious debate between proponents of scientific knowledge and advocates of indigenous knowledge for development, gains new elements. With every disaster, new opportunities to manage and debate resilience building arise.

1.1 RESEARCH PROBLEM AND SCIENTIFIC RELEVANCE

Smallholder farmers in Malawi highly depend on biodiversity, land, and water as resources for their livelihoods. As a consequence, the well-being and food security of rural communities are conditional on climate. With climate variability being naturally quite high and socio-economic challenges persistent in rural areas, Malawi's farming sector is particularly vulnerable to the consequences of human-induced climate change and lacks adaptive capacity. The farmers' reliance on rain-fed, low-input, and small-scale agriculture aggravates the adverse effects of climate change (Winthrop & Kajumba, 2018). While the government and international organizations increasingly take efforts to augment the resilience of the agricultural sector and farming communities in the face of climate change, Malawian farmers who already experience climate variability, autonomously adjust by means of diverse coping and adaptation strategies (Zulu, 2017). Modern scientific approaches as well as indigenous strategies, with the purpose of adapting agriculture to climate change, are thus both in use at the farm level in Malawi. Autonomous adaptation is predominantly based on indigenous knowledge. The benefits of farmers' knowledge in contributing to modern scientific adaptation strategies are increasingly recognized in recent times (Mafongoya & Ajayi, 2017: 309). In Sub-Saharan Africa, there exists a lack of research on the integration of indigenous knowledge into modern climate change adaptation due to a "disconnect between climate science and African agriculture" (Ziervogel, 2008: 3). For the case of Malawi, scholars have dealt with indigenous as well as modern adaptation in the farming sector but studies on their correlations and discrepancies under the new realities of climate change are limited. Anthropogenic climate change is beyond the experience of indigenous farmers and heightens the demand for locally relevant, proactive, and sustainable adaptation strategies to raise the adaptive capacity of the agricultural sector in Malawi (Nkomwa et al., 2014). Therefore, the role of indigenous knowledge needs to be assessed in comparison with modern scientific knowledge for the elaboration of effective adaptation approaches based on the best available knowledge (Moyo, 2010; Mafongoya & Ajayi, 2017: 310).

1.2 RESEARCH AIM AND RESEARCH QUESTIONS

This thesis generally seeks to understand the field of agricultural resilience building under the new realities of climate change in the Republic of Malawi. The specific purpose of the thesis is to evaluate the role of indigenous knowledge systems for climate change adaptation in the agricultural sector of Malawi. The potential of indigenous skills and know-how for the development of proactive modern adaptation strategies will thereby be assessed through the lenses of the capability approach and appropriate technology development. As there exists a lack of research on the comparison between local and modern adaptation strategies in the face of increasing climate variability, the study attempts to contribute to narrowing that research gap in the form of a case study on Malawi. It is thus the aim of this study to connect findings of existing literature on climate change adaptation in Malawi by analyzing the dichotomy between indigenous and scientific elements. Within the scope of this thesis, it is therefore pursued to answer the following central research question which is specified through three concrete sub-questions:

What role does indigenous knowledge play for the development of modern climate change adaptation strategies in the agricultural sector of Malawi?

What are the synergies and tensions between indigenous and scientific knowledge in climate change management at the farm level?

To what extent are indigenous farmers capable of adapting to increasing climate variability in Malawi?

How can indigenous knowledge contribute to the development of appropriate technologies for agricultural resilience building in Malawi?

It is the ambition of this thesis to provide inputs for further research on the significance of indigenous knowledge for the development of locally appropriate and proactive climate change adaptation strategies in the farming sector of developing countries.

1.3 DEFINITIONS IN CLIMATE CHANGE MANAGEMENT

The sensitive field of study around climate-related risks comprises a variety of multi-faceted concepts. In order to ensure clarity about the terminologies adopted in this thesis, the most relevant concepts, and their definitions in context to agriculture are presented below.

Climate change describes long-term changes in average weather conditions as well as human-induced shifts in climate systems (FAO, 2008). Human activities, including agricultural activities, cause long-term changes in climate and weather patterns due to increasing greenhouse gas emissions in the atmosphere (FAO, 2012). ***Climate variability,*** which refers to variations within a climate system, worsens under climate change. Within this thesis, the term climate variability is used as a component of climate change and not as a distinct concept from human-induced climate change.

Adaptation measures address the impacts of climate change and climate variability on ecosystems and societies. The aim is to lower the vulnerability of natural and human systems by making adjustments in the face of current or expected climate change. Agricultural adaptation can be based on specific actions at the farm level or long-term systematic changes in the form of institutional reforms. ***Mitigation,*** on the other hand, deals with the causes of climate change. Reducing greenhouse gas concentration in the atmosphere is the primary objective of mitigation efforts (FAO, 2012; FAO, 2008). In comparison to the world average of 4.981 metric tons of CO2 per capita, emissions in Malawi are relatively low with 0.078 metric tons of CO2 per capita in 2014 (World Bank, 2020b). For this reason, and with mitigation measures being limitedly implemented in Malawi, the focus of this thesis lies on adaptation.

In the absence of adaptation and mitigation activities, climate-related ***vulnerability*** in the developing world is high. Vulnerability is defined as the degree to which a system is sensitive or unable to cope with the adverse effects of climate change. Two dimensions of agricultural vulnerability are apparent in Malawi. While agriculture is particularly vulnerable due to its augmented dependency on rain, the Malawian population is vulnerable as their livelihoods highly depend on farming. The concept of vulnerability stands in direct relation to the socio-economic and biophysical characteristics which are outlined in *section 4.1* followed by a detailed presentation of agricultural vulnerability in the Malawian context in *section 4.2*. By raising agricultural vulnerability, climate change puts ***food security*** at risk. In Malawi, the climate is a critical determinant for food security as industrial agriculture, diversified non-agricultural livelihoods, as well as long-distance marketing chains, are limited. Not only the production of food is impacted by climate change but also food access, food distribution and food affordability for all consumers in Malawi are at stake. The consequences are malnutrition, hunger, and dependency on imported foodstuff (FAO, 2008; Connolly-Boutin & Smit, 2013). Food security is defined as the state "… when all people at all times have physical or economic access to sufficient safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2008: 3).

Food security can be warranted by increasing the ***resilience*** of farming systems. In ecological terms, the concept of resilience is defined as the degree to which a system can cope with disruptions before changing its structure (Miola et al., 2015). With regard to agriculture, resilience describes the coping range to which farmers can handle fluctuating weather conditions without significant yield losses. Outside that coping range, agriculture is unable to absorb disturbances such as extremely high temperatures or unfavorable precipitation and is therefore referred to as vulnerable. In order to improve the resilience levels of the agricultural sector, high adaptive capacity is essential. ***Adaptive capacity*** describes the ability of a system to adjust to climate change and climate variability, to cope with the consequences of climatic disasters, and to alleviate potential losses (FAO, 2012). Determinants of adaptive capacity in the agricultural sector include agricultural infrastructure, technology, land rights, farmers' education as well as equal access to resources (Miola et al., 2015).

1.4 THESIS OUTLINE

Subsequent to this first and introductory chapter, the conceptual framework in regard to understanding indigenous knowledge systems will be introduced within the scope of chapter 2. A literature review follows in chapter 3, consisting of a discussion about the dichotomy and overlaps between scientific knowledge and modern knowledge in literature as well as previous research on indigenous knowledge in climate change adaptation and agriculture in Sub-Saharan Africa. The background information is laid out in chapter 4 and deals with Malawi's risk profile in terms of biophysical and socio-economic stressors as well as vulnerability in the agricultural sector. Chapter 5 presents the methodological approach, followed by the analysis in chapter 6 including findings and discussion. Finally, the research questions are answered and recommendations for further research are given in the concluding chapter 7.

2. CONCEPTUAL FRAMEWORK: UNDERSTANDING IKS

The following chapter presents the conceptualizations which are applied to answer the previously introduced research questions of this study. The conceptual framework rests upon a combination of perspectives that demonstrate the role of indigenous knowledge systems for development. Through the lenses of the capability approach and appropriate technology development, indigenous knowledge and its value for climate change adaptation can be interpreted and allows for a comparison with scientific knowledge.

Indigenous people worldwide are the most vulnerable to even slight variations in climatic conditions, but they possess a unique resource to address the impacts of climate change: Indigenous Knowledge Systems (IKS) comprise the know-how and skills local people in a certain location have accumulated over generations. Developed through specific ecological, sociological, geographical, and climatic conditions, IKS form the information base of a society. IKS are further considered as the social capital which guides societies to ensure their survival. Based on centuries of experience, indigenous communities rely on IKS to conserve their environment and production systems. Acquired through observation and practice, indigenous knowledge is deeply embedded in the culture of communities worldwide (Mafongoya & Ajayi, 2017: 16-18; Tharakan, 2015). IKS are locally distributed through oral transmission and recording in the memories of community members (Islam, 2013). The terms traditional knowledge, local knowledge, indigenous knowledge, and farmers' knowledge are used as equivalents to IKS in this thesis.

Advocates of indigenous knowledge argue for development strategies to focus on local and cultural contexts in order to secure the livelihoods of traditional societies based on their particular needs. Hence, the concept of indigenous knowledge aims to consider the multiplicity of groups and to incorporate farmers' perceptions and needs in the development process rather than using standard economic indicators to measure development. Participatory and inclusive approaches resting on indigenous groups' knowledge and practices are seen as the guidelines of IKS. Indigenous knowledge is thus not regarded as a hindrance to development but as an opportunity (Pfeifer, 1996). The conceptualization of IKS is thereby strongly associated with the notions of empowerment and sovereignty. Even though patterns of IKS are apparent within different indigenous communities, the transfer of traditional knowledge is not a homogenous process but varies with experience, age, gender, occupation, and power status between individuals (Magni, 2016). Hoppers (2004) notes that indigenous knowledge evolves in a constant process of adjustment to changing societal conditions and environmental circumstances. In Hoppers' words, IKS refer to "the totality of all knowledges and practices, whether explicit or implicit, used in the management of socioeconomic, spiritual and ecological facets of life" (Hoppers, 2004: 2) and can hence be contrasted with global scientific knowledge (Hoppers, 2004).

2.1 INDIGENOUS KNOWLEDGE AND THE CAPABILITY APPROACH

Significantly developed by the economist Amartya Sen, the Capability Approach (CA) is a normative theory mainly applied in development studies. It claims that people's freedom to achieve well-being is to be interpreted in terms of their respective capabilities. Capabilities are referred to as people's opportunities to be and to do based on what one has a reason to value (Sen, 1999: 87). Such 'beings and doings', within the meaning of various states and activities people can undertake, are termed 'functionings' and present a central concept of the CA. Thus, capability is a person's ability to attain functionings. 'Being resilient to climate change' is one example of such a functioning and used within this thesis to understand the impacts of IKS on Malawian farmers' capabilities to attain that functioning. Overall, there exists a wide range of functionings and capabilities as human diversity is a significant aspect of the CA.

The emphasis on human diversity is also apparent in the recognition that unique profiles of conversion factors exist. Within the CA, a conversion factor is referred to as the degree in which a resource can be converted into a functioning. Different personal, social, and environmental conversion factors hence mediate people's capabilities (Robeyns, 2011). Climate is one example of a conversion factor. Sen (1999) states that "variations in environmental conditions, such as climatic circumstances … can influence what a person gets out of a given level of income" (Sen, 1999: 70) and hence constrain peoples' capabilities and freedoms. According to Sen (1999), development involves the elimination of sources of unfreedom which can relate to economic poverty, the absence of effective institutions, or a lack of recognition and participation (Sen, 1999: 3-4, 87-88; Schlosberg, 2012).

Sen (1999) regards the free agency of people as the primary engine of development (Sen, 1999: 4, 18-19), which implies that the selection and weighting of capabilities should be based on participatory approaches (Robeyns, 2011). The CA hence highlights the necessity to refocus development on people and what they are capable of by means of the resources they have access to. Sen defined his approach as a general framework that can be combined with other theories and applied to a variety of cultural contexts instead of providing a specific list of capabilities. He thereby emphasizes the involvement of people in their own development as well as the freedom of people to define which capabilities are most valuable in particular local circumstances. Gigler (2005) argues that indigenous people are best suited to define their own capabilities and development objectives (Gigler, 2005).

Within Sen's capability approach, indigenous knowledge can be regarded as a resource obtained from a social network to achieve functionings (Bertin & Sirven, 2006). The CA regards resources as the means to capabilities (Robeyns, 2011, Kronlid, 2014: 33). IKS and CA both criticize an overemphasis on material aspects and stress the importance of basing development on cultural diversity, traditional knowledge, and the worldview of indigenous communities. On account of these similarities, Gigler (2005) regards the capability approach as particularly suitable for evaluating the development of indigenous people. The strong collective indigenous identity urged traditional societies to put emphasis on strengthening their capabilities (Gigler, 2005; Bertin & Sirven, 2006; Sen, 1999: 3). As it is argued by Schlosberg (2012), a broad interpretation of the CA, in terms of taking into consideration environmental factors, offers a particularly suitable way to understand individual local vulnerabilities and the impacts of climate change on the well-being of communities in order to establish what adaptation should look like under specific conditions (Schlosberg, 2012).

2.2 INDIGENOUS KNOWLEDGE AND APPROPRIATE TECHNOLOGIES

Appropriate Technology (AT) development has evolved as an approach dealing with development at the community level and presents an alternative to technology transfer from developed to developing countries. As an ideological movement, AT addresses the cultural and social dimensions of innovation. It involves culturally sensitive, people-centered, environmentally sustainable, and locally controlled ideas and practices. Hence, technology is considered "appropriate" if it is consistent with the economic, cultural, and political institutions of the society in which it is applied. According to Akubue (2000), AT has the potential to improve the level of technology as well as the capabilities of traditional communities (Akubue, 2000). IKS can thereby play an essential role in the form of context- and culture-specific technology and knowledge resources. The profound nature of indigenous knowledge in terms of sustainability and local appropriateness calls for its integration into AT development

(Tharakan, 2015). AT advocates refer to technology as a heterogeneous combination of different social and technical options while emphasizing the importance of technology for tackling development challenges. Advanced technologies and alternatives such as technologies based on indigenous knowledge are evaluated for a particular context in order to reach AT solutions based on a “best fit model” (Akubue, 2000).

AT uses domestically available materials and resources and thereby causes little cultural disruption (Hazeltine, 2003). Appropriate technologies are not only intensive in the use of locally produced inputs and abundant factors but economical in the use of scarce factors and highly trained personnel. Hence, AT is highly compatible with the existing factor endowments whilst enhancing people’s well-being (Akubue, 2000). Amiolemen et al. (2012) distinguish between the categorizations of Appropriate Hard Technology (AHT) and Appropriate Soft Technology (AST). AHT comprises physical structures, engineering techniques, and machinery which meet the defined needs of local communities. Social structures and human interactive techniques that bring about change, such as groups’ decision making and the implementation of choices based on prior analysis, are referred to as AST.

A further important aspect of AT is that it is easy to maintain and durable in its utilization for the local population. At the center of AT stands the perspective of sustainability and environmental conservation. In the face of climate change, minimizing pollution and adapting vulnerable groups to climatic disasters whilst simultaneously fostering socio-economic development are stated as the objectives of AT. The application of indigenous technology in consideration of the resource threshold and eco-efficiency are in the focus of AT. For instance, the implementation of the AT concept in agriculture can protect soils and agricultural productivity from the adverse effects of climate change. Without being wasteful, AT thus remains community-oriented and people-centered (Amiolemen et al., 2012).

The AT concept, as a variant of endogenous technology development, stands in close conjunction with the concept of IKS. Tharakan (2015) outlines the interrelationship between IKS and AT. It becomes apparent that successful AT implementation requires respecting the socio-cultural context and the local understanding of problems that are part of IKS. The consideration of indigenous knowledge in all processes of AT development is thereby essential for the full integration of the local community into operation and management. With regard to local knowledge’s characterization as “people’s science”, the recognition of IKS as an intellectual resource base for technology development in combination with modern science, is significant for climate change adaptation and agricultural resilience building (Tharakan, 2015).

3. LITERATURE REVIEW

This chapter firstly presents existing literature on the discussion about the dichotomy and overlaps between global scientific knowledge and local indigenous knowledge based on modernization and its critics. Thereafter, the findings of previous studies on IKS in Sub-Saharan Africa with respect to climate change adaptation and agriculture are introduced.

3.1 GLOBAL KNOWLEDGE VS. LOCAL KNOWLEDGE

With the process of globalization, the invasion of foreign development concepts began to put IKS at risk to gradually disappear as they were perceived as backward and static (Moyo, 2010). Often referred to as a distinct approach from indigenous knowledge, modernization theory presents a different angle to explain issues of development and regards global scientific achievements as generally valid knowledge. Modernization theory emerged by mid of the 20th century in response to the process of decolonization (Pfeifer, 1996, Sillitoe, 2007: 1-4). As described by the renowned economist Rostow, modernization regards development as a predetermined uniform route which all societies follow to turn from traditional into postindustrial societies. Socio-economic development, secular and democratic political structures, a market-based economy, and formal education are regarded as the guiding principles of modernization.

Within modernization theory, global science is viewed as a tool to fast-track development for less developed countries by importing know-how and technology from the industrialized world. Science thereby serves as a rational protocol to ensure efficiency in the use of available resources. Hence, modernization does not take into account site-specific knowledge production and locally developed technologies. It rather assumes a development scheme that can be applied to all contexts at all times (Ynalvez & Shrum, 2015). Scientific rationalism in modernization is eventually used to achieve a welfare state based on the Western model (Gilman, 2018). Modernization regards science as technical capital from the developed world for developing countries. Scientific methods and skills are transferred to the Global South to serve as catalysts for development. Modern climate change science represents one form of such scientific knowledge and technology (Ynalvez & Shrum, 2015). By contrast to IKS, Modern Scientific Knowledge Systems (MSKS) are derived from international scientific research and acquired through formal education (Tharakan, 2015).

Although hardly any scholar would refer to themselves as modernization theorists today (Gilman, 2018), modernization theory is not dead but extended in different directions. Various sub-fields which confirm the original modernization paradigm, have developed in recent decades. Ecological modernization theory, including modern climate science, has emerged as such a new concept in the 1980s and initially focused on the advanced developed countries (Marsh, 2014). With the pressure of climate change challenges, different forms of ecological modernization emphasize the role of technology and innovations as a perspective towards sustainable development based on climate change science. Opponents of the ecological modernization conceptualization criticize that developing countries and their respective economic, political, and social systems such as IKS are not considered (Ahmed, 2015).

A variety of epistemological, political, and ideological criticisms take issue with the conceptualization of modernization. Critics argue that development approaches based on modernization ignore the utility of indigenous knowledge and do not incorporate the perceptions and needs of traditional communities. Proponents of indigenous knowledge criticize modernization for an ethnocentric bias and for undermining indigenous institutions. Local knowledge does in their view not necessarily challenge scientific findings but wants to further inform global science (Sillitoe, 2007: 1). Modernization theorists are further criticized for suggesting a top-down national policy approach fostering unequal distributions of power (Pfeifer, 1996). By contrast, the idea of "development from below" is based on the incorporation of local knowledge. Such bottom-up perspectives were introduced by IKS scholars to call for the preservation of traditional knowledge and to raise awareness for the creation of sustainable and locally appropriate development solutions (Magni, 2016; Sillitoe, 2007: 1-23).

Beginning in the mid-20th century, western scientists' attitudes towards IKS began to change Mafongoya & Ajayi, 2017: 16). Today indigenous knowledge is recognized as a "complete knowledge system with its own concepts of epistemology, and its own scientific and logical validity" (Battiste, 2002: 7). In recent years, IKS are increasingly addressed in studies in the fields of environmental conservation, land use, natural resource management, and above all, climate change adaptation and mitigation (Magni, 2016). The value of indigenous and local knowledge has been recognized and demonstrated in the domain of natural disaster preparedness and response (Nakashima, 2015). Thereby, it is important to note that IKS are not static but are impacted by non-indigenous elements in the form of indigenous response to innovation such as climate change science (Magni, 2016). Sillitoe (2007) argues that scientific logic and indigenous logic possess the same foundations and mechanisms of thought, which challenges the direct comparison of IKS and MSKS and suggests the study of their linkages (Sillitoe, 2007: 2-3). According to Pfeifer (1996), science holds the potential to mobilize indigenous knowledge by means of methods for obtaining, assessing, and presenting IKS. Indigenous knowledge systems and modernization theory share some common features regarding their respective conceptualization. First of all, modernization as well as indigenous knowledge distinguish between the traditional and the scientific. Moreover, both conceptualizations presuppose the existence of a developed/undeveloped dichotomy. The competition over power through knowledge production presents a third similarity between modernization and IKS (Pfeifer, 1996). Nevertheless, the indigenous knowledge paradigm does not necessarily interpret development in the form of increases in modernization, productivity, and financial capital, but rather aims for individual communities to define their respective developmental aspirations and capabilities (Magni, 2016).

3.2 THE STUDY OF IKS IN SUB-SAHARAN AFRICA

Even though debates and deliberations around local knowledge are ever-present, the practical implementation of indigenous knowledge remains marginalized in the international policy arena. However, studies conducted on IKS in Sub-Saharan Africa have increased steadily and many scholars acknowledge the relevance of traditional knowledge. Maluleka and Ngulube (2019) concluded in their research on publication patterns of indigenous knowledge in Africa that journal articles, reviews, book chapters, and conference proceedings dealing with IKS in Africa have been regularly published between 2008 and 2018. They further find that the subject areas of medicine, pharmacology, and agricultural sciences are predominantly represented in those publications (Maluleka & Ngulube, 2019). Ocholla and Onyancha (2005) before likewise observed an increase in agricultural studies on African IKS between 1990 and 2004 (Ochola & Onyancha, 2005).

Indigenous knowledge and its linkages to climate change and agriculture have become a growing area of investigation which has led to a variety of published material in the African context and platforms of different UN organizations (Mafongoya & Ajayi, 2017: 19-21). Overall, the research body on IKS, covering climate change management and agricultural resilience building, has increased significantly but requires further analysis of their interactions in region-specific cases such as Malawi, particularly in synoptic comparison with scientific knowledge.

3.2.1 IKS AND CLIMATE CHANGE ADAPTATION IN SSA

IKS are increasingly recognized as a promising source of climate information and adaptation measures in the field of climate change management (Moyo, 2010; Mafongoya & Ajayi, 2017: 16). The Post 2015 UN Development Agenda acknowledges the relevance of indigenous knowledge for environmental sustainability stating that "traditional and indigenous knowledge, adaptation and coping strategies can be major assets for local response strategies" (UN, 2012: 28). Climate variability does not present a new phenomenon for indigenous people on the African continent. Particularly rural communities in hazard-prone areas have developed an extensive body of knowledge of disaster prevention, early warning systems, disaster response as well as disaster recovery (Mafongoya & Ajayi, 2017: 16-18).

Studies find indigenous people in Sub-Saharan Africa to be particularly vulnerable to the impacts of desertification, extensive droughts, and declines in rainfall. Indigenous populations consequently adapted in various ways to the adverse effects of climate variability and thereby managed to enhance their resilience. Indigenous adaptation and coping strategies vary with ecosystems, livelihoods, and the impacts of climate change from group to group (Magni, 2016). As outlined by Makondo and Thomas (2018), IKS linked to climate change management are never universal but a highly contextualized and context-specific source of knowledge across the African continent (Makondo & Thomas, 2018).

In Sub-Saharan Africa, indigenous communities have lived sustainably with nature whilst using spirituality and taboos as social norms to protect the environment (Makondo & Thomas, 2018). In terms of indigenous mitigation strategies, reforestation, and forest protection present the most dominant forms on the African continent (Magni, 2016).

Mafongoya and Ajayi (2017) summarized existing literature on the role of IKS in the face of climate change by bringing together different experts and researchers, primarily from Eastern and Southern Africa including Malawi. Their book represents the most extensive publication on local knowledge in connection to climate change adaption in the region. The authors identify IKS as an important resource for communities in SSA to adapt to increasing climate variability. Furthermore, they emphasize the need to compare and incorporate IKS with scientific knowledge so that socially and environmentally appropriate adaptation strategies can be found. The advantage of indigenous knowledge in contributing to climate science lies in providing observations and interpretations at a small spatial scale. The close relationship of development approaches based on IKS and participatory development strategies present a further key finding (Mafongoya & Ajayi, 2017: 16, 20-21, 41).

Maldonado et al. (2016) argue that climate change adaptation strategies that ignore the role of IKS can even aggravate the vulnerability of indigenous groups (Maldonado et al., 2016). Nevertheless, anthropogenically induced climate change poses new challenges to IKS in Africa (Makondo & Thomas, 2018).

3.2.2 IKS AND AGRICULTURE IN SSA

With most farmers in Sub-Saharan Africa practicing low-input farming, indigenous knowledge holds essential potential for sustainable agricultural production. According to studies, the utilization of IKS renders agricultural activities in developing countries more productive and ecologically sound (Lwoga, Ngulube & Stilwell, 2010). Because indigenous people and local farmers easily identify with the IKS of their culture, the potential of agricultural adaptation strategies based on IKS to be accepted by farmers is considerable (Mafongoya & Ajayi, 2017: 16).

Local communities adjust their agriculture and farming activities to various kinds of threats such as changes in climate. Indigenous farming systems are hence dynamic by nature and demonstrate a high level of adaptability (Kothari, 2007). In the agricultural sector, IKS are utilized to secure production during unfavorable seasons and to maximize yields under favorable growing conditions (Mafongoya & Ajayi, 2017: 43-44). Farmers' knowledge of the local environment and site-specific crops and livestock performance is irreplaceable and calls for the integration of IKS into agricultural resilience building at the policy level (Moyo, 2010). Across Eastern and Southern Africa, IKS are applied in the development of sustainable vegetable cultivation, the promotion of local seed fairs as well as the formation of agricultural unions. Results show that such initiatives furthered sustainable food production, cultural rights, local empowerment, household food security, and overall productivity (Tharakan, 2015).

National mitigation approaches such as the creation of natural reserves in indigenous areas reduced the possibilities of agricultural activities for local peoples which stands in contrast with the need for increasing agricultural production to achieve food security (Magni, 2016). Moreover, the modernization of agriculture along with the introduction of mechanization and fertilizers has led to decreases in the genetic diversity of crops and livestock. Neglecting IKS in support of modern scientific findings hence poses a risk to genetic resources in the farming sector. In response to these trends, researchers and producers in SSA now re-introduce domestic species to local agriculture and return to traditional practices and inputs (Lwoga, Ngulube & Stilwell, 2010).

4. BACKGROUND

The following chapter enlarges on country-specific background information about Malawi. The biophysical and socio-economic risk profile, as well as concrete vulnerabilities in the farming sector, are described.

4.1 RISK PROFILE OF MALAWI

Diverse biophysical and socio-economic factors mediate Malawi's level of vulnerability and thereby define the country's risk profile which is crucial to understand impacts and responses in the agricultural sector (Zulu, 2017).

4.1.1 BIOPHYSICAL STRESSORS

Occupying a narrow strip of land in between the borders of Tanzania, Zambia, and Mozambique, the landlocked Republic of Malawi is located in the southern part of the African continent. Its position alongside the East African Rift Valley in a tectonically active area makes Malawi vulnerable to earthquakes and landslides. More than one-fifth of the country's land area is covered by Lake Nyasa also known as Lake Malawi which has significant impacts on climatic conditions. Apart from water surface, Malawi's topography is highly diverse ranging from high plateaus in the northern and central areas to mountains in the South as it is apparent in *Figure 4.1*. The Northern, Central, and Southern Region together comprise a total of 28 districts. Woodlands, tropical rainforests, as well as

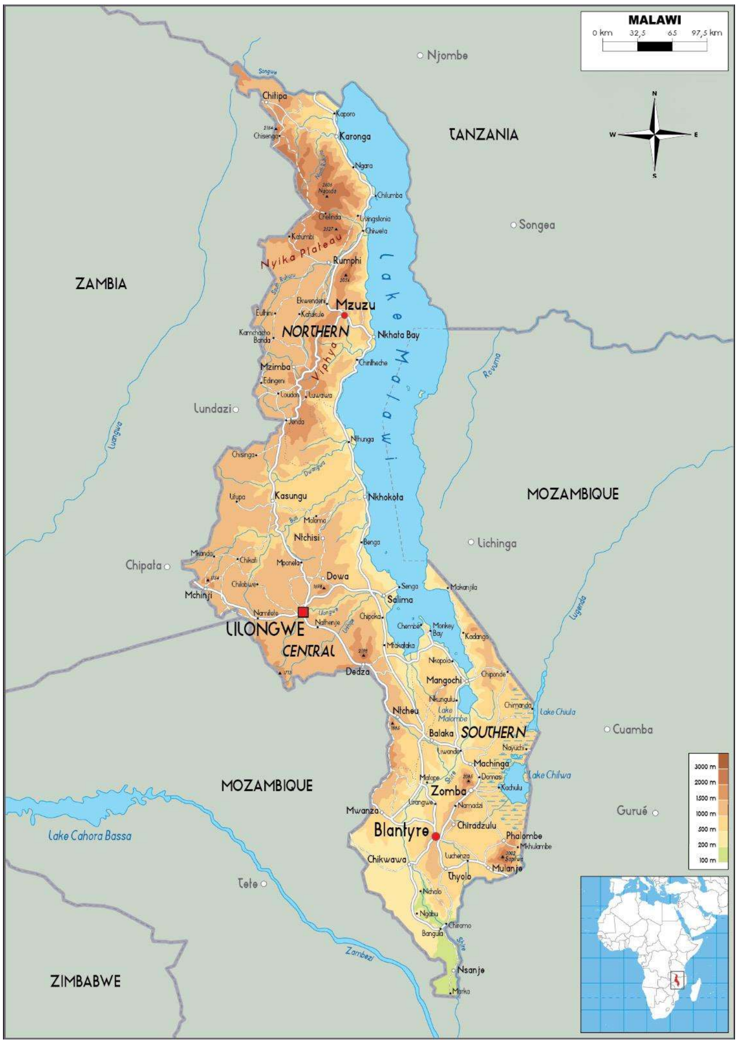

Fig. 4.1 Physical map of Malawi (Worldometer, 2020)

savannah grasslands, make up the variety of Malawian landscapes (UN, 2020a; Saka et al., 2013; McSweeney et al., 2010; Wood & Moriniere, 2013; Government of Malawi, 2019).

Malawi's climate varies with its diverse topography ranging from mean temperatures of 18°C in the coldest months to 27°C in the summer. Temperatures are hence relatively cool even though the country's climate is tropical. Local variations emerge as higher altitudes receive higher amounts of rainfall. Apart from topographical influences, yearly changes in the position of the Intertropical Convergence Zone (ITCZ) cause irregularities in the timing and intensity of the seasons in Malawi. While the hot-wet season usually lasts from November to February up to April depending on the movement of the ITCZ, the cold-dry season presents the second main season whose length equally depends on the ITCZ. Other alterations in the rainy season are impacted by variations in the Indian Ocean surface temperatures which highly differ from year to year. The largest factor contributing to such variations in atmospheric and oceanic circulations is the El Niño Southern Oscillation (ENSO). El Niño conditions lead to above-average rainfalls in eastern equatorial Africa and decreased rainfalls in Southeastern Africa while the opposite conditions occur in La Niña episodes. Due to Malawi's position in between those two regions with opposing responses to the ENSO, weather is exceptionally difficult to predict (McSweeney et al., 2010; Winthrop & Kajumba, 2018, Vincent et al., 2014).

As a result, natural inter-annual, as well as intra-annual variations in climate and weather patterns caused by multiple geo-climatic factors, are already quite high in Malawi. Prolonged dry spells, intense rainfalls, and severe flooding consequently strike Malawi on a regular basis and make the country particularly vulnerable within Sub-Saharan Africa. Although it is not possible to adequately define the limits of natural climate variability in Malawi, human-induced climate change further aggravates climate variability and unpredictability which becomes apparent in an increasing frequency of drought and flooding events perceived by Malawians and recorded by empirical observations in recent years. Climate statistics indicate that the mean annual temperature has increased by 0.9°C between 1960 and 2006 with the highest gains during the hot-wet season and the frequency of hot days increasing. Rainfall variability and intensity have increased substantially. Extreme weather events particularly accelerated since the turn of the millennium. In addition, Malawi is exposed to an occasional occurrence of tropical cyclones or anticyclones (Vincent et al., 2014; Zulu, 2017; Wood & Moriniere, 2013).

Future projections on climate change predict increasing temperatures of 1°C to 3°C by 2050. Uncertainty remains regarding mid-century projections for precipitation in Malawi which range from slight decreases of 25 mm up to increases of 400 mm. Even though studies differ regarding changes in the amount of expected rainfall, significant seasonal and regional variations in precipitation are anticipated. Persistent climate variability between years makes it difficult to establish long-term trends. Hence, research gaps on exact projections of future climate change trends in Malawi remain (Stevens & Madani, 2016; Zulu, 2017; Vincent et al., 2014, McSweeney et al., 2010). Nevertheless, an aggravation of natural climate variations and an increase in mean temperatures as well as extreme weather events are consistently prognosticated by scholars under a business as usual scenario.

4.1.2 SOCIO-ECONOMIC STRESSORS

With expected increases in climate variability, already distressed economic and social systems in Malawi are further strained. While climatic shocks affect the whole region, some factors notably aggravate vulnerability and lower adaptive capacity in Malawi. Holding a Human Development Index (HDI) of 0.485, the Republic of Malawi ranks amongst the poorest countries in the world, positioning at 172 out of 189 countries in 2018 (UNDP, 2020). Despite some improvements in the quality of life, economic indicators, and mean years of schooling since 1990, Malawi's HDI remains below the Sub-Saharan African average of 0.507. Based on the three dimensions of human development, a long and healthy life, economic standards of living, and access to knowledge, Malawi's socio-economic profile is displayed hereafter.

The pace of poverty reduction in Malawi is outstandingly slow, especially in rural parts of the country, where 84% of the inhabitants reside. Over 70% of the Malawian population live below the international poverty line of US$ 1.90 per day (Government of Malawi, 2019; UNDP, 2019). While ultra-poverty rates have declined, moderate poverty rates stagnate at high levels. Rural poverty dominates with about 95% of the poor in Malawi residing in rural areas. Absolute numbers of Malawians living in poverty even increased with rapid population growth being one of the major stressors to the economy and society. The already dense population of about 19 million inhabitants is expected to double within approximately two decades which poses a risk to productivity, farm sizes, and sustainability. With 238 people per km^2 of agricultural land in contrast to an average ratio of 53 people per km^2 in neighboring countries, population density in Malawi is exceptionally high and access to land is declining (Government of Malawi, 2019; World Bank, 2018; World Population Review, 2020). Challenges in the health sector present another major factor impairing development in Malawi. Climate change is proven to intensify the occurrence of diseases such as malaria and cholera. Moreover, maternal mortality rates and child stunting have not been alleviated over the last decade. With an estimated percentage of 9.2% of the adult population infected with HIV or Aids in 2018, Malawi rates among the countries with the highest incidence of HIV/Aids worldwide (Avert, 2020). Due to the high HIV rates, the rate of orphaned children in Malawi amounts to 11%. The ability of orphans to reduce their exposure to climate-induced disasters and to recover from the effects of climate change is strongly limited (Mkandawire, 2018; Government of Malawi, 2019; Magombo et al., 2012). In connection therewith, the prevalence of skipped-generation households (SGH), in which the parent generation is missing and grandparents live with their grandchildren, increases steadily and made up a proportion of 34% in 2015 (UN, 2019).

Malawi's growth performance initially resembled those of other African countries during the years after independence but has fallen behind significantly since 1980. Despite high amounts of foreign aid and the absence of political conflicts, economic growth remains low and macro-economic instability is high. Climate-induced shocks hold back growth in an economy highly dependent on rain-fed agriculture. Evidence suggests that Malawi's stagnating trends in Gross Domestic Product (GDP) growth can be traced back to high climate variability and thereby highlights the country's economic vulnerability to climate change. Economic management and policies respond to external shocks on a short-term basis rather than being proactive. Weak governance and institutions including high levels of corruption further restrain economic development as investments do not encourage sustainability or employment creation. Hence, Malawi's GDP increases slowly, amounting to 389 US$ per capita in 2018 and does not keep pace with growth in demographically and geographically similar developing countries (Stevens & Madani, 2016; World Bank, 2018).

Since the introduction of free primary education in 1994, school enrolment rates in Malawi have increased steadily. However, dropout and repetition rates are high and access to secondary and tertiary education is limited in comparison to regional counterparts. As a result, an adult literacy of 62% positions Malawi below the Sub-Saharan African average of 65% (World Bank, 2018; Government of Malawi, 2019). Climatic disasters further hinder pupils from attending classes as schools are often turned into relief shelters (Mwase, Mtethiwa & Makonombera, 2014). With over 16 spoken languages in Malawi, education and literacy are decisive factors for acquiring language skills in the national language Chichewa and the official language English, which determines socio-economic opportunities (Nishioka & Durrani, 2019).

Together these factors heighten Malawi's exposure to the effects of climate variability and climate change as they create a lack of resources for mitigation and adaptation.

4.2 AGRICULTURAL VULNERABILITY IN MALAWI

As the backbone of the economy and society in Sub-Saharan Africa, agriculture constitutes the focal point of the various biophysical and socio-economic stressors in Malawi. Overall economic growth follows growth trends in the agricultural sector due to strong inter- and intra-linkages to other sectors. Agricultural growth, in turn, depends on climate trends and weather patterns. The share of agriculture to GDP has declined to 30% due to structural transformation processes but remains the dominant source of employment. About 87% of households in Malawi are engaged in farming activities and 65% of total employment stem from agriculture. Over two million smallholder farmers rely on agriculture as their main source of livelihood. Subsistence and small-scale agriculture dominate due to limited agricultural commercialization and market access. Out of all food consumed in Malawi, 80% is produced by smallholders. Furthermore, 80% of Malawi's export earnings are derived from the agricultural sector. Therefore, the performance of agriculture has direct implications on food security, poverty reduction as well as economic development (CIAT, 2018; World Bank, 2018; Mvula & Mulwafu, 2018).

Inter-annual and intra-annual climate variability have crucial effects on agricultural production since Malawi is highly dependent on rain-fed agriculture. Direct effects include significant declines in agricultural output along with increasing prices for most food commodities which makes the country dependent on food imports. Extreme weather events such as floods and droughts reduce the land area suitable for agricultural production and lead to disrupted or shortened growing seasons. It is important to note that agricultural vulnerability is not uniform across Malawi but highly varies between regions depending on weather impacts (CIAT, 2018; Connolly-Boutin & Smit, 2013). Whereas agriculture in some districts is particularly affected by yield losses, other regions with increased rainfall can undergo yield gains, which gives rise to inequalities. Furthermore, farms with small landholdings, which are further decreasing in size due to the rapid population growth, as well as remote farming communities are more vulnerable than others (Anseeuw et al., 2016; Zulu, 2017). These differentiated vulnerabilities make it necessary to look at the different dimensions of agricultural vulnerability more in-depth in order to understand how climate variability affects those smallholder farmers on the losing side.

Due to the high population density, a much larger share of agricultural land is permanently cultivated or under temporary cultivation in contrast to neighboring countries. Land and soils represent the basis of agricultural crop production. Continuous flooding and ongoing droughts harm the nutrient and moisture levels of soils and cause land degradation. In addition to soil nutrient deficiency, soil erosion presents a major challenge to agriculture in Malawi. Intense rainfall, deforestation, and increasing temperatures cause land degradation and thereby significantly reduce the fertility of agricultural soils. Climate change thus aggravates the diminished moisture-holding capacity of soils induced by insufficient soil cultivation measures (Stevens & Madani, 2016; Wood & Moriniere, 2013). Hence, the vulnerability of agricultural land and soils depends on the initial soil composition and individual exposure to climate change risks in a particular region.

Climate change-induced soil loss has direct implications on crop production in Malawi. Rising temperatures and rainfall variability shorten the growing season of crops resulting in significant yield losses in the long term. Moreover, high temperatures heighten the prevalence of pests in plants. The majority of crops planted in Malawi are not sufficiently resistant to pests. All crops cultivated require a particular quantity of water and specific temperatures at certain growth stages. As a consequence, every crop is affected differently by climate variability. Some crops possess a higher adaptive capacity to changes in weather patterns under climate change than others. Maize as the national staple presents Malawi's most important food crop, occupying 80% of the cultivated land. Studies indicate varying effects of climate change on maize production in the short term. On a long-term basis, maize yields are expected to significantly decline, leading to food shortages and high maize prices in the country. Cassava, groundnuts, peas, potatoes, sorghum, and beans are further essential crops in Malawi's agricultural sector and vary substantially in their vulnerability to climate change. Moreover, weather forecasting, which is crucial for crop selection and planting decisions at the farm level, is highly vulnerable to the process of global warming across Malawi (Wood & Moriniere, 2013; Steven & Madani, 2016; Joshua et al., 2017: 186-187; Yengoh, personal interview, 2020; Saka et al., 2013).

Climate change adversely impacts livestock farming and cattle breeding. Livestock across Sub-Saharan Africa suffers from changes in the quantity and quality of feeds, heat stress, water availability, and diseases, which severely affects the productivity, fertility, and sexual behavior of animals (Thornton et al., 2009; Yengoh, personal interview, 2020). Goats, cattle, poultry, and pigs are held as the most common livestock, mostly in Malawi's communal land under extensive grazing. The effects of climate change on livestock predominantly comprise an increasing occurrence of diseases due to rising temperatures. Regarding productivity and reproduction, studies indicate moderate impacts of climate change on livestock in Malawi. In general, livestock ownership in Malawi is outstandingly low by regional standards with few households primarily relying on livestock. Pastoralism has no significant history in Malawi due to a scarcity of pasture and historical reliance on fishing from Lake Malawi. Livestock is rather seen as a measure of wealth accumulation that can be sold in times of adverse weather conditions (CIAT, 2018; Wood & Moriniere 2013).

Lastly, agricultural vulnerability is expressed in terms of labor which constitutes the backbone of agriculture. As outlined above, several socio-economic stressors render Malawian farmers differentially vulnerable. Climate change further aggravates their level of vulnerability and thereby weakens the agricultural working force. When disasters strike or temperatures are increasingly high, the farmers are less active what results in reduced agricultural productivity. Alternative livelihood options and income diversification present another key factor that defines the vulnerability of farmers. Households combining diverse livelihood strategies with agriculture are considered less vulnerable than other farming households. Female-headed households, which make up approximately 30% of the households in Malawi, are identified to be more likely to diversify away from agriculture than male-headed households. This is related to the fact that female farmers are considered more vulnerable because they are disadvantaged in the access to technological and financial inputs for resilience building as well as land using rights (Simtowe, 2010; CIAT, 2018; Yengoh, personal interview, 2020, World Bank, 2020a).

5. METHODOLOGY

The methodological approach, comprising research design and delimitations, methods and empirical material, as well as limitations and biases, is outlined in the following chapter with regard to the purpose of evaluating the role of IKS for agricultural resilience building in Malawi.

5.1 RESEARCH DESIGN AND DELIMITATIONS

In order to analyze existing literature on climate change adaptation from a qualitative and in-depth angle, the thesis follows a case study design, with the agricultural sector of the Republic of Malawi portraying the unit of analysis. According to Yin (2009), case studies are used to examine contemporary events and their effects on individual groups, such as the impacts of climate change on small-scale farmers. A case study aims to gain a holistic perspective of a topic, as to understand the complex factors around the integration of IKS into modern climate change adaptation. Yin further argues that case studies are advantageous for analyzing phenomena without clear boundaries to the context. This fits the research questions of the study since the relations and boundaries between IKS and MSKS in agricultural resilience building in Malawi are not evident yet and require further exploration (Yin, 2009: 3-4, 18). Nevertheless, clear delimitations to narrow down the scope of this thesis are necessary. First of all, the focus on the Republic of Malawi presents a geographical boundary (Punch, 2014: 142-148). Being a small landlocked country, which is regularly hit by climatic disasters, heightens the need for research on site-specific agricultural adaptation strategies and thus makes Malawi a relevant case to investigate. The second delimitation refers to agriculture as a sector, which is regarded as the backbone of the Malawian economy and is commonly referred to as the "primary engine of growth and development" (Gollin, 2015: 91). The analysis thereby looks at processes at the farm level rather than the policy level. Thirdly, the thesis focuses on the role of indigenous knowledge systems and their linkages with modern science as a further delimitation.

5.2 METHODS AND EMPIRICAL MATERIAL

The method applied within the framework of this thesis is qualitative content analysis as it fits the case study design in terms of "aiming to understand complex social phenomena" (Kohlbacher, 2006: 7). According to Kohlbacher (2006), content analysis can be used as a tool to interpret documents and literature (Kohlbacher, 2006). Bryman (2004) describes qualitative content analysis as “a searching-out of underlying themes in the materials being analyzed" (Bryman, 2004: 392). The analysis focuses on the dichotomy between the scientific and the indigenous and their respective advantages and disadvantages concerning climate change management. Hence, existing empirical material on farm-level adaptation measures and agricultural resilience building in Malawi is screened for the integration of IKS as well as synergies and tensions with MSKS (Kohlbacher, 2006).

An expert interview with Genesis T. Yengoh has been conducted early in the research process in order to gain an overview of climate change management at the farm level in Sub-Saharan Africa and the dichotomy between the scientific and the indigenous in the field as background information. The respondent is a researcher at the Lund University Centre for Sustainability Studies and specializes in global environmental challenges and smallholder production systems with a focus on Sub-Saharan Africa. The semi-structured interview was held via a 45-minute telephone conference, recorded via notetaking, and then converted into an interview summary (Punch, 2014: 175-176). The utilized interview guide is attached in the appendix.

Data sources for the analysis comprise exclusively secondary empirical material derived from the online libraries “Google Scholar”, “ResearchGate” and “LUBsearch”. The advantage of using secondary data lies in the usage of high-quality data issued by experienced researchers (Punch, 2014: 103). Moreover, findings from different locations in Malawi can be compared so that a pattern of resilience building can be established. The keywords “climate change adaptation”, “resilience building”, “indigenous knowledge” and “agriculture” have been used in combination with “Malawi” to create a selection of relevant articles. After reading the collected sources for the first time, targeted snowballing helped to identify further significant scholars and publications. The utilized literature consists predominantly of scholarly articles and single book chapters dealing with Malawi as a case. In the next stage, all relevant sections of the literature have been copied into separate documents. By means of color-coding, the “assessment of climate change”, “weather forecasting” and the “modification of agricultural practices” have been identified in the course of the content analysis as underlying repeated themes of agricultural resilience building and are used to structure the analysis section. Within the framework of the capability approach, the three themes are interpreted as functionings in terms of ‘doings’ and serve to assess indigenous farmers’ capabilities to sufficiently adapt decision making at the farm level to increasing climate variability. Moreover, sub-themes within each theme have been determined through further coding. The sub-themes are used to divide the subchapters of the analysis section into paragraphs for more clarity. To discuss IKS in comparison to MSKS, the literature has been coded by distinguishing between indigenous and scientific adaptation methods. Hence, the thesis combines and evaluates findings of existing literature with regard to indigenous knowledge and scientific knowledge in agriculture and climate change adaptation in the form of a case study on Malawi.

5.3 LIMITATIONS AND BIASES

For reasons of transparency, the limitations and biases of this study are stated hereafter.

The thesis' sole reliance on secondary sources reduces the validity of the study due to a lack of control over the accuracy and content of the literature used. However, the documents have been retrieved from renowned journals that ensure the reliability of data through peer review processes and quality checks before publication. The underlying assumption of this thesis is that the selected sources for the analysis are accurate. A clear limitation of a single case study design poses the lack of generalizability. The findings of this thesis are only limitedly applicable to other settings, particularly because indigenous knowledge possesses a highly context-specific character. The high environmental and natural diversity within the Republic of Malawi entails a diverse range of climate change impacts as well as adaptation strategies. It is important to note that the findings from the analysis are not equally valid for all regions and rural communities in Malawi. While some of the utilized literature deals with Malawi overall, the majority of sources refer to certain districts. It has been noted by the author that there exists a publication bias in existing literature towards the southern districts which are more severely affected by climatic disasters. Even though data from all regions in Malawi are included in the analysis, not all districts are represented equally. However, this will be stated whenever appropriate in the text.

The study of IKS implies a variety of biases. First of all, defining people as 'indigenous' and 'non-indigenous' from an outsiders' perspective appears problematic (Tharakan, 2015). This study assumes all small-scale farmers to possess indigenous knowledge even though knowledge is asymmetrically distributed within a farming community, which is not explicitly taken into consideration in the utilized literature. Moreover, IKS are difficult to categorize as they are holistic in nature rather than disciplinary (Mafongoya & Ajayi, 2017: 34-35). The scientific study and categorization of traditional knowledge imply the danger to interpret IKS in terms of scientific concepts. The used literature hence might contain a bias towards the respective perspective of the researcher on agriculture and development. By their nature, indigenous knowledge is not a conscious form of knowledge as it is informally transferred, which is why there is a risk of biases when IKS are formally archived by researchers. Therefore, the concept of AT and the CA have been chosen to interpret the data whilst emphasizing farmers' participation in the development process.

A further limitation of the thesis is that it focuses on farm-level decision making and does not go further into details at the policy level. As it is challenging for climate organizations operating at larger-scale levels to incorporate specific IKS (Mafongoya & Ajayi, 2017: 46) and policy papers by the Malawi Government only narrowly address IKS, data sources at the policy level, which integrate local knowledge, are scarce.

Lastly, it is important to note that this thesis does not cover all complexities and details of AT and the CA but makes use of those aspects of the two concepts which appear relevant for analyzing indigenous knowledge and climate change adaptation. For the case of the CA, no predetermined lists of basic capabilities are taken into account but a rather broad interpretation of the CA that considers climate change as an environmental factor, is applied.

6. EMPIRICAL ANALYSIS

With a view to finding answers to what role indigenous knowledge plays for the development of modern climate change adaptation strategies, the data analysis is outlined in this chapter. In order to explore the synergies and tensions between indigenous and scientific knowledge in climate change adaptation at the farm level, to investigate the extent to which indigenous farmers are capable of adapting to increasing climate variability in Malawi, and to find out how indigenous knowledge can contribute to the development of appropriate technologies for agricultural resilience building in Malawi, the analyzed literature is put in relation to the conceptual framework and the country-specific background of Malawi.

6.1 FINDINGS

This section presents the findings from the content analysis by looking at the assessment of climate change and climate variability, weather forecasting, and the modification of agricultural practices.

6.1.1 ASSESSMENT OF CLIMATE CHANGE AND CLIMATE VARIABILITY

Consensus among scientists and farmers on how climate is changing is essential for agricultural resilience building at the farm level. The ignorance of discrepancies between scientific and indigenous perceptions can result in inefficient and locally inadequate adaptation strategies (Simelton et al., 2013; Ziervogel et al., 2008). The analysis of research on the assessment of climate change and climate variability has shown that there exist synergies and tensions between the perceptions of Malawian farmers and scientific measuring. Whereas the occurrence of climatic changes in Malawi is acknowledged by both sides, discrepancies regarding the aspects and nature of changes in climate and weather patterns exist, which poses a risk to farmers' capabilities for resilience building and calls for an integration of scientific and indigenous knowledge. Research of several scholars (Fisher & Snapp, 2014; Simelton et al., 2013; Magrath & Sukali, 2009; Zulu, 2017; Joshua et al., 2017; Kalanda-Joshua et al., 2011; Nkomwa et al., 2014) has captured field data on how changes in climate are perceived by farmers at the local level in Malawi. Although these studies cover different regions, agricultural environments, and cultural backgrounds within the country, similarities in the perceptions of indigenous farmers are apparent. The changes assessed by locals indicate climate variations relating to rainfalls, temperature, and winds. ‘Adequately assessing climate change and climate variability’ is here understood as a ‘functioning’ in order to comprehend farmers’ real opportunity or capability to assess the changing climate.

Farmers consistently report that familiar patterns of rainfalls and rainy seasons are disrupted and consequently complicate farm-level decisions. First of all, decreasing amounts of annual precipitation are experienced by indigenous farmers in recent times as opposed to rainfall quantities in earlier decades. Declines in precipitation are accompanied by increasing incidences of dry spells according to farmers’ perceptions. Such shifts are attributed to changes in the intensity and frequency of rains. While rainfall events are reported to have reduced in frequency, they are perceived as more concentrated and intense. As a consequence, accounts on the number of dry days and the occurrence of droughts have augmented significantly (Joshua et al., 2017: 193-194, Simelton et al., 2013; Zulu, 2017; Magrath & Sukali, 2009; Fisher & Snapp, 2014). Meteorological evidence, by contrast, does not indicate substantial changes in annual amounts of rainfall. Scientific observations of rain over Malawi do not find statistically relevant long-term trends as there is no consistent evidence of decreasing precipitation except for a small part of the country. Even though scientists do not agree with farmers on a reduced quantity of rain, meteorological data confirm increases in droughts. Scientific information shows that dry spells are more frequent and extended across Malawi than in previous times. Further scientific results, displaying that the total annual precipitation is derived from fewer but more intense rainfalls, verify farmers’ impression of increasing rainfall intensity (McSweeney et al., 2010; Wood & Moriniere, 2013; Vincent et al., 2014; Joshua et al., 2017: 193).

Changing rainfalls are not only perceived in terms of quantity but also in terms of the intra-annual distribution of rains. The usual length of the main rainy season is observed by villagers to have reduced what constrains their capabilities for farming (Kalanda-Joshua et al., 2011). Such indigenous observations can be partially confirmed by meteorological data for individual years, but studies do not register a permanent reduction in the length of the wet season (Vincent et al., 2014). Farmers’ statements on alterations regarding the onset of the wet season are striking. The starting of rainfalls is referred to as increasingly delayed and unpredictable. The absence of rain at the beginning of the rainy season adversely impacts the length of the growing season. Rainfalls diminished towards the end of the rain period and ended up to two months earlier according to farmers’ impressions. The early cessation of rainfalls presents an additional factor that shortens the duration of the planting season. A perceived increase in mid-season droughts and intra-seasonal dry spells further points out the unequal distribution of rains over the course of the year. Farmers' perceptions of delayed onset of the rainy season are scientifically explained by high inter-annual climate variability rather than a consistently delayed onset of rainfalls. During the recent four to five decades scientific studies did not find empirical evidence of changed onset and cessation of the wet season. However, data from nearly all meteorological stations in Malawi notice patterns of mid-season droughts in late February (Vincent et al., 2014; Simelton et al., 2013; Zulu, 2017; Nicholson et al., 2014; Kalanda-Joshua et al., 2011). Farmers' specifications regarding the occurrence of floods are scientifically confirmed. The observations of floods vary in spatial terms with locals stating a decline in flooding events in some areas of Malawi and significant increases in other places (Magrath & Sukali, 2009; Zulu, 2017; Simelton et al., 2013; Joshua et al., 2017: 194; Nkomwa et al., 2014). This underlines the usefulness of local knowledge for formulating adequate national policies in response to climate change in a topographically and climatically diverse country such as Malawi.

Indigenous communities' perceptions of increased droughts and dry spells are not only described with respect to changes in rainfall patterns but also to changing temperature trends in Malawi. Overall, temperatures are noticed to have warmed substantially since the 1980s. Farmers thereby refer to a premature start of the hot season, an increasing number of hot days, longer summers, and more months of sunshine per year (Simelton et al., 2013; Joshua et al., 2017: 193; Kalanda-Joshua et al., 2011; Magrath & Sukali, 2009; Zulu, 2017). Indigenous observations date the beginning of climatic changes more recent than scientific data. Empirical studies track climate variations in Malawi back to the 1970s. Meteorologists' findings are in line with farmers' observations on substantial increases in temperatures across the country. Studies demonstrate that mean annual temperatures have risen about 0.9°C between 1960 and 2006 (McSweeney et al., 2014; Vincent et al., 2014; Simelton et al., 2013; Kalanda-Joshua et al., 2011; Wood & Moriniere, 2013).

Farmers further mention the increasing occurrence of strong winds as a hindering factor for agricultural activities. Therefore, winds can be interpreted as conversion factors that lower farmers' capabilities for functional farming. Joshua et al. (2017) report that indigenous people emphasize the augmentation of winds since the mid-2000s (Joshua et al., 2017: 193-194). Nkomwa et al. (2014) and Magrath and Sukali (2009) equally notice indigenous perceptions of changes in air circulations. According to farmers' observations, heavy winds come from all directions simultaneously, in contrast to solely one compass direction in former times, which adversely affects rainfalls (Magrath & Sukali, 2009; Nkomwa et al., 2014). Nevertheless, science has not yet confirmed climate-induced changes in wind regimes due to potential other direct causes such as high rates of deforestation or topographical features of the Lake Malawi Basin (Magrath & Sukali, 2009; Wood & Moriniere, 2013). Such discrepancies undermine the necessity to recognize farmers' perceptions of their respective vulnerabilities and capabilities.

The recognition of erratic weather patterns for precipitation, temperature, and winds, as well as an increasing unpredictability of climate and extreme weather events, present the major synergies between IKS and meteorological evidence regarding the assessment of climate change in Malawi. Indigenous observations and scientific findings slightly diverge regarding the amounts of rainfalls, rain season patterns, and winds. Such tensions are attributed to the spatial inexactness of scientific models and the vague memories of indigenous respondents (Marin, 2010; Marx et al., 2007; McSweeney et al., 2014). Relating back to the diverging nature of indigenous and scientific knowledge, the critique that science-based methods do not always appropriately consider local conditions might thereby serve as an explanation. Moreover, the high prevalence of HIV/AIDS and SGH in Malawi in conjunction with the fact that IKS are informally transferred, might distort the assessment of climate change and variability in comparison with earlier decades because the parent generation's knowledge is missing. Nevertheless, the evaluation has shown that indigenous observations of rainfalls, temperatures, and winds are largely consistent with empirical evidence. This demonstrates the capability of indigenous farmers to accurately define weather and climate variations in their local environment based on experiences and traditional know-how on climate assessment even though this capability is threatened by socio-economic stressors such as SGH. Such a conclusion agrees with Magrath and Sukali's (2009) statement that farming communities are aware of the issues of climate change and perceive it as directly connected to their agricultural livelihoods. However, as opposed to scientists, indigenous farmers do not necessarily attribute climate change to global issues of increasing greenhouse gas emissions but to environmental changes in their close surroundings (Magrath & Sukali, 2009). The low adult literacy rate of 62%, which is described in the background section, hence hinders farmers from being capable to identify the concrete causes of climate change even though they possess the capabilities to correctly assess climate change. The failure to understand the causes of a changing climate might limit their capability to correctly assess climate change and to heighten adaptive capacity in the farming sector.

While scientific measuring holds the advantage of benefitting from a long record of empirical data and the establishment of long-term trends, indigenous knowledge holds the potential to provide climatic information at smaller spatial scales and tailored to local farmers' demands. High inter-annual climate variability impedes meteorological as well as the indigenous assessment of climate change. Given Malawi's geographical position in between two climatic zones, modern scientific climate measurements and farmers' perceptions of climate change need to complement each other in order to generate accurate and appropriate climate models by combing their strengths and outweighing their respective weaknesses. These findings are in line with Marin (2010) who suggests that farmers' site-specific climate knowledge holds the potential to contribute to scientific data collection on climate change (Marin, 2010). The development of shared interpretations of weather and climate patterns can eventually create a community based sustainable AST and thereby enhance Malawian farmers' capabilities to build up adaptive capacity.

6.1.2 WEATHER FORECASTING

Closely related to the assessment of climate change and climate variability, is the generation of weather forecasts which is equally regarded as a functioning hereafter. With high climate variability acknowledged on indigenous and scientific side in addition to rain-fed agriculture presenting the prevailing source of livelihoods in Malawi, climate- and weather forecasting forms the basis of decision making at the farm level. Hence, choices regarding the type, timing, and location of crop production largely depend on the reliability and the preciseness of seasonal weather forecasting (Makwara, 2013). The significance of seasonal forecasts for climate change adaptation in the agricultural sector is increasingly emphasized by scholars. Anticipating weather at short-term scales heightens the resilience level of indigenous farming communities and serves as the basis to ensure food security (Kolawole et al., 2014). Based on the knowledge gained through assessing changes and variability of climate as well as past disasters, indigenous farmers have developed complex systems to coordinate agricultural activities by predicting future weather events. Modern scientific forecasting performed by trained meteorologists tends to replace IKS in weather forecasting. An analysis of studies on indigenous and scientific weather forecast doctrines has shown that there exist advantages and disadvantages to such a process of modernization of weather forecasting in Malawi.

In Malawi, indigenous knowledge and experience are used to guide farm-level decisions regarding planting, land use, harvesting, irrigation, processing, and storage by anticipating short-term and seasonal weather trends. The analyzed literature (Mwase, Mtethiwa &

Makonombera, 2014; Kalanda-Joshua et al., 2011; Joshua et al., 2017) consistently finds that indigenous communities in Malawi still highly depend on weather forecasting based on IKS in contemporary situations. Smallholder farmers make use of various indicators to predict upcoming rainfalls, temperatures, and winds. All studies find the indicators to be based on environmental and cultural beliefs, which are typical components of IKS. Farming communities across Malawi utilize astronomical features, changes in animal behavior, plant phenology, and observations of current weather conditions as key indicators for agricultural weather forecasts. The appearance of certain stars such as the morning star in the east, the presence of the Venus in the west as well as the emergence of the moon during the wet season present astronomical indicators that are applied by Malawian farmers to predict rainfalls and dry spells. Moreover, indicators analyzing birds and insects such as the increasing or decreasing prevalence of ants or termites, the appearance of certain birds, the croaking sounds of frogs, or the behavior of domesticated and wild animals, are applied in indigenous weather forecasting. Indigenous farmers traditionally make agricultural decisions conditional on the flowering time of certain plant species. The amount of fruits harvested from mango trees is consistently referred to as a measurement of upcoming rainfalls in all studies. Lastly, the timing and intensity of rainy days and dry days, reduced and rising river flows, and observations of winds are used as signals of seasonal weather changes (Mwase, Mtethiwa & Makonombera, 2014; Kalanda-Joshua et al., 2011; Joshua et al., 2017: 204-209). Local farmers' autonomous development of weather forecast models through experiences gained from social networking and generational interaction as well as the utilization of multiple indicators demonstrates the rationality and reliability of traditional ecological knowledge as a variant of IKS. Indigenous farmers' knowledge of weather forecasting in principle improves their capabilities to attain functional weather forecasts. However, anthropogenic climate change entails new practical limitations.

Even though IKS in weather forecasting provide predictions at fine spatial scales and show significant potential for the development of community-based AT, climate change increasingly undermines the utility of indigenous weather predictions and hence farmers' capabilities. The analysis of studies has shown that farmers nowadays rarely depend solely on traditional indicators and have lost confidence in indigenous weather forecasts. This is evident in the increasing performance of staggered planting by small-scale farmers. The adverse effects of climate change have rendered ecological indicators less reliable as they present a conversion factor and lower farmers' agency to achieve successful decision making at the farm level. The loss of biotic species, initially used for weather forecasting, and unpredictable climate patterns reveal the limitations of IKS for accurate farm-level decisions in recent and future times (Kalanda-Joshua et al., 2011; Joshua et al., 2017: 186, 199, 205-208; Mwase, Mtethiwa & Makonombera, 2014). As it is the case with climate change assessment, the high number of SGH in Malawi threatens the preservation of knowledge on weather forecasting as the young farming generation might fail to gain adequate knowledge from their grandparents before their death. The sole reliance on traditional weather forecasting thus restrains the capability of farmers to build up resilience to climate change. Furthermore, traditional weather forecasts do not seem to be adaptive to long-term changing climatic conditions unless mitigation efforts re-establish the value of indigenous weather predictions through the regeneration of indicator vegetation. Such findings challenge the contribution of IKS-based weather forecasting to AT under the new realities of climate change. Modern scientific forecasting models on the other hand, hold the advantage of informing peasants with robust weather and climate information based on quantitative evidence. Local farmers acknowledge the role of the National Meteorological and Hydrological Agency of Malawi in providing training sessions and weather information from 22 full meteorological stations in Malawi. The Climate Information Platform in Malawi benefits from historical trends of satellite rainfall, average seasonality as well as long-term variability. Further councils and research institutes, funded on national and international levels, deliver medium-term forecasts for the Southern African region (Department of Climate Change and Meteorological Services, 2020; Climate Information Platform, 2020; Vincent et al., 2014; Kalanda-Joshua et al., 2011).

It is apparent that scientific weather forecasting models hold a substantial advantage over IKS in terms of their extensive data sets and their adaptability to climate change. However, the current accuracy and availability of meteorological forecasts and scientific workshops are not sufficient. Modern scientific forecasting is criticized for having spatial and temporal limitations for its implementation at the village level. Weather information based on conventional methods lacks preciseness and therefore does not adequately address the practical needs of farmers. The high rural poverty rates and Malawi's poor economic performance might further hinder farmers from gaining access to scientific weather forecasts. The content of scientific weather information is limitedly understandable due to the use of technical terms and often not available in the local languages. Workshops and campaigns are still limited in some areas, which indicates an inadequate communication procedure of weather information. Insufficient education, as well as the ignorance of cultural diversity in the distribution of scientific weather information, consequently undermine the agency of Malawian farmers. Current meteorological forecasts lack reliability as weather stations do not regularly undertake measurements, which causes statistical errors (Mwase, Mtethiwa & Makonombera, 2014; Makwara, 2013; Joshua et al., 2017: 187-188; Vincent et al., 2014; Kalanda-Joshua et al., 2011). Such inaccuracies do not enhance farmers' capabilities and might result in misleading decisions at the farm level.

It can be reasoned that weather forecasts using traditional ecological indicators are limited in their potential to increase farmers' capabilities in the face of climate change unless mitigation efforts have success in the long term. Modern science-based forecasting therefore presents a future-oriented path to improve agricultural resilience building if it is adjusted to the local application. Unless the current shortfalls and gaps of meteorological information distribution are not addressed, forecasting based on IKS appears a valuable and necessary complement. In order to make scientific forecasting an AT in Malawi, the inclusion of farmers and their knowledge of local agricultural conditions, the timing of agricultural activities, and traditional practices rather than their knowledge on now-distorted indicators of changes in weather patterns, is hence needed. The engagement of communities in meteorological data generation and utilization can enhance adaptation strategies and ultimately food security. Moreover, individual traditional indicators are still applicable despite climatic changes and can complement scientific weather forecasting. Such conclusions from the analysis are in line with studies referring to other countries in SSA (Roncoli et al., 2001; Makwara, 2013; Chang'a et al., 2010) which suggest the integration of IKS into scientific forecasting and to understand local models of weather forecasting in order to develop appropriate technologies. Current discrepancies between indigenous and scientific models are attributed to a "clash of value systems between modernization philosophy and the traditionalist value system" (Makwara, 2013: 135-136). The systematic documentation of indigenous knowledge is suggested to facilitate the embedding of IKS in meteorological forecasting models and to preserve farmers' knowledge (Roncoli et al., 2001; Makwara, 2013; Chang'a et al., 2010). The inclusion of indigenous communities can eventually enhance the reliability and accessibility of science-based seasonal forecasts under changing climatic conditions in Malawi and eventually render farmers capable of attaining functional weather forecasts.

6.1.3 MODIFICATION OF AGRICULTURAL PRACTICES

Apart from assessing climate change and predicting weather patterns, modifying agricultural practices presents a central element of resilience building in the agricultural sector and can be interpreted as a functioning that farmers attempt to achieve in the face of climate change. Existing research on scientific and traditional agricultural practices in the field of climate change adaptation features some overlapping ideas whilst discrepancies regarding the current adoption by farmers and the degree of risk exposure are apparent.

Most of all, the issue of crop selection is articulated in previous research. Different studies (Stevens & Madani, 2016; Moyo & Moyo, 2014; Mwase, Mtethiwa & Makonombera, 2014; Kerr, 2014; Chidanti-Malunga, 2011; Magombo et al., 2012; Saka et al., 2013; Fisher & Snapp; 2014) consistently find that Malawian farmers autonomously adapt to changing climatic conditions by making use of crop diversification and mixed cropping. With maize as the traditional staple crop being highly vulnerable to heat, adding more drought-tolerant traditional crops such as cassava, sorghum, and millet to the fields reduces the risk of harvest losses in the case of unfavorable temperatures and precipitation. The ability of small-holder farmers to interpret several soil fertility indicators demonstrates their capability to manage the risk of crop failure by diversification as their local knowledge is based on empirical evidence and derived from years of observations and engagement in crop planting. Multiple researchers further report that in periods of increased climate variability, Malawian farmers augment food availability by gathering wild plants and tubers, which underlines their agency to bring about change based on their indigenous knowledge. In the face of climate change, indigenous crop diversification serves as an insurance against food insecurity and thereby heightens the capabilities of farmers to expand the adaptive capacity of farming systems (Stevens & Madani, 2016; Moyo & Moyo, 2014; Mwase, Mtethiwa & Makonombera, 2014; Kerr, 2014; Chidanti-Malunga, 2011; Magombo et al., 2012; Saka et al., 2013; Fisher & Snapp; 2014). Nevertheless, the decreasing farm sizes in Malawi, as well as the initial soil composition in a particular place, might present conversion factors that limit farmers' capability to engage in traditional crop diversification.

Scientific and indigenous adaptation strategies share the objective of choosing the best suitable crops for certain soil fertility levels. Modern strategies primarily include improved crop varieties such as modified seed types, drought-tolerant and early maturing plant species. While some study results (Nkomwa et al., 2014; Fisher & Snapp, 2014; Magombo et al., 2012) indicate significant yield gains, drought tolerance, and durability from improved crop types, other findings (Moyo & Moyo, 2014, Fisher & Snapp, 2014) emphasize the disadvantageous aspects of hybrid varieties in terms of taste, storability, and flour-to-grain ratio. Critics of hybrid varieties mention that a substantial share of farmers adversely affected by the impacts of climate change back down from modern crop varieties, and that small-holder farmers only limitedly benefit from the use of hybrid crops due to a lack of opportunities for storing. In that case, modern crop varieties do not augment farmers' capabilities for a functioning modification of agricultural practices. The promotion of modern hybrid varieties is often associated with the promotion of monocropping as hybrid maize is highly encouraged by scientists and development experts in the case of Malawi. Such an overreliance on maize contradicts traditional Malawian practices of crop diversification and undermines long-term resilience according to Moyo and Moyo (2014) and Kerr (2014). Stevens and Madani (2016) by contrast, question the value of diversifying farming systems since maize presents the staple crop in Malawi and therefore holds high cultural value. However, this issue is not raised by other researchers, neither proponents of indigenous knowledge-based adaptation nor advocates of modernized crops for climate change adaptation (Stevens & Madani, 2016; Moyo & Moyo, 2014; Mwase, Mtethiwa & Makonombera, 2014; Kerr, 2014; Chidanti-Malunga, 2011; Magombo et al., 2012; Saka et al., 2013; Fisher & Snapp; 2014). Overall, crop diversification presents a promising approach to enhance farmers' capabilities for adequately modifying agricultural practices under changing climatic conditions. Nevertheless, the high rural poverty rates in Malawi and food insecurity brought about by climatic disasters might constrain those capabilities. Such external conversion factors limit farmers' agency to perform indigenous as well as science-based crop diversification. Combining indigenous and scientific diversification techniques in the form of AT might help to enhance such reduced capabilities. Encouraging the diversification of crops by planting traditional crops as well as including non-traditional crops into Malawian farming systems can help farmers to adapt to climate change. Modernized crop varieties have the potential to successfully contribute to resilience building by providing higher yields if current deficiencies concerning post-harvest processing are addressed by scientists who consider the preferences and local knowledge of farmers. Nevertheless, other capabilities such as health, nutrition, and education need to be addressed in order to facilitate farmers' capability to diversify crops.

Besides adaptation through altered crop selection, traditional and scientific ways of agricultural resilience building involve changes in the usage of inputs and technologies. To enhance yields under the conditions of climate change and to address the insufficiencies of current hybrid varieties, science-based external development initiatives promote the utilization of inorganic fertilizers and pesticides (Zulu, 2017). As the continuous spraying of crops is labor demanding and cost-intensive, farmers in Malawi have difficulties to access modern fertilizer due to a lack of financial resources. However, studies have shown that the application of small doses of chemical fertilizers can augment yields in Malawi significantly. On the other hand, local farmers are capable of using traditional organic fertilizers such as compost, legumes, and animal manure to build up adaptive capacity (Magombo et al., 2012; Nkomwa et al., 2014; Aswaf et al., 2014). Crop-specific combinations of organic fertilization as the basis and inorganic fertilizers provided to farmers as supplements can hence present a viable opportunity for farmers affected by climate change. The use of locally available material in combination with modern scientific inputs can be regarded as an AHT.

With regard to irrigation technologies, local farmers engage in a variety of activities to raise resilience. Malawian farmers are capable to change the management of water resources by using watering canes, furrow and canal irrigation, flood recession agriculture, river diversions, and mulching techniques to conserve soil moisture for agricultural production. Apart from small-scale irrigation, farmers simultaneously cultivate plots in uplands and wetlands as a proactive adaptation measure. This capability might be constrained by the high population pressure and the associated decreasing farm sizes in Malawi. Overall, farmers predominantly prefer simple irrigation techniques over expensive high-technology irrigation systems such as motorized or treadle pumps (Chidanti-Malunga, 2011; Mwase, Mtethiwa & Makonombera, 2014; Nkomwa et al., 2014). In areas highly affected by climate change as a conversion factor, limited water supplies and damages render modern irrigation schemes vulnerable and dependent on external influence so that they only limitedly augment farmers' capabilities. This has been noticed by Johnstone (2011) in a study on the Bwanje Valley in Central Malawi. Areas, in which the onset of climate change is experienced at lower levels, are found to profit more from modern irrigation schemes than high-risk areas. However, modernized irrigation can improve the capabilities of farmers adversely affected by climate change, if the adaptation of irrigation technology and management is sufficiently funded, occurs on time, and respects IKS on practices in the respective agricultural system (Johnstone, 2011).

It is apparent from the analysis of existing research on the modification of agricultural practices that farmers' agency is highly influenced by a changing climate. Climate change thus has a significant impact on farmers' capability to modify agricultural practices based on available resources, and hence to build functioning lives. Other conversion factors of agro-ecological and socio-economic nature equally affect decision making at the farm level and mediate farmers' capabilities for resilience building. Farmers residing in the lower risk areas of Malawi are better able to profit from modern crops, inputs, and technologies. Such a conclusion is in line with a study by Aswaf et al. (2014) who find that farming communities exposed to a high risk of being adversely affected by climate change, are better off performing adaptation strategies based on traditional knowledge (Aswaf et al., 2014). Nevertheless, scientifically developed techniques, which are designed by incorporating farmers' perceptions, can significantly enhance agricultural resilience in the future. In accordance with these findings, it is concluded by the author that combining indigenous and scientific methods presents a form of diversification in itself and thereby holds the potential to augment Malawian farmers' adaptive capacity. Connecting scientific findings and IKS through the collaboration between land users and scientific experts can create appropriate technologies that expand farming communities' capabilities for adjusting agricultural practices to changes in climate patterns. The recognition of indigenous knowledge can provide locally produced inputs and thereby facilitates durable utilization and sustainability. As observed by Zulu (2017), climate change adaptation, in terms of proactively modifying agricultural practices, is currently dominated by Malawian farmers' autonomous responses based on local knowledge (Zulu, 2017). Adding modern scientific knowledge might therefore expand current capability resources as means to successfully modify agricultural practices under the circumstances of a changing climate.

6.2 DISCUSSION

The following discussion attempts to connect the findings from the previous three subchapters in order to establish a pattern of the role of IKS for farmers' capabilities in agricultural resilience building in Malawi. Furthermore, striking features observed by the author during the literature analysis are mentioned.

The analysis has shown that farmers in Malawi use their indigenous knowledge to assess changes in climatic patterns, to perform weather forecasting, and to adjust agricultural practices to build up resilience in the farming sector. IKS hence significantly influence farmers' capabilities to accomplish the 'assessment of climate change', 'weather forecasting', and the 'modification of agricultural practices' which are interpreted as functionings. By using IKS for agricultural resilience building, farming communities are the agents of their own development rather than being dependent on external interventions. However, diverse personal and social conversion factors such as insufficient education, poverty, decreasing land sizes, and SGH, constrain the agency of farmers to use their knowledge for resilience building. Various other capabilities and capability resources are thus interconnected with the capabilities that are essential for resilience building and climate change adaptation.

Human-induced climate change reduces farmers' freedom to solely rely on IKS since practical adaptation knowledge is distorted. This has been pointed out in terms of less reliant weather indicators and a necessity for altered farming practices in Malawi's smallholder sector. As a consequence, climate change, as an environmental conversion factor, clearly limits farmers' abilities to function because basic capabilities such as a 'stable environment' are undermined. Such a conclusion is in line with arguments by Holland (2008) and Schlosberg (2012), who note that a sustainable environment can be regarded as a 'meta-capability' that enables all other capabilities (Schlosberg, 2012; Holland, 2008: 328). MSKS are equally affected by climate change since projections of future climate change are uncertain and science-based adaptation strategies have been found to be ineffectively established in areas with a high risk of adverse climate change effects. Both knowledge systems are thus threatened by climate change. Neither modern scientific nor indigenous adaptation strategies offer a single ideal adaptation approach for agriculture in Malawi. In the course of analysis, it has been further noticed that IKS and MSKS coincide with each other in terms of the recognition of increasing climate variability, the more frequent occurrence of extreme weather events, the significance of weather forecasting, the value of crop diversification, and the necessity to adjust fertilization and irrigation. Overall, it is not always possible to precisely distinguish between methods of modern and traditional resilience building. Such a perception by the author can be explained by insights of Magni (2016) who states that IKS are influenced by indigenous responses to scientific innovations. At the same time, diverse scientific disciplines are historically developed based on the influx of traditional knowledge (Mafongoya & Ajayi, 2017: 31). The intertwining of IKS and MSKS questions the usefulness to strictly differentiate between modern and traditional knowledge. Indigenous knowledge, as well as scientific knowledge, can serve as resources to expand Malawian farmers' capability to attain the functioning of 'being resilient to climate change'. Nevertheless, it has been perceived that scholars arguing for more science-based external adaptation use economic indicators as measurements of resilience to climate change while scholars who study IKS, emphasize the role of well-being based on farmers' perceptions. It is argued here that the recognition of indigenous farmers and their specifications of their respective vulnerabilities and capabilities, are essential for the successful integration of indigenous and scientific knowledge in the field of climate change adaptation.

As the nature of climate change adaptation calls for site-specific solutions, individually balanced combinations of indigenous and scientific knowledge hold the potential to significantly contribute to agricultural resilience building. By combing their strengths and outweighing their respective weaknesses, indigenous and modern adaptation complement each other and thereby enhance the adaptive capacity of farming systems affected by climate change. This has been described as a process of diversification by the author. The findings from the analysis further emphasize the necessity to consider the perceptions of farmers and to foster community empowerment, indigenous culture and identity, as well as self-determination, during the development of modern adaptation strategies. For these purposes, AT development, which has been introduced in the conceptual framework (Tharakan, 2015; Amiolemen et al., 2014; Akubue, 2000), has been found to foster Malawian farmers' agency in facing the rapid pace of climate change. Interaction between scientists and indigenous knowledge holders has the potential to generate multiple technology choices for rural communities vulnerable to climate change. The analysis has demonstrated that combinations of IKS and MSKS are useful for developing AST such as climate change information, weather forecasts, and practical adaptation knowledge as well AHT such as climate and weather measuring stations, irrigation schemes, and fertilizers. Appropriate technologies which include scientific elements enhance farmers' capabilities to adapt to a changing climate if they are implemented in consideration of the community and the environment. While climate change threatens capabilities, AT can expand Malawian farmers' capabilities. It is important to note that the findings of this thesis do not suggest replacing MSKS with IKS in agricultural resilience building but to regard them as complementary systems. This is in line with a statement by Yengoh (2020) who mentioned that "local knowledge provides the context to scientific explanations" (Yengoh, personal interview, 2020).

7. CONCLUSION

The paper has explored the role of indigenous knowledge for adaptation strategies in the agricultural sector of Malawi under the new realities of climate change. It has been shown that indigenous smallholder farmers use their know-how and skills as capability resources to build up resilience by assessing climate change and climate variability, conducting weather forecasting, and modifying agricultural practices. Malawian farmers' knowledge thus presents a valuable source of information for climate change management, which highlights the dynamism and efficiency of indigenous knowledge systems. Diverse external conversion factors undermine the foundations of farmers' adaptation capabilities and hence restrict their agency to use their local knowledge for becoming resilient to climate change. These conversion factors include decreasing farm sizes, a lack of education, the high prevalence of skipped-generation households, food insecurity, as well as insufficient access to financial capital. For resilience building to be successful in Malawi, other capabilities that are indirectly linked to resilience building, need to be considered. Climate change and climate variability present major environmental conversion factors as they impair all other capabilities.

The complex impacts of global climate change on agriculture, simultaneously threaten and necessitate the application of indigenous knowledge for decision making at the farm level. With a "modern" climate, indigenous knowledge needs to be supplemented with modern scientific knowledge to develop agricultural adaptation strategies and policy frameworks based on the best available knowledge. The co-production of knowledge has been identified as a potentially effective tool for the development of appropriate technologies in the farming sector of Malawi. Indigenous knowledge can thereby provide in-depth inputs based on locally relevant and long-standing experiences in an uncontested way. Modern scientific approaches that consider local farmers' perceptions have the potential to enhance adaptive capacity in Malawi's agriculture. Therefore, it is essential to resolve tensions between indigenous and scientific climate change management and to reinforce their synergies. Inconsistencies are apparent in the assessment of rainfall amounts, rain season patterns, and winds, as well as the current adoption of strategies by farmers and the applicability in high-risk areas. The recognition of increasing climate variability and a more frequent occurrence of extreme weather events, the significance of weather forecasting and crop diversification, as well as the characterization as a capability resource, are the major synergies between indigenous and scientific adaptation at the farm level, which provides a common point of departure for their merging. The deemphasis of one-sided knowledge and technological monoculture to foster agricultural resilience building in Malawi presents a key finding of this thesis. To answer the central research question, one can conclude that indigenous knowledge holds the potential to complement modern scientific knowledge on climate change adaptation in terms of providing locally accepted and site-specific inputs and enabling the self-determination and empowerment of farming communities in Malawi in the form of a capability resource.

For the interaction of indigenous and scientific knowledge to successfully adapt Malawian smallholder farmers and rural communities to increasing climate variability, further country-specific research is necessary. In order to prevent the loss of indigenous knowledge, local databases need to capture farmers' knowledge in all regions of Malawi and include their distinctive features as well as shared challenges and similarities. While further research that assesses climate change adaptation in agriculture from a scientific perspective and research that deals with indigenous knowledge at the farm level, are both indispensable, studies that explicitly evaluate their interactions are particularly important. National policy frameworks and modern scientific studies should incorporate indigenous knowledge systems through the collaboration between local knowledge holders, climate scientists, social scientists, and policymakers. Lastly, indigenous knowledge of agriculture and climate change adaptation should be part of the curriculum of schools and agricultural extension services in Malawi.

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APPENDIX

EXPERT INTERVIEW GUIDE

I. Agricultural vulnerability in SSA

In what ways is African agriculture affected by increasing climate variability / global climate change?

What are the main dimensions of agricultural vulnerability (water, livestock, soils, labor)?

What are the major challenges at the farm level (that you experienced during fieldwork)?

II. Resilience building

How do farmers perceive and assess climate variability and change?

What are farmers' responses to enhance their adaptive capacity (independently of national policies but based on their local knowledge and experiences)?

How has land use and soil use changed in the face of increasing climate variability at the farm level?

III. Indigenous knowledge vs. modern knowledge

In your opinion, what is the potential of local knowledge for agricultural climate change adaptation in comparison to modern scientific solutions?

To what extent do adaptation policies on agriculture consider local conditions and to what extent are they using 'international best practice frameworks'?

IV. Knowledge integration

In your experience, what are practical ways of integrating the perceptions of local farmers with scientific recommendations to develop structured and proactive adaptation strategies?

What are the reasons for farmers not to adopt approaches or techniques recommended by agricultural extension services?

What are the limitations of using indigenous knowledge for agricultural resilience building?