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CONFLICT IN AGRICULTURAL POLICIES IN ACCOMMODATING RECENT ADVANCEMENTS IN THE AGRICULTURAL SECTOR IN AFRICA: A CASE STUDY OF MALAWI

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DECLARATION

I, Chikondi Chizu, hereby declare that this research thesis represents my work realized to the best of my knowledge. I also declare that all information, materials, and results from other works here have been fully cited and referenced in accordance with the academic rules and ethics.

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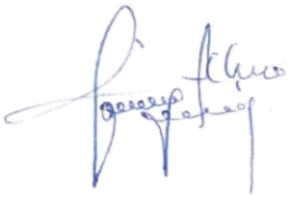

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ACRONYMS AND ABBREVIATIONS

ADMARC	Agricultural Development and Marketing Corporation
AFB	African Development Bank
AGCOM	Agricultural Commercialization Project
ASWAP	Agriculture Sector Wide Approach
CA	Conservation agriculture
CAADP	Comprehensive African Agricultural Development Program
CCAFS	Climate Change, Agriculture and Food Security
COMESA	Common Market for Eastern and Southern Africa
CSA	Climate-smart agriculture
DAT	Digital agriculture technologies
EP	Energy Policy
FAO	Food and Agriculture Organization
FISD	Foundation for Irrigation and Sustainable Development
FISP	Farm Input Subsidy Program
GBI	Greenbelt Initiative
GDP	Gross Domestic Product
GHG	Green House Gas
GOM	Government of Malawi
GWP	Global Water Partnership
GWPSA	Global Water Partnership-Southern Africa
IMF	International Monetary Fund
IOT	Internet of Things
ITCZ	Inter-Tropical Convergence Zone
IVR	interactive voice response
MASAF	Malawi Social Action Fund
MCSAA	Malawi Climate Smart Agriculture Alliance
MDGS	Malawi Growth and Development Strategy
MERA	Malawi Energy Regulatory Body
MIP	Malawi Implementation Plan
MRA	Malawi Revenue Authority

NAIP	National Agricultural Investment Plan
NEPAD	New Partnership for Africa's Development
NFAP	National Fisheries and Aquaculture Policy
NIP	National Irrigation Policy
NWP	National Water Policy
NWRA	National Water Resources Authority
PAP	Poverty Alleviation Program
PV	Photovoltaic
SADC	Southern African Development Community
SDG	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
SSA	Sub-Sahara Africa
TAAT	Technologies for African Agricultural Transformation
UN	United Nations
WEF	Water, Energy and Food
WRA	Water Resources Act
WRR	Water Resources Regulation

ABSTRACT

Malawi, just like many African countries is struggling with inadequate agricultural productivity, making it difficult to meet the food demand of its growing population. This leads to increased demand for water and energy resources in agriculture production, posing environmental threats. Recent advancements like the water, energy, and food (WEF) nexus concept can increase food production and reduce greenhouse gas emissions. This could improve food availability, ensuring a steady supply amidst climate change, and poverty. However, national policies often adopt a sectorial approach, neglecting potential interdependencies and conflicts that may arise from cross-sectoral integration. This study, therefore, examines the conflict in agricultural policies in accommodating recent advancements in the agricultural sector in Malawi. The study set out to explore four research questions. The study uses a qualitative method design with Key-informant interviews and document reviews. A total of twenty-eight respondents were interviewed which included sixteen experts and twelve farmers and ten policy documents were purposelessly sampled. The NVIVO 14 Software was used to analyze the data collected. The results show that the use of the WEF nexus concept as a selected recent advancement in the agriculture sector in Malawi boosts crop yields, diversifies cropping patterns, and extends the growing season beyond traditional rain-fed cycles. It also contributes to rural development, job creation, and entrepreneurship. However, the implementation of the WEF nexus faces challenges such as poor irrigation development, catchment conservation, and technical, socioeconomic, and policy issues. The study further reveals that policies like Malawi Vision 2063 and Nation Agriculture Policy align with the WEF nexus concept in Malawi's agriculture sector, but inconsistencies and conflicts within existing frameworks hinder the effective implementation of integrated WEF approaches for sustainable development, including a lack of coordinated sectoral policies, competing interests, poor governance, and climate change. The study recommends the government create a coordinated policy framework that accommodates recent advancements and integrates water, energy, and food sectors, and the government should incorporate the WEF nexus concept into the Universities, Secondary, and Primary school curriculums.

Keywords: Malawi; recent advancements; policy; water, energy and food nexus; conflicts

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CHAPTER 1: INTRODUCTION

1.1 Chapter Overview

This chapter gives an overview of the research. It provides information that, in general, establishes the scope of the study. It describes the research topic, objectives, the relevance of the study, the scope of the investigation, and an outline of the study's preliminary chapters.

1.2 Background

The global population continues to grow and the United Nations projects that it will reach 10 billion by 2100, with urban areas accounting for the majority of the population (Mohtar & Lawford, 2016). The global population boom is projected to increase the demand for food consumption by 70 percent by 2050, water by 40 percent by 2030, and energy by 25 percent by 2040 (Shimeles et al., 2018). The rising food demand, particularly in African nations, is posing a threat to the environment by increasing water and energy consumption in food production. Malawi, along with other African countries, is grappling with inadequate agricultural productivity and production, making it difficult to meet the food demand for its growing population. For instance, Sub-Saharan Africa is home to 220 million out of the 795 million people worldwide suffering from chronic malnutrition, highlighting the significant issue of food insecurity in the region (Shimeles et al., 2018). Recent advancements in the agricultural sector have significantly benefited farmers by increasing global agricultural production and decreasing greenhouse gas (GHG) emissions (Wolde, 2021). Recent advancements in agriculture have the potential to improve food availability by increasing crop production and food volume per unit of land, thereby ensuring a steady supply amidst challenges like climate change, food insecurity, and poverty.

In Africa, the African Development Bank (AFB) started the Technologies for African Agricultural Transformation (TAAT) program in 2018, intending to increase agricultural production, lowering risks, and promote diversification and processing of agriculture value chains. Its major goal is to raise food production by 100 million tons by 2025 to meet the increased food demand and bring 40 million Africans out of poverty (AFDB, 2024).

The recent advancements include the use of new technologies such as smart irrigation or frontier technologies, novel digital technologies as well as the introduction of new concepts such as climate-smart agriculture and Water Energy Food Nexus. Agriculture technologies refer to

improved farming techniques, higher-yielding crop varieties, and a variety of agricultural machines and tools aimed at improving the agricultural production system(Rehman et al., 2016). Agriculture technologies improve agricultural productivity by optimizing water resources and minimizing waste. The Food and Agriculture Organization (FAO, 2017), refers to emerging digital technologies as e-agriculture technologies. Digital technologies include the usage of Internet of Things (IoT) sensors, mobile applications, and artificial intelligence algorithms (Schulz, 2019). The IoT technologies are used in irrigation or the application of fertilizers and pesticides.

Climate-smart agriculture (CSA) is a new idea that combines agricultural development with climate change adaptation. CSA is defined as a method for transforming and redirecting agricultural expansion to reflect the climate change new challenges (Lipper et al., 2014). According to the FAO, CSA aspires to achieve three objectives: sustainable production and income growth, climate change adaptation, and greenhouse gas emissions reduction. The Malawi Climate Smart Agriculture Alliance (MCSAA) was formed in April 2015, following the inaugural workshop held at the 2015 Regional Beating Famine Conference in Lilongwe, Malawi (Gee et al., 2016). Its goal was to accelerate the implementation of CSA in Malawi. CSA incorporates traditional techniques like mulching, intercropping, and pasture management, as well as innovative practices like improved crop varieties, improved weather forecasting, and risk insurance. The CSA in Malawi is categorized into soil management, crop management, water management, and energy management, just to mention a few (Schulz, 2019).

Smart irrigation technologies are boosting crop yields in Africa, particularly in regions with less predictable rainfall patterns. Despite this, only 0.005% of Africa's land is irrigated especially in Northern and Southern Africa (Suri & Udry, 2022). Rainfed agriculture is a key source of income for many farmers in Central, Eastern, and West Africa. For example, Malawi's population, specifically 83 percent, primarily resides in rural areas, and agriculture employs more than 80 percent of the economically active population (Ministry of Agriculture, 2018). In Malawi, smart irrigation technologies are being used to monitor water quantity and quality, soil properties, weather conditions, and fertilizer consumption. Smart irrigation technologies enhance efficiency, and productivity, and mitigate the impact of climate change in the face of evolving agricultural challenges (Ringler et al., 2020). The adoption of irrigation technologies represents a paradigm

shift in traditional farming practices and demonstrates Malawi's commitment to leveraging modern innovations for the benefit of its farmers and overall food security.

The Water Energy and Food nexus concept is becoming an increasingly important worldwide policy, governance, and research area. African countries have begun to implement WEF concepts and technology in agriculture to manage water, energy, and food resources sustainably (Dayioğlu & Türker, 2021). The WEF nexus concept was first introduced at the 2011 Bonn Nexus Conference, organized by the German Federal Government to contribute to the United Nations Conference on Sustainable Development, focusing on solutions for the green economy. The WEF nexus is defined as the idea that water security, food security, and energy security are inseparably interdependent, and actions taken in one sector will influence one or both of the other sectors (Proctor et al., 2021). The WEF nexus idea emphasizes the interconnection of the water, energy, and food sectors, recognizing that changes in one sector can have a negative impact on others.

Water security is defined as the long-term availability of sufficient quantities and quality water for resilient societies and ecosystems in the face of unpredictable global change (Lutz-Ley et al., 2021). Food security, as defined by the 1996 World Food Summit, is achieved when all people have physical and economic access to enough, safe, and nutritious food that meets their dietary needs and food choices for an active and healthy lifestyle (FAO, 2009). Furthermore, energy security is defined as the ongoing availability of energy in a variety of forms, in sufficient amounts, and at affordable prices (Khatib et al., 2015).

Access to WEF resources is regarded as a basic need for human life and is required to achieve Sustainable Development Goals (SDG) such as SDG 1(no poverty), SDG 2(end hunger), SDG 6(clean water and sanitation), SDG 7 (access to energy), SDG 11(sustainable cities) and SDG 12(sustainable consumption). However, over 759 million people globally, most of whom live in rural Sub-Saharan Africa, continue to have limited access to reliable energy, 771 million people do not have access to adequate and clean drinking water, and approximately 750 million are experiencing food insecurity (United Nations, 2020).

The use of recent advancements in the agriculture sector has the potential of reshaping the landscape of agriculture practices in Africa, Malawi inclusive. However, in many African countries, especially in the Sub-Sahara Africa, national policies, often adopt a sectorial approach,

focusing on individual sector needs and challenges without considering potential interdependencies and conflicts that may arise from cross-sectoral integration. This led to unsustainable resource utilization and management due to the siloed approach across different sectors. Embracing recent advancements in the agriculture sector demands an exploration of the enabling environment necessary for their successful implementation.

1.3 Problem statement

Malawi, one of the Sub-Saharan African countries is experiencing food insecurity as smallholder farmers account for the majority of agricultural producers, and have the lowest agriculture production growth rates, with a 1.8 percent annual drop (Mungai et al., 2020). Projections show that sustainable cultivation land for Malawi's two primary crops (maize and beans) will be reduced by 20% to 40% by 2050 (Dinesh et al., 2015). This decline is attributed to climate change as agriculture production in Malawi is mostly rainfed which makes it vulnerable to erratic rainfall patterns. According to the Global Climate Index, Malawi is among the top five countries globally affected by climate change (Eckstein et al., 2021). For instance, the 2023 tropical cyclone Freddy which hit Malawi resulted in approximately $110 million loss in the agriculture sector (Government of Malawi, 2023).

Malawi government in its quest to address the impact of climate change on agriculture production and achieve United Nations sustainable development goals, SDG 1, SDG 2, SDG 6, SDG 7, SDG 11, and SDG 12 by 2030, is slowly shifting from traditional farming practices and harnessing the use of advancements in the agriculture sector such as WEF Nexus approaches. The use of recent advancements such as the WEF nexus approaches and technologies in African countries is emphasized by the African Union's Agenda 2063 which considers the interconnectedness of water, energy, and food security (UNFCC, 2021). Additionally, the introduction of novel ideas like the WEF Nexus has played a crucial role in shaping the discourse around sustainable agricultural practices in Malawi.

Despite these advancements, the smooth implementation of these technology and concepts in Malawi's agricultural sector faces challenges. One of the challenges is the adoption of these new advancements in the absence of an enabling environment may lead to a gap between agriculture policies and practices. This gap may cause conflicts within present agricultural policies hindering

the optimal integration of these innovations. These will impede the agriculture sector from contributing effectively to food security, poverty eradication, and economic growth in Malawi.

Another major issue is the unexpected consequences of sectoral policy initiatives. Malawi's agricultural policies frequently adopt a sector-specific paradigm, ignoring its complex interdependence and possible conflicts with other sectors. This oversight causes conflicts, which limit the implementation of agricultural advancements compromising overall agricultural production and sustainability.

The issue in Malawi, just like many other African Countries, is the need for a more holistic and integrated strategy to accommodate agricultural innovations. To realize the full potential of these technologies and concepts, it is critical to address the obstacles associated with a lack of an enabling environment and unforeseen conflicts caused by sectorial policy approaches. It is against this background that this study was undertaken to examine the conflict in agricultural policies in accommodating recent advancements in the Malawian agricultural sector.

1.4 Main objective

The main objective of this study is to examine the conflict in agricultural policies in accommodating recent advancements in the agricultural sector in Malawi.

1.4.1 Specific objectives

I. To identify one recent advancement in the agriculture sector in Africa, particularly for Malawi.
II. To assess the opportunities and challenges of the selected advancement when compared to the traditional form of agriculture in Malawi.
III. To analyze the agricultural policy in Malawi and identify gaps or conflicts arising in accommodating the recent advancement.

1.4.2 Research questions

I. What is the selected recent advancement in the agriculture sector in Africa, particularly in Malawi?
II. What are the opportunities and challenges of selected specific recent advancements or new concepts in the agriculture sector in Africa, specifically Malawi compared to the traditional farming methods?

III. What are the gaps or conflicts arising in accommodating the recent advancements in agriculture policies in Malawi?

1.5 Relevance of the study

The use of new agricultural advancements in the African agriculture sector without enabling the environment may result in some challenges, as most African agricultural policies follow a sectorial approach. A gap exists in understanding how African countries accommodate these advancements in their national policies. This study, conducted in Malawi contributes to the literature and provides insights for other African countries facing similar issues. The findings will promote the accommodation of recent advancements such as WEF Nexus approaches in agriculture policies, contributing to food security and ending poverty in Malawi.

Furthermore, the main objective of this study aligns with the United Nations Sustainable Development Goals: SDG 1, SDG 2, SDG 6, SDG 7, SDG 11 and SDG 12. Therefore, this study will be beneficial as it will provide data that will help policymakers, planners, and academic institutions in coming up with evidence-based policy adjustments to solve challenges in accommodating recent agriculture advancements in agriculture policies hence ensuring food security in Malawi and African countries at large.

1.6 Scope of the Study

The scope of this study includes an in-depth investigation of conflicts within agricultural policy, with an emphasis on the incorporation of the Water Energy Food Nexus concept and technology. The research will use examples from Malawi to give a comprehensive understanding of the challenges and opportunities involved with adapting these advances in the agriculture sector.

1.7 Tentative thesis chapter outline

The thesis has five chapters. The first chapter is an outline of the study's history, as well as the problem statement, research objectives and questions, study importance, and study organization. The second chapter includes a literature review related to the research topic. The third chapter includes research methodology. The fourth Chapter discusses the outcomes of the study's findings. Lastly, chapter five presents a summary of major findings, limitations, and recommendations. After chapter five, it is followed by references and an appendix.

CHAPTER 2: LITERATURE REVIEW

2.1 Chapter Overview

This chapter presents an in-depth analysis of the literature on the subject related to the objectives of this study. It includes an overview of the agriculture sector in Malawi, historical contents of agriculture policies in Malawi, and recent advancements in the agriculture sector, with an emphasis on the Water, Energy, and Food nexus concept and technologies as a case study in Malawi. It also presents conflicts in agricultural policies in implementing these advancements and drivers of policy conflict in the agriculture sector in Malawi.

2.2 Overview of the Agriculture Sector in Malawi

The agricultural sector is a crucial component of the economic development of Africa, particularly in Sub-Saharan Africa as it is the primary sector (Ba, 2016). For example, in Malawi, agriculture plays a key role in the economy, providing around 30 percent of the National Gross Domestic Product (GDP) and producing more than 80 percent of national export revenues (Mwahafa Rafael et al., 2023). Furthermore, the agricultural sector supports 85 percent of the Malawian population with their livelihoods. Smallholder farmers who practise small-scale farming in Malawi are responsible for over three-quarters of agricultural production, mostly through maize-based rain-fed cropping methods. Small-scale agriculture is defined as a family-owned business that primarily focuses on producing crops or livestock on a plot of land of 2 hectares or less (International Finance Corporation, 2018).

The smallholder farming system in Malawi is predominantly subsistence-based, with customary land tenure. Land tenure forms the foundation for land allocation and ownership. Malawi's land is in three categories: public, private, and traditional or customary. Only 7% of cultivated areas in Malawi are irrigated while the remaining 93% of its land is rain-fed, leading to poor harvests and worsening poverty (Chafuwa, 2017). Over 70% of Malawi's cultivated area is under customary land tenure, which is practiced by about 3.5 million smallholder farmers with land holdings ranging from 0.5 to 2.5 hectares (Bae, 2021). As a result, 5.4 million Malawians are facing moderate food insecurity (IPC, 2022).

2.2.1 Challenges in the agriculture Sector in Malawi

Despite agriculture being an important sector in Malawi, it is facing numerous challenges which include climate change, water scarcity, over-dependence on rain-fed agriculture, food insecurity, energy deficiency, inadequate technology adoption, and institutional challenges. The negative implications of climate change on food security and agriculture are particularly evident in Sub-Saharan African countries, including Malawi (Baptista et al., 2022). This is attributed to Africa's agricultural sector's reliance on rain-fed crop production making it vulnerable to negative impacts of climate change. Malawi has extreme weather occurrences such as dry spells seasons, droughts, strong rains, riverine floods, and flash floods, all of which have an impact on agricultural production. Malawi has experienced a surge in extreme weather events since 1980, causing over 50 hydrometeorological disasters that negatively impact agriculture production (Government of Malawi, 2023). In the last decade, over 25 severe rainfall disasters have occurred, which has had a significant impact on agriculture production and the country's economy. For instance, a recent study has shown that crop production in Malawi was affected by floods and drought resulting in a crop production loss ranging from 32 to 48 percent (McCarthy et al., 2021).

Water scarcity also has a negative impact on the agriculture sector in Malawi. Water scarcity is defined as a situation in which water demand exceeds the available supply (Ding, 2023). Water scarcity can be categorized into two types: economic and physical. Economic water scarcity is primarily caused by inadequate water infrastructure or inadequate management of existing water resources. Physical water scarcity arises when there isn't enough water to meet demand. Water shortage affects agriculture because water is required for agricultural production and food security. Agriculture, for example, accounts for about 79 percent of total water withdrawals in Malawi (Kumwenda et al., 2015). Malawi experiences economic water scarcity despite having vast water resources, especially during the dry season, due to inadequate infrastructure and inadequate water management (see Figure 2.1). Malawi's freshwater water total withdrawals from developed sources account for only 7.9% of total renewable water resources.

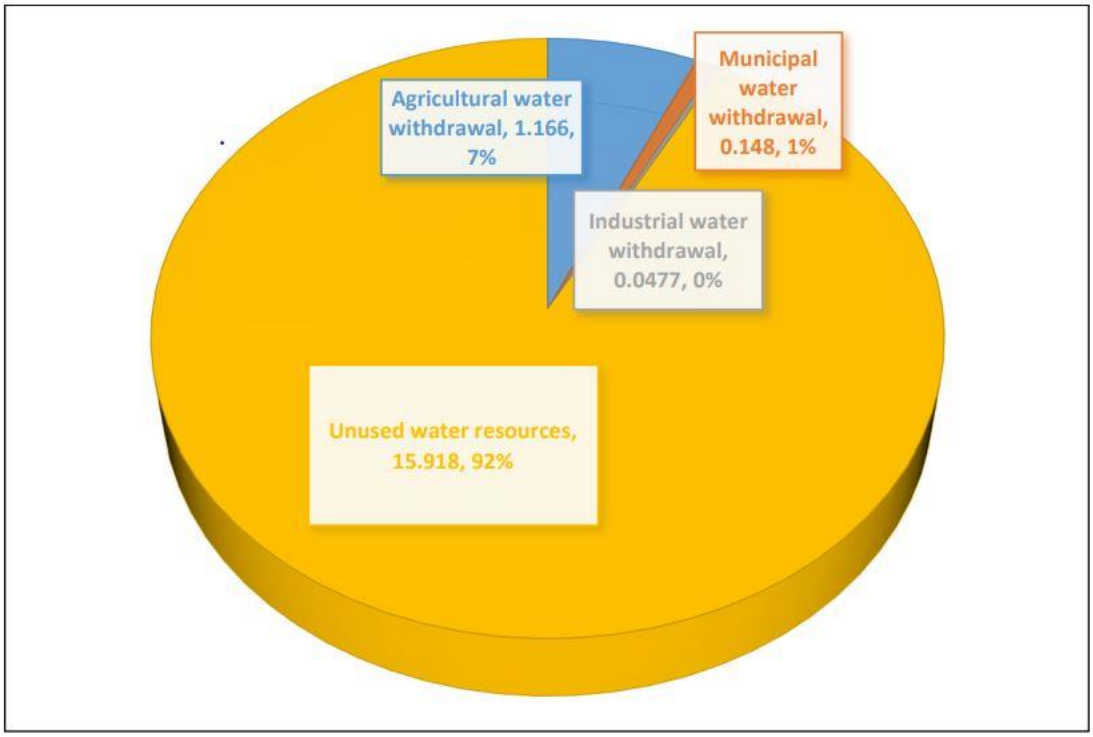

Figure 2. 1: Water resources volume in Malawi (km3/year) and percentage of water withdrawal by sector

Source (Kumwenda et al., 2015)

Another challenge in Malawi's agriculture sector is an overreliance on rain-fed agriculture methods, which account for more than 90% of agricultural production in the country (FAO, 2015). Farmers' reliance on a single rainy growing season limits their potential agricultural output, resulting in Malawi's food insecurity problems. Erratic rainfall has also had a severe impact on food production in Malawi; for the 2023 growing season, total production was estimated to be 3.5 million metric tonnes, 3% lower than the previous five-year average (FAO, 2024). This is due to the 2022 cyclone Freddy that hit Malawi, as well as low rainfall. Even during a perfect rainy season, Malawian farmers are frequently only able to harvest enough to sustain their family for eight or nine months, leaving them with insufficient surplus to save or invest.

Food Insecurity is also another challenge for the agriculture sector in Malawi. For instance, according to the IPC report (2022), about 5.4 million Malawians are experiencing food insecurity due to the impacts of climate change, decline in agriculture production, high population growth, and poverty. Malawi was self-sufficient in maize production in the 1960s and 1970s due to fewer

people and larger farms. Malawi's food security suffered severely in the late 1990s as a result of the credit system's collapse and an increase in fertilizer prices caused by the removal of subsidies. The recent government of Malawi's support for smallholder farmers through the Agricultural Farm Input Subsidy Program (FISP) has resulted in a substantial rise in aggregate production of maize in Malawi (Chakrabarti et al., 2024). Malawi's agricultural production has been fluctuating over the years, leading to insufficient consistency in the sector's growth performance, despite the implementation of the FISP (table 2.1). The issue of Malawi's food insecurity is primarily attributed to government policies and poor weather conditions.

Table 2. 1: Shows Maize production in Malawi from 2012 to 2023

Source (USAID, 2023)

Market Year	**Area (1000ha)**	**Production (1000 Tons)**	**Yield (T/Ha)**
2011/2012	1675	3699	2.21
2012/2013	1650	3619	2.19
2013/2014	1677	3,640	2.17
2014/2015	1705	3978	2.33
2015/2016	1676	2776	1.66
2016/2017	1674	2369	1.42
2017/2018	1725	3464	2.01
2018/2019	1685	2698	1.60
2019/2020	1735	3392	1.96
2020/2021	1762	3692	2.10
2021/2022	1700	4200	2.47
2022/2023	1700	3000	1.76
5-Year Average (2017/18-2021/2022)	1721	3489	203
Percent change from 5-year average (%)	-1	-14	-13

Finally, energy deficiency is another challenge facing the agriculture sector in Malawi. In Malawi, smallholder farmers contribute significantly to the agriculture sector's production, surpassing estate farmers in this area. Malawi's smallholder farmers rely heavily on manual labour known as "ganyu" in the Chichewa language and traditional farming methods, resulting in low agricultural productivity and efficiency. Energy shortages further exacerbate these challenges, hindering mechanization and modernization efforts in the agriculture sector. Malawi's renewable hydropower resource is underutilized, with over 84.7 percent of the population living in rural areas relying on wood and paraffin as primary energy sources (Jagger et al., 2022). The country's electrification rate is 12.4 percent, with 48.7 percent of the urban population and 3.9 percent of the rural population having access to electricity. Malawi's smallholder farmers in rural areas face limited electricity access, leading to reduced agricultural production.

2.2.2 History of agriculture development policies in Malawi

Malawi's agricultural development policies have been dominating since 1964, with over 80% of the population living in rural areas and farming serving as the primary livelihood strategy. The country's economic policies are centered on two approaches: estate agriculture on leasehold land and smallholder agriculture on customary land. In Malawi, leasehold refers to all private land owned, held, or occupied under a leasehold or freehold title (Government of Malawi, 2016). Estate agriculture has resulted in unequal land distribution across rural Malawi. Malawi's economic and agricultural policy regimes are divided into three periods: pre-reform, reform, and post-reform.

- The pre-reform period (1964–1980). Malawi's first 15 years of independence witnessed strong government engagement in the economy and agriculture sector, intending to diversify the economy away from agriculture by increasing import substitution and industrialization. The First Development Plans (1961-1964), Second Development Plans (1965-1969), and the First Statement of Development Policies (1971-1979) were three key development strategies that significantly influenced agricultural policies in Malawi(Ephraim et al., 2014). The economy had a large labor force and fertile agricultural soils, and the government identified capital and skilled labor as productive elements in short supply. The emphasis was on agricultural innovation and selling unskilled labor to mineral-rich nations. Agriculture was the economy's core, accounting for around 60% of

GDP in 1964. The government invested in state-owned enterprises and state-holding organizations, especially in smallholder agriculture.

- The Reform Period (1981–1994). The country faced an economic crisis in 1979 and 1980, leading to the adoption of structural adjustment programs under the World Bank, and the International Monetary Fund (IMF) in 1981 (Conroy, 2006). These programs aimed to improve the performance of the smallholder agricultural sector, diversify the export base, ensure appropriate price and income policies, expand the role of the private sector in marketing agricultural produce, and increase the efficiency and incomes of smallholder farmers. The second Statement of Development Policies (1987-1996) outlined the reforms embodied in these programs. The government liberalized the pricing of agricultural produce and marketing in various ways, including periodic adjustments to pan-territorial and pan-seasonal prices, introducing a price band for maize, and reducing export licensing requirements. However, the government has always intervened in the pricing of maize, particularly during lean seasons and times of food crises.

  The Agricultural Act of 1987 (General Purpose) deregulated the marketing of smallholder agricultural produce, eliminating the Agricultural Development and Marketing Corporation (ADMARC)'s monopoly power in produce marketing (Maonga & Mgomezulu, 2020). However, private traders' competition and increasing financial constraints have resulted in the decline of the state's involvement in maize marketing during the food crisis. The gains and losses from these reforms have heavily affected the poor, and net food buyers, while net sellers of maize have benefited from high prices and private traders have achieved higher profit margins due to the weakening position of state marketing activities.

  The liberalization of the production of burley tobacco by smallholder farmers in 1990 led to an increase in smallholder farmers, accounting for about 70% of national production (Masanjala, 2006). Market reforms expected private traders to take on the function of governmental marketing agencies in rural areas. Studies in Malawi reveal that private traders cannot reach remote areas deemed unprofitable by state marketing agencies. Private

traders are primarily small-scale entrepreneurs who have enterprises in rural areas, facing constraints such as transport, storage, processing, financing, and credit facilities.

- The Post-Reform Period (1995–2007). From 1995 to 2005, Malawi underwent major structural reforms, leading to several policy changes, particularly in the agricultural sector. The government published the Policy Framework for the Poverty Alleviation Programme (PAP) in 1995, which outlined broad policies for fighting poverty (Bwalya et al., 2004). In 1998, the Malawi Vision 2020 document was published, focusing on increasing food crop production, promoting livestock development, reducing postharvest losses, and improving market efficiency. The Malawi Poverty Reduction Strategy (MPRS) launched in 2002, focuses on increasing agricultural incomes through inputs, technology, extension services, domestic and international markets, irrigation promotion, crop diversification, and livestock development.
- In 2003, the government developed the Malawi Economic Growth Strategy (MEGS) in 2004, which focused on economic sectors and private sector-driven growth. In 2005, the Malawi Growth and Development Strategy (MGDS) was published, emphasizing agriculture's contribution to economic growth through food crop production and value addition for domestic and export markets. Safety net activities, such as smallholder agriculture input support programs, were introduced to protect the poor from market reforms. In 1996, the Malawi Social Action Fund (MASAF) project implemented cash-for-work in food-insecure areas. Since 2005, the government has implemented a nationwide Agriculture Input Subsidy Programme targeting 2.8 million smallholder farmers, providing over 67 percent subsidy on fertilizer and seed purchases (Dorward et al., 2005). This policy has contributed to increased maize production and reduced the need for expensive maize imports.

2.3 Recent advancements in the agricultural sector in Malawi

2.3.1 History of agriculture in Malawi

Malawi has made significant progress in agriculture development in terms of extension contact levels, extension-farmer ratios, and credit distribution over the 1973-84 period, with annual fertilizer supply increases and cash crop prices staying ahead of inflation. However, it faces

criticism due to fluctuating trends and its narrow development base, particularly in agro-support services.

The farmer club strategy in Malawi during the rate 1980 aimed to channel credit to farmers and facilitate repayment, but only 18.6 percent of smallholder farmers were involved in clubs. Credit levels vary across clubs in four selected districts, with an average of 91.6 Malawi Kwacha for each club member in Lilongwe and a lowest of 30.4 Malawi Kwacha in Ngabu (Sofranko & Fliegel, 1989). Despite a dramatic increase in credit over the period 1977-78 through 1984-85, there was still relatively little credit per farmer or farm household. Credit for members in better-funded Agricultural Development Districts was only 91.6 Malawi Kwacha, slightly more than the required amount for planting a half hectare of maize. Most club members received a smaller amount of credit, and most farmers did not belong to clubs.

The emphasis on farmers, and extension training in Malawi was primarily on enhancing farmers' use of new agriculture inputs and other agriculture innovations or recent advancements. Malawi's extension service experienced significant growth, with a 66 percent increase in field-level technical assistants (TAs) from 1010 in 1977-78 to 1680 in 1985, resulting in a farm assistant-to-farm household ratio of 1:827 (Sofranko & Fliegel, 1989). This ratio was closer to the target of 1:600-700 in agricultural development circles. Malawi's farmer-to-government and non-government extension worker ratio has risen significantly, with a range of 1568-2232 to 1, indicating a poorer situation than in many African countries (Lee et al., 2023). The 1982-83 Annual Agricultural Survey showed that 4% of Malawian farmers had field visits by a Training and Visit Authority (TA), 66 percent attended farming demonstrations, and over 20 percent participated in group meetings under the modified system.

The government has been promoting farmer groups and clubs to facilitate farmers' contact with extension personnel. This approach was based on the realization that staff limitations and information diffusion from model farmers to the general farm population hinder farmers' interaction. Clubs were voluntary, with ideal sizes of 20-30 members, and were encouraged by field assistants. The government put a condition that farmers must function as clubs to receive credit and ensure regular extension contact and the use of appropriate cultural practices.

Agriculture is crucial for human civilization, but it faces challenges like sustainable practices, biotechnology controversies, and policy implications. Malawi's traditional farming systems are declining due to labor-intensive practices. Modern advancements in agriculture can boost productivity, sustainability, and resilience in the face of climate change, food insecurity, and poverty. Advancements in agriculture can help address these issues and shape human civilization in the future.

2.3.2 Overview of recent advancements in the agriculture sector in Malawi

Realizing the importance of recent advancements, the Malawi Government is collaborating with the FAO on a project called Developing Capacities in Agricultural Innovation Systems, aimed at enhancing the country's ability to innovate in the agricultural sector (FAO, 2020). Malawi has made significant strides in the agriculture sector by adopting recent advancements. The recent advancements in the agriculture sector have led to numerous innovations and developments, including conservation agriculture, digital technology integration, water management, energy-efficient farming techniques like solar irrigation systems, precision farming, and new concepts like climate-smart agriculture and Water Energy Food Nexus (McCarthy et al., 2023).

2.3.3 Climate-Smart agriculture

Climate-smart agriculture (CSA) practices are crucial for achieving climate change adaptation objectives, as they enhance agricultural productivity and resilience, and decrease greenhouse gas emissions (Lipper et al., 2014). CSA is an innovative approach to agriculture that aims to strengthen subsistence farming and food security for small-scale farmers by effectively managing natural resources and adopting suitable methods. It considers social, economic, and environmental factors and adapts to climate changes by focusing on farmers' perceptions and socio-economical, geographical, and farm-related properties. Amadu et al.'s 2020 study found that the adoption of the CSA in Malawi led to a 53 percent increase in maize production among CSA adopters during the 2016 drought year (Amadu et al., 2020). Another study highlights that the Malawi Social Action Fund (MASAF), the country's largest public works program, increases the likelihood of farm households adopting CSA practices (Ignaciuk et al., 2021). Malawi faces challenges in promoting the adoption of the CSA due to weak local institutions and poor coordination among many factors.

2.3.4 Conservation agriculture

Conservation agriculture (CA) has gained attention in Malawi as a sustainable farming technique that promotes the control of soil disturbance, soil cover, and crop rotation. FAO (2024) defines Conservation Agriculture as a farming method that prevents arable land loss and regenerates degraded lands. CA encourages the preservation of soil cover to be permanent, minimal soil disturbance, and the diversification of plant species. CA is being promoted in Malawi aiming to address issues like soil degradation, high labor demands, and low and variable yields in conventional agriculture which result in food insecurity. Since the 1990s, third-sector organizations, including Sasakawa Global 2000, World Vision Malawi, and the International Maize and Wheat Improvement Centre, have been driving the promotion of the CA in Malawi (Jew et al., 2020). Additionally, Malawi's National Agricultural Policy (2016) lists 'promote conservation agriculture' as a strategy to promote climate conservation agriculture and largely depends on externally funded projects run by third-sector organizations for a period.

Malawi has been adopting resource-conserving practices under CA such as agroforestry, enhancement of soil fertility, and soil-water conservation. In the recent decade, various technologies have been introduced, including in-situ rainwater collecting methods such as planting pits, swales, and infiltration trenches. Table 2.2 shows resource-conserving technologies used in Malawi (Mloza-Banda & Anthambwe, 2010).

Table 2. 2: Resources-conservation technologies used in Malawi

Soil and Water Management Technologies	Soil Fertility Enhancement technologies
Contour ridging	Agroforestry
Box ridging Contour stone lines	Organic and inorganic fertilizers
Stream bank protection	Liming
Terracing	Residue incorporation
Basin planting	Crop rotation
Storm drains	Improved fallows

(Adopted from Mloza-Banda & Anthambwe 2010)

2.3.5 Digital agriculture technologies (DATs)

The DATs have the ability to transform access to information, goods, and services for Malawi's agri-food operators. DATs are advanced digital breakthroughs that improve production, efficiency, and competitiveness in agriculture. These technologies include the IoT, mobile phones, drones, satellite images, moisture sensors, geographic information systems, and machine learning, which assist farmers, agribusinesses, governments, and development partners in addressing major value chain concerns (USAID, 2022). The digital technologies used in the agriculture sector in Malawi, include mobile phones and remote sensing which provide farmers with timely information on weather forecasts, market prices, and agricultural practices.

The Malawian government has significantly contributed to the implementation and utilization of DATs to enhance agriculture productivity in Malawi. The government is collaborating with DATs to enhance extension services and market information through Esoko and Airtel M'chikumbe platforms (USAID, 2017). Esoko offers analytics, data collection, biometric profiling, and communication services, including weather forecasts, agronomic advice, and market price information via SMS, voice messages, and a call center. Airtel M'chikumbe supplies farmers with practical information regarding agriculture through interactive voice response (IVR) and SMS.

2.3.6 Water-Energy-Food Nexus Conceptual Framework

The WEF Nexus is a framework that focuses on the interconnections and trade-offs between water, energy, and food systems, particularly in Malawi, where challenges like water scarcity, energy deficits, and food insecurity are prevalent. The framework aims to enhance security in all three sectors while also considering various other factors (figure 2.2). Society's consideration of changing human behavior, the economy's various growth approaches, and the environment's promotion of ecosystem sustainability are all contributing factors to the nexus framework (David, 2014). To implement this framework, there is a need to understand individual securities' key aspects and connect them through natural, built, and institutional systems.

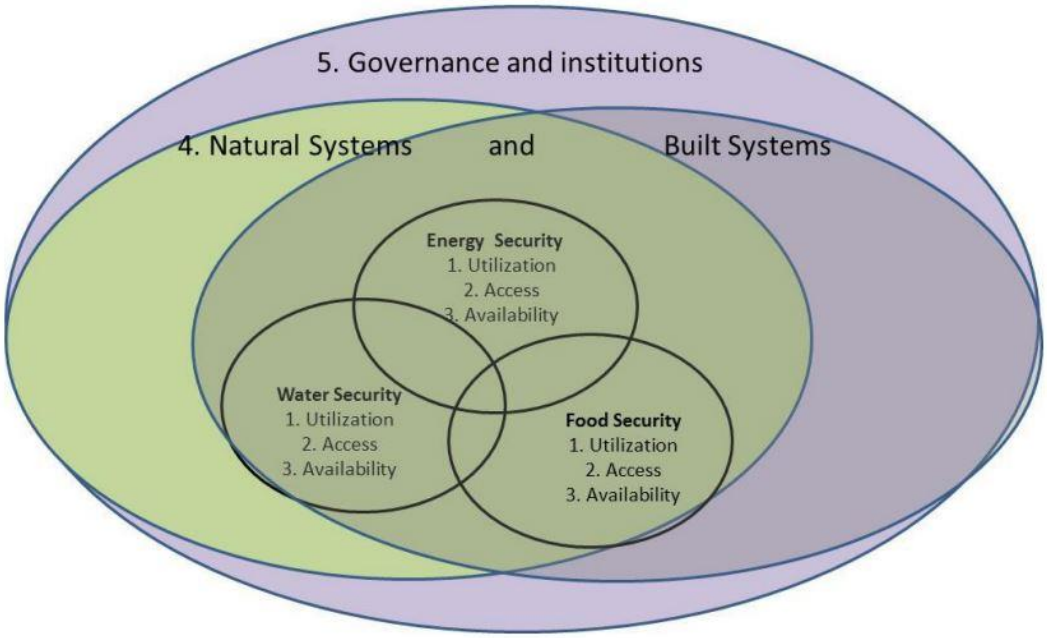

Figure 2. 2: Water, energy, and food framework

Source (David, 2014)

For instance, the natural and built systems, such as irrigated systems for food production and natural water availability, and built infrastructure for transportation, influence food production and energy production. Governance and institutions encompass institutions, policies, and mechanisms for water, energy, and food production, or management. Hence, the WEF nexus thinking emphasizes the importance of integrated management strategies that consider interdependencies and optimize resource use efficiency across various sectors.

2.3.7 WEF Nexus Technologies in Malawi's Agriculture Sector

The use of WEF nexus technologies in Malawi's agricultural sector has the potential to boost water, energy, and food security, improve livelihoods, and promote sustainable development. Understanding and implementing technologies that optimize the WEF nexus thinking in agriculture is crucial for improving productivity, resilience, and sustainability in Malawi's agricultural sector. Despite the WEF nexus concept and technology potential benefits in the agriculture sector, its implementation and adoption remain largely isolated in Malawi, like many African countries.

Malawi has a long history of interconnecting water and energy through hydropower plants and large multipurpose dams. For instance, the Diamphwe multipurpose dam project in Malawi aims to increase water supply, irrigation systems, and generation of hydropower in Malawi (Mati & Kenyatta, 2014). The relationship among water, energy, and agriculture has been forming new interactions that are yet to be thoroughly understood and explored. Energy consumption in crop production and farm operations is significantly increased due to the increasing use of energy-consuming groundwater pumps for irrigation. The Malawi agriculture sector is utilizing the following WEF nexus technologies.

2.3.8 Irrigation technologies

Malawi has abundant water resources as over 20 percent of the country's area is water in the form of lakes and rivers and it also has groundwater. Despite this, only 7 percent of the cultivated land is irrigated while 93 percent of the cultivated area is rain-fed. The agricultural sector in Malawi is significantly hindered by low irrigation development. Malawi has an estimated irrigation potential of over 600,000 hectares, but only 103,000 hectares have been developed (Chafuwa, 2017). The current situation in Malawi has led to a decrease in agricultural productivity, resulting in issues of food insecurity. Low-cost irrigation technologies, and traditional irrigation methods including the use of the furrow, and flood irrigation, are still prevalent in Malawi among the smallholder farmers. Traditional irrigation technologies have been primarily used for small-scale irrigation, primarily targeting low-value crops like maize for food security.

While high-cost irrigation technologies such as motorized pumps are being used by private estates such as Nchalo Sugar Estate. Since colonial times, the private sector has been instrumental in Malawi's large-scale irrigation development, with tea farming in Mulanje and Thyolo being pioneers. The Illovo Group's Nchalo Sugar Estate, the largest equipped irrigation scheme in Malawi, and other estates now boast over 23,200 hectares of irrigated fields. The Illovo Group in Malawi, established in 1965, now owns 13,800 hectares of land under the Nchalo Sugar Estate and 6,000 hectares under the Dwangwa Sugar Estate (World Bank, 2011). Motorized pumps, powered by electricity or diesel generators, can enhance water accessibility by enabling deeper boreholes. However, fuel-powered irrigation systems in Malawi face a lot of challenges due to their dependence on oil prices which is volatile as it changes with the change of Malawian currency which is not stable.

2.3.9 Renewable energy technologies

Renewable energy technologies are gaining global attention for their potential to reduce climate change and promote sustainable development. In Malawi, where grid electricity is limited, integrating renewable energy technologies into agriculture can improve productivity, reduce fossil fuel dependency, and enhance climate change resilience. Malawi's high insolation makes solar photovoltaic (PV) irrigation systems a viable option. Studies indicate that groundwater resources over 20 meters deep are less susceptible to drying and contamination, suggesting they may not require treatment. Solar-powered irrigation pumps offer farmers in Malawi access to water without relying on grid electricity or fossil fuels.

Solar photovoltaic (PV) irrigation systems are increasingly being deployed in Malawi to power irrigation pumps, lighting systems, and other agricultural machinery. Solar pump technology consists of a photovoltaic array connected in series or parallel and an electronic controller that matches PV power to the motor and regulates its operation, electric motor, and pumps. Solar photovoltaic systems offer a sustainable solution while also contributing to the goals of the Sustainable Energy for All (SE4All) initiative.

Solar pumping is being implemented globally due to public capital investment incentives, an energy shortage, and a shift towards greener energy sources. Solar-powered pumps are more efficient and cost-effective than diesel pumps. The policy implications of solar-powered irrigation systems are multifaceted, encompassing environmental, economic, and social aspects. Recent Studies conducted in Malawi revealed that solar-powered systems have the potential to increase crop yields, improve water management, and reduce labor costs for Malawi’s smallholder farmers (Phiri et al., 2023). A similar study conducted in Sub-Sahara Africa (SSA) found that over one-third of unmet crop water requirements for 19 major crops in smallholder, cropland could be met by using solar photovoltaic irrigation systems, which farmers can repay within 20 years (Falchetta et al., 2023).

Despite the benefits of solar-powered pumps, the assessment of the real financial costs of solar pumping systems is complex due to fiscal incentives, commercial policies, and state-controlled markets (Closas & Rap, 2017). While studies suggest government policies and investment, such

as capital subsidies and low-interest loans, can make the solar-powered pumps viable, many project justifications and cost comparisons overlook the cost of these subsidies, leading to market distortions and potential losses for some firms (Closas & Rap, 2017). Studies often overlook the environmental sustainability of using solar-powered irrigation due to assumptions about unlimited groundwater availability and stock. However, poor valuation of water abstraction rates and unrealistic assessments of hydrogeological variables can reduce project life spans.

For instance, in Morocco, targeted subsidies for solar pumping have been put on hold due to groundwater resource depletion (Closas & Rap, 2017). Studies indicate that while solar irrigation systems may have positive impacts, they may also have negative effects in Malawi. For instance, a modeling study conducted in Malawi found that Lake Malawi discharges into the Shire River is critical to Malawi's WEF security. The study revealed that potential irrigation expansion, including the use of solar irrigation, could result in low lake levels and downstream flood risks in Malawi (Bhave et al., 2022). Despite the negative impacts of the adoption of WEF nexus approaches, food security will only be achieved in Malawi through the implementation of WEF nexus policies.

The possibility of the achievement of sustainable food security is possible through cautious and integrated policy implementation in the WEF nexus (Fader et al., 2018). As in developing countries, most especially in Sub-Saharan Africa, poverty and food insecurity reduction are vital policy goals (Sinyolo et al., 2014). Creating policies that promote the sustainability of water, energy, and food resources while ensuring accessibility to all societal levels is a significant challenge in Malawi (Simpson and Jewitt, 2019). The relatively poor households find it always challenging to access resources, constraints include but are not limited to, affordability, and availability.

Non-governmental organizations are at the forefront of promoting solar irrigation in Malawi, for example, Concern Worldwide introduced a solar pump scheme that can be used for three hours before recharging for half an hour (Concern Worldwide, 2023). The government of Malawi is also supporting solar-powered irrigation through different projects. For instance, the government has allocated nearly $28 million for the National Environment and Natural Resources Management

(ENRM) project, which includes the installation of a solar-powered irrigation system along the Shire River. Nearly 450 farmers currently own land where solar panels were installed.

Furthermore, the government of Malawi, with Global Environment Facility support, has launched a 4.4 million US dollars five-year project to mitigate climate change's effects on vulnerable rural communities in the Lake Chilwa basin (UNDP, 2023). The project aims to reduce the country's greenhouse gas emissions by transitioning away from maladaptive practices that degrade natural resources. The project enhances small-scale producers' access to profitable markets for the use of climate-resilient practices, including sustainable agriculture, briquettes, and eco-tourism. Briquettes, a renewable energy technology, provide an eco-friendly method for generating energy from agricultural waste, reducing reliance on traditional biomass fuels and reducing greenhouse gas emissions.

2.4 Opportunities and Challenges of Implementing WEF Nexus Approaches and Technologies in the Agriculture Sector

The implementation of the WEF nexus framework in Malawi's agriculture sector has the potential to address sustainable resource management challenges, enhance productivity, promote sustainable development goals, and ensure food security (Zheng & Lam, 2024). The use of WEF Nexus strategies in the agriculture sector aligns with the Sustainable Development Goals (SDGs), focusing on poverty alleviation, food security, clean water, and affordable energy access (Davide et al., 2022). By adopting integrated strategies that address multiple dimensions of development, Malawi can make significant progress toward achieving these SDGs while promoting sustainable agricultural practices. The widespread adoption of WEF nexus technologies is hindered by high initial investment costs, lack of technical expertise, and insufficient financing access (Upadhyaya, 2016).

Furthermore, the current sectorial policy and regulatory frameworks in Malawi often fail to fully support the integrated nature of WEF nexus approaches, resulting in fragmented and inefficient resource management. Poorly regulated subsidies targeting specific sectors, such as crop production, can lead to wasteful use of groundwater resources, posing a threat to agricultural productivity (Ringler et al., 2013). In Malawi, initiatives are underway to integrate the WEF nexus concept into government policies and objectives. The National Irrigation Policy (2016), for example, prioritizes the development of sustainable irrigation systems and encourages the use of

efficient irrigation technologies. Similarly, measures promoting renewable energy, such as the National Energy Policy and the Renewable Energy Strategy, seek to speed up the use of clean energy solutions in agriculture. Hence, policy is crucial for promoting the operationalization of the WEF nexus to optimize water, energy, and food resources.

2.5 Overview of agricultural policies related to Water, energy, and food Nexus in Malawi

Currently, in most African countries, Malawi inclusive, their policy frameworks are developed based on a sectorial approach neglecting the cross-sectoral approach. This approach creates a gap in the implementation of the WEF nexus approach, and also demand and supply of WEF resources.

2.5.1 The water sector policies

Malawi has abundant freshwater resources which cover 21% of the country's land area (Nhamo et al., 2016). The freshwater resources include Lake Malawi with an area of 28, 750 square kilometers is Africa's third biggest fresh lake; Lake Malombe is an inflation of the Shire River that forms part of the East African Rift Valley; Lake Chirwa is an inland lake basin; and a dense network of perennial rivers (Nhamo et al., 2016). Groundwater is also another water resource in Malawi which is composed of two major aquifers, the basement complex aquifers, and the alluvial aquifers.

Despite Malawi having abundant water resources, poor water governance coupled with the recurrence of extreme weather events such as drought and flooding in recent years has resulted in increased water, energy, and food insecurity. The country is water-stressed with less than 1700 m3 of freshwater per capita and the Minister of Water and Sanitation recognizes that Malawi will be water-stressed by 2025.

The following are related policies, legislations, acts, and strategies that are relevant to Malawi's water sector.

- Waterworks Act (1995). The Act authorizes the Minister in charge of water resources to declare water resources areas and form a Water Board for each area. Except for water supply in rural areas, the Board regulates and manages waterworks, supply, and distribution. It also has the authority to the construction of waterworks and certain rights over private property. The Act establishes standards for public water supply and sewage system operation, oversees board actions, and makes damaging waterworks and polluting water sources an offense. It also includes provisions for private land rights.

- Water Resources Act (1969). This Act governs the management, conservation, allocation, and use of water resources. It establishes the Water Resources Board and governs it on the distribution of water rights to use public waters and conduct inspections of water works. It also prevents the contamination of public water. The act also empowers the Minister responsible for water to designate regulated areas to develop a natural resource development plan.

- Water Resources Regulation (1969). The regulations were enacted under Section 24 of the Water Resources Act of 1969. It prescribes the rules regulating the application and the granting of water rights concerning surface water and groundwater by the Water Resources Board. The regulation is guided by section 10 of the Water Resources Act of 1969.

- Water Resources Regulation (1978). The regulations set out ways to prevent or decrease water pollution in Malawi. It states that, without the Minister's clearance, no one may build septic tanks more than 220 yards from a borehole, or septic tanks larger than 5000 gallons. It also encourages wells to be constructed in such a way that water is not polluted. Furthermore, it says that prohibits the effluents discharged into public water without the Minister's written approval. Applications for approval must be in the form provided in the Schedule under the regulation. It gives power to the Board to publish applications and consider them together with objections.

- National Water Policy (2005). The 2005 National Water Policy tackles all elements of water management, including water resource development and service delivery following current global and regional trends and requirements reflected in the Millennium Development Goals and Sustainable Development Goals. Its goal is to supply clean and safe water in sufficient quantity, as well as to assure the availability of efficient and effective water and sanitation services that meet the basic needs of every Malawian and contribute to the enhancement of the country's natural ecosystems. One of its goals is to encourage public and private sector involvement in water resource management, development, supply, and conservation. The policy is based on the notion that everyone should have access to safe

drinking water and proper sanitation services to limit the prevalence of water-related diseases. This strategy prioritizes the conservation and utilization of water resources over all other uses.

- Water Resources Act (2013). The act recognizes the importance of water to human survival and the variety of functions it offers. The law specifies the steps to be followed for water abstraction for both individuals and businesses. The processes outline the actions that must be performed to acquire water, beginning with the process of sending formal notices to persons with existing property interests and ending with the payment of compensations and formal ownership transfer. It has laws governing water use authorizations or permit systems, and it enforces the effective dates when such permits became effective and how they were implemented. It also contains rules and laws that are utilized to put permit systems in place. Registration of Existing Rights, Licensing of Water Abstraction and Use, Surface Water Management, Development and Administration, Groundwater Management, Development and Administration, Water Quality Management and Pollution Control, Water Works, Conditions of Authorization, Permits and Approved Water Uses, and Water and Effluent Charges.

- Water Resources Regulation (2018). These Regulations address a wide range of water resource management issues and implement the Malawi Water Resources Act. The Regulations will apply to any policies, plans, programs, and activities that are covered by the Act. It has 176 regulations which are organized into fifteen parts: preliminary; registration of existing rights; water use and abstraction licensing; surface water management, development, and administration; groundwater management, development, and administration; management of water quality and control of pollution; waterworks; conditions of authorization, permits, and approved water uses; water and effluent charges; conservation of riparian and catchment areas; catchment management; protected catchment areas; the water reserve; qualified professionals and contractors; and other provisions.

2.5.2 The agriculture sector policies

The following are related policies, legislations, acts, and strategies that are relevant to Malawi's Agriculture sector.

- The Malawi Agenda 2063 (MW2063). MW2063, Malawi's long-term development roadmap, was introduced in January 2021 and focuses on three important pillars: agriculture productivity and commercialization, industrialization, and urbanization. From 2021 to 2030, it will be guided by the first 10-year implementation Plan (MIP-1) and focus on agriculture diversification, irrigation development, anchor farms, agriculture inputs, mechanization, structured markets, and research.

- The National Irrigation Policy (2016). The policy is mandated to address critical issues affecting the irrigation sector in Malawi by improving incomes, food security, irrigation service delivery, employment opportunities, and land and water productivity. It aims to achieve its goals through sustainable land tenure arrangements, catchment management, and water harvesting while considering climate change irrigation technologies.

- The National Agriculture Policy (2016). The National Agriculture Policy (NAP) strives for long-term agricultural transformation, which will result in significant sector growth, higher farm household incomes, better food and nutrition security for Malawians, and enhanced agricultural exports. (NAP) aims to provide comprehensive policy guidance in Malawi's agriculture sector, with eight priority areas which include sustainable agricultural production and productivity, sustainable irrigation development, agricultural market development, agro-processing and value addition, and food and nutrition security.

- The National Nutrition Policy (2013). The National Nutrition Policy in Malawi aims to enhance the nutritional status of all Malawians, with a particular focus on vulnerable groups. The Malawian state is obligated to implement policies and legislation promoting adequate nutrition, good health, and self-sufficiency, in line with the Millennium Development Goals and the Malawian Constitution. Access to nutritious food is a fundamental right for each individual in Malawi.

- The Malawi Food Security Policy (2006). The Food Security Policy is a national instrument aiming to enhance population food security through increased agricultural productivity, diversity, and sustainable growth and development, utilizing a multi-sectoral approach.

- National Fisheries and Aquaculture Policy (NFAP) (2016). The NFAP is a five-year amendment to Malawi's 2001 policy that aims to solve major concerns in fisheries and aquaculture development. The policy emphasizes strengthening monitoring and evaluation, utilizing Public-Private Partnerships, and aiming for sustainable growth in fisheries and aquaculture productivity for nutritious food and economic growth.

- The National Agricultural Investment Plan (2018). The NAIP is a five-year plan by Malawi's government, aimed at implementing the 2016 National Agriculture Policy, focusing on medium-term investment to accelerate agriculture transformation, economic growth, and poverty reduction.

2.5.3 The Energy sector policies

The following are related policies, legislations, acts, and strategies that are relevant to Malawi's Energy sector.

- Energy Regulation Act (2004). The act established the Energy Regulatory Authority to regulate and control the production and distribution of energy from both renewable and non-renewable sources.

- The National Energy Policy (2003). The policy offers a transparent and dynamic operational framework, with guidelines on energy development, supply, use, distribution, pricing, and industry governance. The policy also aims to create a more liberalized, private sector-driven energy supply industry, ensuring pricing reflects competition and efficiency. for Malawi's Energy Sector. It also provides guidelines on energy development, supply, use, distribution, pricing, and industry governance. It also aims to transform the country's energy economy from a biomass-dependent one to a modern energy mix.

- The Malawi Energy Policy (2018). The policy intends to increase Malawians' access to affordable, dependable, sustainable, efficient, and modern-day energy services. It includes an Implementation Plan and a Monitoring and Evaluation Plan with time-bound deliverables, outlining updated goals, objectives, strategies, and priority actions. It reflects the latest developments in the energy sector and new national goals.

2.6 Chapter conclusion

The literature review highlights Malawi's agricultural sector's significant advancements, such as climate-smart agriculture, Conservation Agriculture, Digital technologies, and the Water Energy Food Nexus. However, these advancements face challenges due to a lack of a comprehensive environment and conflicts from sectorial policy approaches. Understanding these issues is crucial for developing effective policies promoting sustainable practices and addressing complex interdependencies in Malawi.

CHAPTER 3: METHODOLOGY

3.1 Chapter Overview

This chapter discusses the methods used to collect and analyze data for the study. It describes the study area, study population, and data collection techniques employed in the study. This section also discusses data processing and analysis, as well as the study's limitations.

3.2 The study area

The study will be conducted in Malawi, a landlocked country located in Southern Africa, between latitudes 9°S and 17°S and longitudes 33°E and 36°E. The nation borders with Mozambique, Tanzania, and Zambia. Malawi has a population of approximately 20.4 million and covers an area of 118,480 km2, with surface water resources totaling 28,760 km2, the majority of which is Lake Malawi (World Bank, 2023a). The country is divided into 28 districts and three regions: northern, central, and southern (Figure 3.1).

Figure 3. 1: The Study Area - map of Malawi

Source (Ezilon Maps, 2015)

3.3 Climate of Malawi

Malawi has a subtropical climate and is affected by the Inter-Tropical Convergence Zone (ITCZ), which is located over Malawi, as well as other important systems such as the Congo Air and the South-Easterly winds (Zuza et al., 2021). The country experiences two seasons: the rainy season starting in November to April which receives approximately 95 percent of annual precipitation which ranges from 600mm to 3,200mm, and the dry season (May to October) (Kambauwa et al., 2015). Malawi has an average annual minimum and maximum temperatures of 12 and 32°C, respectively, with the lowest in June and July and the highest in October. Malawi's geography, as well as its closeness to the Indian Ocean and Lake Malawi, affect the local patterns of temperature and precipitation. Furthermore, Climate change was projected to pose a danger to the southern African sub-region (including Malawi) by significantly affecting water availability, people's health, natural biodiversity, agriculture and food security, ecosystems, and environmental migration.

3.4 Political Landscape for Malawi

The country has a multiparty democracy and the president is elected through voting and runs the country for a five-year term. The President of Malawi serves as both the head of state and the head of government. The government exercises executive power. The administration and the National Assembly each have legislative power. The National Assembly is made up of Members of Parliament (193) who are elected directly in single-member constituencies by simple majority and serve five-year terms. Malawi has a cabinet, which is appointed by the president. The judiciary in Malawi operates independently of both the executive and the legislature.

In July 1964, Malawi gained its independence. The country was administered as a one-party dictatorship system by Hastings Banda from the Malawi Congress Party until 1994 (W. Chirwa et al., 2000). In the early 1990s, pressure mounted on the regime to democratize. A multi-party democratic system was formed in 1994 following the victory of pro-democracy forces in a referendum in 1993. The country's sixth tripartite election was held in May 2019. In February 2020, the Constitutional Court nullified the presidential results. On June 23, 2020, the Malawi Congress Party's Dr. Lazarus Chakwera and the United Transformation Movement Party's Saulos Chilima were elected as president and vice president, respectively (World Bank, 2023b).

3.5 Research design and approach

The study used a case study research design. A case study is defined as a thorough assessment of one or more subjects of study and their contextual settings (Sovacool et al., 2018). This study selected one recent advancement to examine the conflict in agricultural policies in accommodating recent advancements in the agricultural sector in Malawi. The study employs a qualitative research approach in collecting and analyzing data. Qualitative research involves analyzing non-quantifiable data, including opinions, attitudes, perceptions, and understandings of people and groups in various contexts (Sovacool et al., 2018). Qualitative research methods are open-ended and use multiple data sources like interviews, observations, documents, and audio-visual information, allowing participants to freely share their ideas without predetermined scales (Creswell & Creswell, 2018). This study included policy document reviews and key informant interviews with policymakers, experts, farmers, and key stakeholders to collect primary and secondary data hence using this approach.

3.6 Study population and sample selection

The population for this study included respondents from major government ministries (water, energy, and agriculture), regulatory institutions, research institutions, non-governmental organizations, farmers, and other relevant key stakeholders involved in the selected recent advancement in the agriculture sector. Participants were chosen through a preliminary literature search on key actors involved in recent advancements in the agriculture sector in Malawi.

A purposive-non-probability sampling method was employed to select twenty-eight key informant respondents who have vast knowledge and expertise related to the selected recent advancement in the agriculture sector in Malawi. Furthermore, ten policy documents were purposelessly sampled for document analysis. The policy documents included the Agriculture Sector Wide Approach, Malawi Vision 2063, National Agriculture Policy, National Irrigation Policy, Malawi's Farm Input Subsidy Program, National Water Policy, Water Resources Act, Water Resources Regulation, Malawi tax incentives, and the Malawi Energy Policy. Purposive non-probability sampling is a method that intentionally selects a sample based on the study's requirements. A purposive non-probability sampling method was ideal for this study because the researcher wanted to gather in-depth information from key informants with extensive knowledge or experience, ensuring the researcher had complete control over the selection of sample units (Shaheen et al., 2018). The

respondent received a semi-structured questionnaire before the interview. Table 3.1 below shows the 28 participants for this study.

Table 3. 1: Research target population

Institution Name	Category of Institution	Number of Participants	Respondent Code
Farmers	Farmers	12	P_1 to P_12
Ministry of Water and Sanitation Representatives	Government	2	P_13, P_14
Ministry of Energy Representative	Government	2	P_14, P_15
Ministry of Agriculture Representative	Government	2	P_16, P_17
Mzuzu University	Research or Academic	2	P_18, P_19
Lilongwe University of Agriculture and Natural Resources	Research or Academic	2	P_20, P_21
Malawi University of Science and Technology	Research or Academic	1	P_22
Natural Water Resources Authority	Regulatory Authority	2	P_23, P_24
FAO	Non-Governmental Organization	1	P_25
Foundation for Irrigation and Sustainable Development (FISD)	Non-Governmental Organization	1	P_26
Department of Agriculture Research and Technical Services	Government	2	P_27, P_28
Total Respondents		28	

3.7 Methods and instruments of data collection

The study used two types of data-collecting methodologies to collect primary and secondary data. The primary data were collected through interviews with key informants which included policymakers, experts, farmers, and other key stakeholders. Written semi-structured open-ended questionnaires were used as data collection instruments. Face-to-face or phone calls interviews with key informants were also used to collect primary data for the study. This method ensured thematic coherence and comparability, allowing participants to discuss topics of interest in greater depth. The written questionnaire was in English language but was translated into Chichewa (Malawi local language) to get proper responses from respondents. The interviews were audio recorded, with brief notes taken during the interview process. The responses were later transcribed and translated into English.

The document review was used as a second method of data collection to collect secondary data. Document review or analysis is a systematic method used to review and evaluate printed and electronic materials to interpret data, extract meaning, understand, and develop empirical knowledge (Bowen, 2009). The review is an iterative process that involves skimming, reading, and interpretation, combining content and thematic analysis elements. The study used a variety of published and unpublished documents, including reports, policy documents, online sources, journal articles, thesis dissertations, and books. The study used literature as secondary data sources to supplement primary data from interviews, based on its relevance to the study topic. The study employed the two data collection methods and various evidence sources to validate its findings.

3.8 Data analysis

The study used both thematic and content analysis to analyze the qualitative data. Thematic analysis was used to analyze data collected through interviews and focused group discussions. Thematic analysis is a qualitative descriptive method used to identify, analyze, and report patterns or themes within data (Braun & Clarke, 2006). The researcher transcribed the audio recordings and cross-checked them with short notes for additional information. Thematic analysis was employed to identify key themes related to selected recent advancements in Malawi's agriculture sector through multiple reviews of the interview transcriptions. The method was employed due to its flexibility in identifying and describing themes within the data set (Dawadi, 2020).

Content analysis was used to analyze secondary data obtained through document review. Content analysis is a systematic method used to analyze text, focusing on trends, patterns, frequency, relationships, and communication structures (Knapp et al., 2005). It is a systemic coding and categorizing approach that helps uncover the characteristics of a document by examining who says what, to whom, and with what effect. This approach helps to understand the communication structures and discourses within a large amount of textual information. The study used NVivo 14 software for data coding based on the study findings.

3.9 Ethical considerations

The researcher collected an introductory letter from PAUWES which was presented to the Ministry of Water, energy, and Agriculture to authorize data collection. The study also maintained the confidentiality of the names and contact information of the respondents involved. Respondents were given a full explanation of the purpose of the research and their participation in the research was voluntary. Each data-collecting instrument included a preamble that described the study's main objective and assured respondents that the data gathered would be used solely for academic purposes and that respondents would be kept confidential and anonymous. Any quotation from respondents used to support findings excluded any personal identifications.

3.10 Study limitations

I. Challenges in accessing parts of Malawi for data collection as the study was conducted during the rainy season. This raised ethical concerns regarding the safety and well-being of respondents. However, the researcher issued the health safety of the respondents by giving them hand sanitizer and facemasks during time of the interview.

II. Political and administrative challenges arose as government officials and policymakers were preoccupied with other important office matters, diverting their attention away from discussions concerning agriculture policy. This increased the time required to identify and meet with responders for interviews. It also restricted the number of female respondents due to their availability. Nonetheless, data was collected despite the limits.

III. Financial Challenges such as the research budget were affected by conducting the study during the rainy season causing potential delays, additional travel expenses, rainfall protective equipment expenses, and a high rate of inflation in Malawi.

IV. Time limitations. The four months' time for research was not sufficient to look for research internship placement place and to gather comprehensive data, analyze it effectively, and draw meaningful conclusions. This limitation could potentially impact the study's ability to capture the complexity of the issues at hand and explore all relevant factors influencing agricultural policy conflicts.

CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 Chapter overview

This chapter highlights the findings of the study based on analysis of focused group discussions interviews, and documents analysis. It examines the conflicts in agriculture policy in accommodating recent advancements in Africa's agriculture sector, with a focus on Malawi and the Water, Energy, and Food Nexus concept. The chapter discusses opportunities and challenges of adopting WEF nexus thinking in agriculture sector in Malawi compared to the traditional farming methods. Qualitative data from both primary and secondary sources are combined to create a systematic view of the outcomes. Malawi's case study offers a comprehensive overview of the agricultural sector's issues and potential.

4.2 Background information of participants

The interviews conducted in Malawi focused on examining the views of experts and farmers on conflicts in agriculture policy in accommodating recent advancements such as the WEF nexus concept in the agriculture sector in Malawi. The interviews ensured that adequate opportunities were given to representatives across various sectors (water, energy, and food) to contribute to the study. However, since the interviews were based on convenience (willingness to participate, knowledge and experience in the subject area, and the availability for the various interview sessions, the participants leaned towards male domination as opposed to females) 71% of respondents were male (Table 4.1). The study's findings were not significantly influenced by biases, as the information provided aimed to identify opportunities and challenges for integrating recent advancements into agricultural policies in Malawi and identify gaps in policies. The participants' years of experience in the agriculture sector and the number of years doing farming for farmers were used to assess the validity and reliability of their responses. Over 80% of study participants had at least five years of experience, indicating familiarity with the context and suitable suggestions (Table 4.1). In addition, over 90 percent of experts had Bachelor's degrees, Master's, and a PhD as their maximum qualification level indicating more knowledge in their field. Furthermore, focused group discussions with farmers and experts also ensured the validity of the suggestions from the key informant interviews.

Table 4. 1: Respondent's background information

Respondents	Number of respondents	Gender		Education Level					Years of Experience/Farming	
		Male	Female	Primary	Secondary	BSc Degree	Masters	PhD	Max	Min
Experts	16	11	5	0	1	5	9	1	19	5
Farmers	12	9	3	10	2	0	0	0	20+	5
Total	28	20	8	10	3	5	9	1		

4.3 Selecting WEF Nexus and Technologies as a case study of recent advancements in the agriculture sector in Malawi

In Malawi, a landlocked Sub-Saharan African country, agriculture plays a major role in the economy, contributing approximately 30% to the National Gross Domestic Product (GDP) and generating over 80% of national export earnings (Mwahafa Rafael et al., 2023). The agriculture sector is the greatest water user, accounting for around 79% of all irrigation water consumed yearly, and 98% of electricity is generated from hydropower installed along the Shire River (IWA, 2015). The large population of Malawians depend on rainfed agriculture which is vulnerable to the impacts of climate change, resulting in food insecurity. For example, over 5.4 million Malawians residing in rural areas are experiencing food insecurity (Malawi Government, 2022). Hence, low food production has an impact on both the people and the economy. Climate change is also causing an increase in water scarcity, a decrease in water quality, an increase in water and soil salinity, biodiversity loss, and an increase in irrigation requirements. To address these challenges, Malawi

is adopting recent advancements in the agriculture sector such as the WEF concept and technologies.

The WEF nexus concept has been chosen because, the Ministry of Forestry and Natural Resources, in partnership with the Southern African Development Community (SADC) Water Division, the Global Water Partnership-Southern Africa (GWPSA), and the Malawi Water Partnership, hosted the Malawi Water, Energy, and Food (WEF) Nexus Dialogue on December 20, 2021 (GWP, 2022). The discussion focused on the WEF Nexus concept's potential to alleviate poverty, improve climate change adaptation, and boost social-economic development in Malawi.

The WEF Nexus is also closely linked to the Malawi Vision 2063, Malawi's Growth and Development Strategy III, and Sustainable Development Goals making it easy for the government to incorporate it into the Agriculture sector, but its interdependencies are not being adequately addressed. Other supporting policies include the National Water Resources Policy (2005), the National Energy Policy (2018), and the National Agriculture Policy (2016). On the national level, the water, energy, and agriculture sector representatives shortlisted five WEF nexus investment projects for potential screening through the WEF Investments Screening Tool. The projects include the Mpatamanga Hydro-power, the Malawi Watershed Services Improvement Project, the Songwe River Basin Development Programme, and the Agriculture Sector Wide Approach.

Additionally, the WEF nexus concept has been chosen as it can be scaled up in Malawi on a local level due to the increasing interplay between water, energy, and agriculture sectors, with crop production relying on energy-consuming groundwater pumps, resulting in significant energy consumption in pumping and farm operations. Solar water pumps and powered irrigation are currently being used in Malawi to increase agriculture production. The government of Malawi introduced the Greenbelt Initiative in 2011 which is aimed at intensifying irrigation farming by encouraging smallholders and commercial farmers to harness Malawi’s water resources, particularly Lake Malawi (Chinsinga, 2017a). Further, the government is offering investors land for farming near the country's three lakes and perennial rivers in exchange for 1 million hectares of irrigated farmland and settlement relocation.

The government of Malawi is also committed to transforming agriculture production through large-scale farming, specifically mega-farms, which will serve as centers of production and attract

private markets for inputs and outputs, supporting surrounding farmers (Gondwe et al., 2022). One of the Mega Farm initiatives includes the promotion of irrigation such as solar water pump powered irrigation systems offering the opportunity to investigate the WEF nexus concept. The Malawi Government is implementing the Agricultural Commercialization Project with World Bank support, focusing on small-scale irrigation infrastructure to increase irrigation capacity. The WEF nexus concept has the potential to improve Malawi's agriculture sector.

Lastly, several studies have examined the WEF nexus thinking in the context of Malawi, highlighting the necessity for integrated approaches to resource management and policy development. For example, research by Ngwira et al. (2018) emphasizes the importance of considering trade-offs and synergies among water, energy, and food resources in agricultural planning and decision-making. Similarly, Manda et al. (2020) underscore the part of renewable energy technologies in enhancing water and energy security in smallholder farming communities.

4.4 Opportunities and challenges of WEF nexus compared to the traditional form of agriculture in Malawi

The use of recent advancements in the agriculture sector in Malawi has the potential of enhancing food security and ending poverty. The use of WEF nexus in the agriculture sector holds promise in addressing critical gaps in food security, water access, and energy availability. This section discusses the opportunities and challenges associated with the use of the WEF nexus concept in Malawi’s agriculture sector. The section specifically explores the integration of solar irrigation systems into the agricultural sector in Malawi.

4.4.1 Opportunities of WEF nexus specifically the use of solar-powered irrigation in Malawi rural areas

Enhanced water management: The integration of water, energy, and food systems offers sustainable development opportunities, particularly in Malawi's agriculture sector. Solar-powered irrigation can address water scarcity during the dry season and energy constraints by harnessing abundant solar energy available in Malawi for irrigation (Malunga, 2021). This can boost agricultural productivity, thereby increasing food production and enhancing food security for local communities.

In Malawi, where agriculture plays a pivotal role in the economy and livelihoods of its people, the adoption of solar-powered irrigation systems presents numerous opportunities. Firstly, the use of solar-powered irrigation tackles the issue of unreliable electricity supply, particularly in rural areas, where nearly 95% of Malawi's rural population lacks access to electricity (Aung et al., 2021). The limited access to electricity in rural areas in Malawi has hindered the implementation of conventional irrigation methods. By tapping into solar energy, farmers in Malawi can address this limitation, ensuring consistent access to water for crop irrigation. Respondents from both farmers and experts also agreed as follows:

"… using solar water pumps has helped me to plant different types of crops three to four times a year compared to my old traditional farming method where I only planted once a year. I am very happy as this farming method improves the efficiency and productivity of my farming operations as it enables me to optimize water and energy resources usage, resulting in higher yields and reduced labor costs compared to traditional methods…" (P_4 and Farmer).

Farmers and experts in Malawi affirmed that Solar water pumps have the potential to revolutionize agricultural practices, increasing planting frequency, efficiency, and productivity. They provide a reliable, sustainable energy source, allowing precise water distribution and scheduling, and allowing farmers to increase crop yields while minimizing water wastage. Solar-powered irrigation optimizes resource usage, especially in regions with high energy costs and low rate of electrification rates. This reduces reliance on fossil fuels and minimizes environmental impact. Solar water pumps lead to higher yields, reduced labor costs, improved profitability, and sustainability, highlighting the transformative potential of renewable energy technologies.

In addition, a focused group discussion with farmers and experts also affirmed that Solar-powered irrigation systems offer farmers a reliable alternative to unpredictable rainfall, reducing their dependence on unpredictable rainfall and ensuring a consistent water supply for crops. The discussion also revealed that solar-powered irrigation systems also provide greater control over their water supply, allowing them to be deployed in rural areas with limited electricity access. This allows farmers to optimize water usage, leading to improved water management practices and potentially higher crop yields. The potential of solar-powered irrigation systems in enhancing

water management in agriculture is significant, as they harness renewable energy sources and provide a promising solution to climate change and erratic rainfall.

Spurs economic development: Solar-powered irrigation and other recent advancements can stimulate economic development in rural areas by increasing crop yields, and creating opportunities for entrepreneurship and job creation (Chirwa et al., 2008; Phillips et al., 2021). The installation and maintenance of these systems create job opportunities. The use of WEF nexus technologies such as solar-powered irrigation systems can empower local communities by allowing farmers to harvest crops more than once a year and enhancing crop yields. The initial financial gain can enable farmers to invest in critical infrastructure like irrigation systems and buy hybrid seeds, bolstering agricultural productivity and resilience in the face of climatic uncertainties. Additionally, solar-powered irrigation systems and other technological innovations can have broader socio-economic ramifications by reducing the labor burden on farmers, freeing up resources for additional income-generating endeavors or personal pursuits, and enhancing overall well-being and livelihoods. The respondents from both farmers and experts also agreed as follows:

"...one notable outcome highlighted was the increased food production attributed to the use of solar-powered irrigation methods…" (P_20 and expert).

Another participant also said:

"...it helps farmers, especially in rural areas to achieve food security using a small piece of land to grow crops since farming is no longer seasonal but they can also do winter cropping. In turn, it helps farmers fight the effects of climate change, increasing crop yield hence increased financial benefits for farmers…"(P_22 and expert).

Figure 4. 1: Showing solar powered irrigation system

Another responded also affirmed that:

*"... when I started using solar powered irrigation farming, I no longer get tired as I used to be when using the traditional farming method of irrigating with water canes. Additionally, this farming method is very simple to use, even my niece is able to operate the systems when I have traveled to attend to other important business in town...." (*P_10 and farmer).

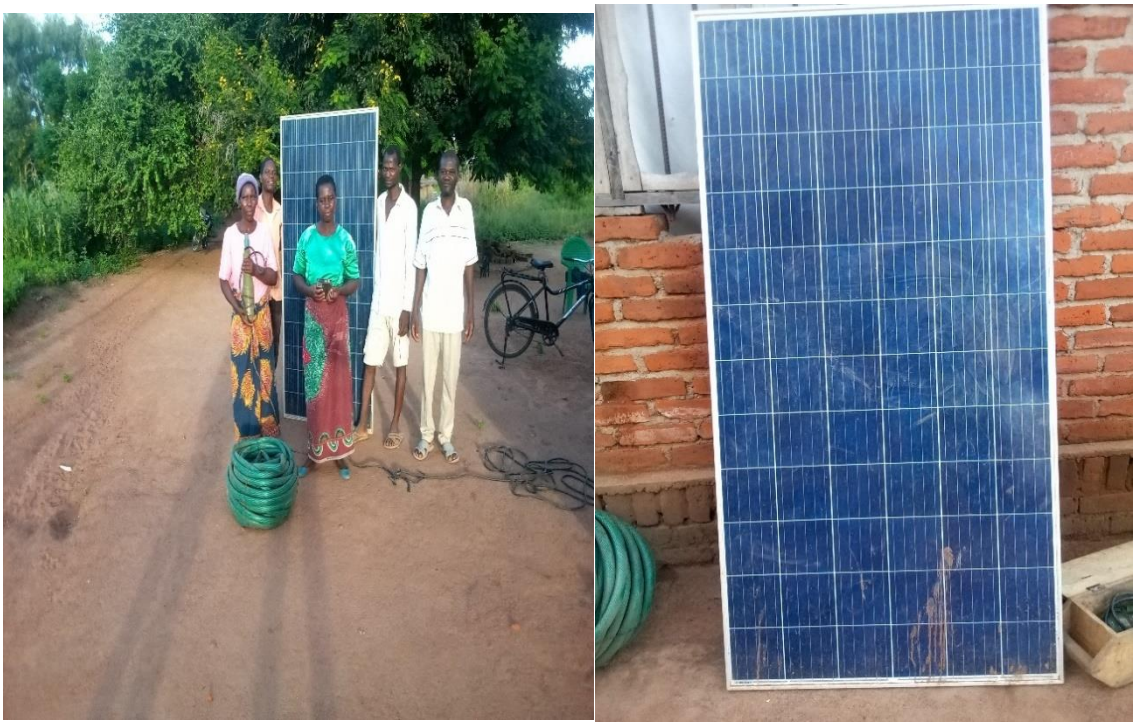

Figure 4. 2: Showing movable solar irrigation system

Both respondents (farmers and experts) plus the two focused group discussions revealed that using Solar-powered irrigation and other recent advancements in the agriculture sector offers numerous benefits, including increased food production and food security for rural farmers. It allows cultivation on small plots of land throughout the year, transcending seasonal farming limitations. This versatility also helps combat climate change impacts, enhancing crop yields and financial gains for agricultural practitioners. It also facilitates winter cropping and equips farmers to combat climate change.

Gender empowerment: Malawian women have an important role in agriculture, producing 70% of the country's food (Vincent & Mkwambisi, 2017). However, land rights and regulations limit their agricultural holdings to only one-third of agriculture. Women frequently obtain land through the family head (male), resulting in restricted control over land and yields. Female-managed plots are 12 percent smaller and 25 percent less productive, owing to varying expertise and availability of inputs for increasing farming efficiency (Vincent & Mkwambisi, 2017). Furthermore, women are also affected by gender roles which reduces their labor availability. Solar-powered irrigation systems and other agriculture innovations offer women farmers the opportunity to break free from the restriction of growing on a small piece of land and the dependency on seasonal rainfall,

extending the growing season and diversifying agricultural activities. This empowerment can lead to augmented household income and improved nutrition in Malawi, mirroring successful implementations observed in other regions.

Climate change mitigation: Additionally, the implementation of solar-powered irrigation aligns with climate change mitigation efforts by reducing greenhouse gas emissions associated with conventional energy-intensive irrigation methods. The respondents agreed that solar-powered irrigation and other recent advancement in the agriculture sector can help farmers in Malawi adapt to unpredictable weather patterns, such as erratic rainfall and cyclones, which negatively impact agricultural productivity in Malawi. By harnessing solar energy, farmers can reduce their reliance on rainfall and adapt more effectively to changing climatic conditions. This contributes to environmental sustainability and resilience, mitigating the adverse impacts of climate change on agricultural productivity. The respondents from both farmers and experts also agreed as follows:

"... I think one of the biggest opportunities with solar-powered irrigation in Malawi is its potential to provide a reliable water source for our crops, especially during dry seasons. Our traditional farming methods heavily rely on rainfall, which can be unpredictable…."(P_1 and Farmer)

Another participant also affirmed that:

"... solar-powered irrigation helps me to solve the effects of climate change and reduce my farming dependency on erratic rainfall patterns. It offers me a chance to have more control over our water supply to my field…."(P_10 and Farmer).

Farmers in Malawi are highlighting the transformative potential of solar-powered irrigation systems and other recent advancements in the agriculture sector in addressing challenges faced by traditional farming methods. The systems offer a reliable water source, especially during dry seasons, which is crucial for food security and agricultural productivity in areas with water scarcity due to climate change. Solar-powered irrigation also helps mitigate climate change impacts by reducing dependence on unpredictable rainfall patterns, allowing farmers more control over their practices. This autonomy can lead to increased yields, improved crop quality, and a wider variety of crops year-round. The ecological and economic advantages of integrating solar power into

farming practices include stabilized crop production, increased resilience to climate variability, reduced greenhouse gas emissions, and more efficient irrigation techniques.

4.4.2 Challenges of WEF nexus specifically the use of solar-powered irrigation in Malawi

The following section presents the findings and discussion on the challenges in implementing the recent advancements such as the WEF Nexus concept, with a specific emphasis on the utilization of solar irrigating systems in Malawi's agriculture sector. The challenges encompass poor irrigation development, poor catchment conservation, technical, socio-economic, and policy and regulation.

Poor irrigation development: Malawi faces a long-standing issue of poor irrigation development especially in rural areas due to climate change, environmental degradation, and inadequate storage facilities (Wiyo, 2018). Malawi has abundant water resources and the country is divided into 17 Water Resources Areas (WRAs) and 78 Water Resources Units, complicating water resources management efforts at the country level (Chipofya et al., 2017). Despite government efforts, water demand surpasses supply in many WRAs, with deficits projected to worsen in the coming years. Malawi has significant irrigation potential, but only 26 percent of it has been developed due to insufficient financing, high investment costs, and extended return periods (Chinsinga, 2017b). The integration of solar irrigating systems, aligned with the WEF Nexus concept, presents a promising solution to enhance irrigation efficiency and mitigate water scarcity challenges. However, addressing financing constraints, investment costs, and investment payback periods is crucial for successful implementation.

Poor catchment conservation: Currently, Malawi is grappling with severe sedimentation issues in its rivers and lakes (Wright & Scholz, 2023). The degradation of catchment areas results in the accumulation of large volumes of sediments in water bodies, leading to the obstruction of water treatment facilities for domestic use, irrigation canals, and hydropower infrastructure. Malawi has a lot of small earth dams and major dams supporting irrigation, hydropower generation, and domestic water supply. However, many of these schemes and dams have ceased functioning due to excessive siltation. For instance, the sedimentation of Kamuzu Dams has caused a drastic reduction in the water supply to Lilongwe City, primarily due to the destruction of the Dzalanyama Forest Reserve, which serves as the primary water source for these dams(Banda et al., 2019). The challenge of poor catchment conservation in Malawi not only exacerbates food insecurity but also contributes to the degradation and depletion of water resources. Addressing this challenge is

crucial for the successful implementation of initiatives like solar irrigating systems, as it directly impacts the availability and quality of water resources necessary for sustainable agricultural practices.

Technical challenges: The implementation of solar-powered irrigation systems and other recent advancements in the agriculture sector in Malawi encounters technical hurdles at different stages, from purchasing the solar system to operation. These challenges include a shortage of skilled labor for installation and maintenance and limited local capacity for maintenance and after-sales service. Furthermore, challenges in the supply chain to supply solar products in rural areas in Malawi, such as logistical issues and high transportation costs, further complicate deployment efforts. Ensuring efficient logistics and addressing safety concerns are crucial, as is building local capacity to respond swiftly to operational issues. The respondents from both farmers and experts also agreed as follows:

"... there are frequent calls from farmers enquiring on how to maintain and do repairs for the system since in the rural areas they don't have experts to do the maintenance and repairs. This often results in high non-functionality of installed solar-powered irrigation systems...."(P_26 and Expert).

The participants highlighted that the implementation of solar-powered irrigation systems in rural areas in Malawi faces a significant challenge due to the lack of expertise in maintenance and repairs. Farmers often seek guidance on these issues, highlighting the need for ongoing support and technical assistance. The inability to promptly address maintenance needs can lead to high non-functionality rates, potentially undermining the benefits of WEF nexus technologies including solar-powered irrigation. Therefore, comprehensive training programs and accessible technical support networks are crucial for the long-term success and sustainability of these systems.

Social and economic challenges: Community engagement and ownership are critical to the success of solar-powered irrigation systems. External funding from charity organizations may contribute to a lack of ownership among communities, resulting in reduced caretaking and maintenance efforts. Socioeconomic variables like poverty and gender roles also influence the maintenance of such systems. conflicts may emerge due to opposing interests in energy-consuming activities, emphasizing the need for thorough planning and active community participation. Furthermore,

income-generation issues exacerbate the socioeconomic situation, limiting the use of solar-powered irrigation systems. The respondents from both farmers and experts also agreed as follows:

"... one major concern is the high upfront cost of buying and installing solar-powered irrigation systems. For me and my friends, we could not afford to buy this system from town but thanks to the government program of Agricultural Commercialization Project (AGCOM) which provided us with loans to start solar-powered irrigation farming on a large scale. Most of my other friends cannot afford the irrigation system without financial support or subsidies....."(P_10 and Farmer).

The respondents emphasize that the high upfront cost of solar-powered irrigation systems in Malawi is a significant barrier to their adoption, posing financial constraints for individuals. However, government initiatives like the Agricultural Commercialization Project (AGCOM) have helped overcome this obstacle by providing loans to farmers, enabling farmers to invest in large-scale solar-powered irrigation farming ventures in Malawi. AGCOM's role in promoting sustainable agricultural practices underscores the importance of government and other institutions' support for WEF nexus technologies in the agriculture sector.

Policy and Regulatory Challenges: The Malawian agriculture sector has obstacles in deploying technologies aligned with the WEF Nexus concept including solar-powered irrigation systems. Challenges include the unreliability of utility services, an unstable grid network, and governance issues. The complexity of the energy sector, involving multiple ministries and actors, complicates policy implementation and communication. Strengthening institutional frameworks and reform processes is essential to create a sustainable and competitive business environment conducive to private investment.

4.5 Supportive policy framework for provisions of water, energy, and food nexus concept in the agriculture sector in Malawi including the use of solar irrigation systems in Malawi

4.5.1 The Agriculture Sector-Wide Approach (2010)

Malawi's government developed the Agriculture Sector Wide Approach (ASWAP) in partnership with its development partners after recognizing the importance of a robust policy framework to steer the growth of Malawi's agriculture sector. The ASWAp prioritizes four major areas: agriculture, food security, irrigation, and disaster risk reduction. ASWAP aims to increase agricultural productivity in Malawi, improve food security, diversify output, improve household

nutrition, and raise rural incomes by contributing to 6% annual growth (Malawi-ASWAP, 2010). The ASWAP is a priority agricultural investment program that complements the Malawi Growth and Development Strategy (MGDS) and the Comprehensive African Agricultural Development Programme (CAADP) as part of the New Partnership for Africa's Development (NEPAD).

ASWAp emphasizes developing irrigation systems such as solar irrigation and promoting efficient water use to significantly impact the agricultural sector. ASWAP aims to safeguard and manage Malawi's water resources for agricultural, residential, and industrial use, resulting in more irrigation land and less reliance on rain-fed agriculture. The actions relating to the expansion of the solar irrigation system in Malawi include;

"…ASWAp will promote the expansion of sustainable water management by improving utilization efficiency and increasing the area under irrigation for increased high-value commodity production. The high-value crops considered a priority include rice, paprika, chilies, green maize, vegetables…. and fruits (banana, pineapple, citrus, mango, strawberry, pawpaw) …." (Malawi-ASWAP, 2010).

This statement emphasizes water management, energy, food security, and environmental sustainability in agricultural production. It advocates for sustainable practices and increased irrigation infrastructure while promoting renewable energy sources like solar-powered systems. It also recognizes the importance of high-value crops to Malawi's food security and nutrition, while ensuring environmental sustainability. The policy also emphasizes water recycling and soil conservation measures. However, it doesn't explicitly address equity in agricultural development, but it should benefit both the smallholder farmers, women, and marginalized groups in Malawi.

The ASWAP further emphasizes irrigation intensification in Malawi under the Greenbelt Initiative (GBI), a large-scale irrigation policy for smallholders and commercial farmers to use the country's water resources, primarily Lake Malawi. The government offers investors agricultural land near the lakes and rivers to install irrigated agriculture, aiming to increase food and cash crop output and reduce poverty (Chinsinga, 2017a). The ASWAP recommends the development of labor-saving irrigation technology, rehabilitating existing irrigation schemes, and building new ones to increase irrigation areas from 20,000 ha to 40,000 hectares on a nationwide scale. It also emphasizes the importance of increasing research and extension workers' capacities, strengthening

technical competence for irrigation management, and providing training on new technologies to promote agricultural output. The ASWAP aims to promote agriculture sustainability in Malawi by facilitating the use of solar irrigation systems by smallholder and estate farmers, thereby enhancing the efficiency and effectiveness of irrigation systems.

4.5.2 The Malawi Vision 2063 (2063)

The Malawi Vision 2063 (MW2063) was formed in January 2021 and sets key goals and priority areas for Malawi's development, to transform the country into one that is prosperous, resilient, and self-sufficient by 2063. The vision document outlines strategic goals and priority areas across sectors like agriculture, energy, water resources, and environmental sustainability. It focuses on three key pillars: agricultural production and commercialization, urbanization, and industrialization. The government recognizes the national, regional, and global settings in which its objective of inclusive wealth creation and self-reliance will be realized, linking it with the global Sustainable Development Goals, the Continental Agenda 2063, and regional economic community plans. The findings reveal the following goals and strategies on how the MW2063 accommodates recent advancements in the agriculture sector including the WEF nexus concept in Malawi.

- Sustainable Agriculture Practices: The government recognizes agriculture's crucial role in economic growth and prioritizes sustainable practices to boost productivity, conserve resources, and enhance climate change resilience.

  "*…several opportunities for enhancing agricultural production and productivity to catalyze the realization of our Vision of inclusive wealth creation and self-reliance, including an enabling and supportive policy environment; endowment of natural resources; availability of developed technologies that are ready for scaling up; existence of some basic irrigation infrastructure; existence of well-organized extension deliver systems….and existence of a supportive Government and development partners. Transformation of the agriculture sector is central to the achievement of our Vision not only for the welfare of citizens but also given that the linkage between the sector and industry would spur socio-economic development…* (GOM, 2021)*."*

  The vision emphasizes the importance of a supportive policy framework, efficient use of natural resources, and access to advanced agricultural technologies. It highlights the

interconnectedness of water, energy, and food systems, urging for resource-efficient technologies, integrated water management, and renewable energy adoption. It also calls for access to advanced technologies like precision irrigation systems and renewable energy-powered machinery such as solar-powered irrigation systems to optimize water and energy use and mitigate climate variability risks.

- Renewable Energy Development: The vision highlights the significance of renewable energy sources like solar and biomass for agricultural productivity, including irrigation systems, processing facilities, and rural electrification initiatives in Malawi.

  "*…we shall continue investing in the energy sector beyond hydro, which is currently the main source of energy. Alternative sources, including solar… and thermal, shall be tapped into, in ways that avoid or minimize environmental degradation. We aim to reduce the current shortage in power generation that has led to frequent power outages…"* (GOM, 2021).

  The vision focuses on the interconnection of water, energy, and food systems, notably in agriculture. It calls for energy diversification, particularly solar and thermal energy, to ensure security and minimize environmental degradation in Malawi. The statement also acknowledges the current power shortage and its impact on agriculture. It also suggests potential synergies with water and food systems, such as solar-powered irrigation systems, to improve water efficiency.

- Integrated Water Resource Management: The Malawi Vision 2063 emphasizes the significance of integrated water resource management for sustainable agricultural production. The integration of water conservation, watershed management, and irrigation expansion strategies is a crucial part of enhancing water security and resilience in the face of climate variability.
  "…beyond this, we shall develop water networks that cater for agricultural, industrial, and household usage across the country… (GOM, 2021).*"*

The above statement demonstrates a commitment to sustainable development and addressing the nexus challenges related to the agriculture sector. The Malawi Vision 2063 emphasizes the significance of water networks in agriculture, industry, and households, recognizing their interconnectedness. It also promotes efficient water resource allocation, sustainable use, and renewable energy integration. It also emphasizes equal access to water resources, maximizing resource utilization, and avoiding trade-offs between competing uses in Malawi.

- Climate Resilience and Adaptation: Malawi Vision 2063 emphasizes climate resilience and adaptation, focusing on building adaptive capacity among farming communities through investments in recent agriculture advancements in the agriculture sector such as climate-smart practices, weather forecasting systems, and early warning mechanisms to mitigate climate-related shocks on agricultural productivity and livelihoods. The statement is as follows;

  "…promotion of climate-smart technologies and practices in the sector shall be given priority. We recognize that increasingly variable and adverse climatic conditions continue to affect our rain-fed agriculture system…investment in sustainable irrigation systems and technologies...new technologies and expertise will be required to ensure sustained and resilient productivity…" (GOM, 2021).

  The Malawi Vision 2063 statement above emphasizes the need for recent advancements in the agriculture sector such as climate-smart technologies and practices to tackle climate change challenges. It also emphasizes the interdependence of the water, energy, and food systems, emphasizing the significance of effective water use, renewable energy solutions, and sustainable food production methods. The government realizes that Sustainable irrigation systems can improve water efficiency, reduce wastage, and enhance agricultural productivity, promoting food security and resilience. Investments in these systems can mitigate the impact of droughts and water scarcity on crop yields and livelihoods, especially for smallholder farmers in Malawi. Furthermore, innovation and capacity-building initiatives are crucial for promoting climate-smart practices in Malawi's agriculture sector.

4.5.3 The National Agriculture Policy (2016)

The National Agriculture Policy (NAP) outlines the government's vision, objectives, and strategies for sustainable agricultural development, food security enhancement, and improving smallholder farmers' livelihoods. NAP aims to provide comprehensive policy guidance in Malawi's agriculture sector, with eight priority areas which include sustainable agricultural production and productivity, sustainable irrigation development, agricultural market development, agro-processing and value addition, and food and nutrition security. The policy aligns with various international goals, including the United Nations' Sustainable Development Goals, the World Food Summit declarations, the African Union's Maputo and Malabo declarations, and the Common Market for Eastern and Southern Africa (COMESA) and SADC treaties on agriculture policy. The main policy goal and specific goal relating to WEF nexus thinking in the agriculture sector include;

- Sustainable Land and Water Management: The NAP emphasizes sustainable land and water management methods in Malawi to boost agricultural productivity and resilience, promoting conservation agriculture techniques, soil and water conservation measures, and improved irrigation technologies.

  "…promote proper use of agriculture land in collaboration with the Ministry responsible for Agriculture, Irrigation and Water Development…promote efficient and sustainable use of water in all irrigation schemes… support the integration of irrigation in power generation and sustainable water management investments where feasible… (NAP, 2016)*"*

  The policy emphasizes the importance of collaborative efforts between relevant ministries responsible for agriculture, irrigation, and water management to optimize land use while addressing water and energy considerations. By working together, ministries can align their efforts to promote sustainable land use practices that consider water availability and energy requirements. The NAP also emphasizes the importance of water efficiency and sustainability in irrigation schemes, as it maximizes agricultural productivity while minimizing water wastage and environmental degradation which aligns with the water-energy-food nexus approach, enhancing food security through improved crop yields.

  Furthermore, NAP emphasizes the potential of integrating irrigation with energy generation, suggesting that irrigation infrastructure could be used for power generation. It

also underscores the importance of sustainable water management practices, which can enhance energy diversification and resilience in rural areas hence aligning with nexus thinking.

- Climate Smart Agriculture: The NAP policy encourages the adoption of recent agriculture advancements specifically the climate-smart agricultural practices that integrate WEF considerations, to enhance resilience to climate change, promoting the use of climate-resilient crop varieties and agroforestry systems.

  "…promote investments in climate-smart agriculture and sustainable land and water management…" (NAP, 2016).

  The policy calls for the use of Climate-smart agriculture techniques which focuses on efficient use of water resources, promoting techniques like drip irrigation, rainwater harvesting, and water recycling. It also incorporates energy-efficient technologies and renewable energy sources, such as solar-powered irrigation systems and biomass energy. These practices reduce energy inputs and greenhouse gas emissions associated with energy-intensive agricultural activities. Additionally, climate-smart agriculture enhances food security and nutrition outcomes by improving soil health, conserving water resources, and enhancing crop resilience to climate variability. These practices protect ecosystems and biodiversity, preserving natural resources essential for food production and ecological balance.

4.5.4 The National Irrigation Policy (2016)

The National Irrigation Policy (NIP) outlines the government's vision, objectives, and strategies for promoting sustainable irrigation development in Malawi. The policy is in line with international policies as Malawi is a signatory to international agreements and protocols on sustainable water and land management, including the Revised Protocol on Shared Watercourses in the Southern African Development Community which emphasizes African ownership and leadership in agriculture. The NIP targets to solve critical issues affecting the irrigation sector in Malawi to improve incomes, food security, irrigation service delivery, employment opportunities, and land and water productivity. It also aims to achieve its goals through sustainable land tenure arrangements, catchment management, and water harvesting, while considering climate change

irrigation technologies. The main policy goal and specific goal relating to WEF nexus thinking in the agriculture sector include;

- Water Resource Management: The NIP emphasizes promoting sustainable water resource management, focusing on efficient irrigation use and promoting water-saving technologies like drip irrigation and micro-sprinklers to reduce water wastage and enhance agriculture production in Malawi.

  "…enhanced land and water productivity through sustainable land tenure arrangements, catchment management, and water harvesting…" (NIP, 2016).

  The NIP emphasizes sustainable land tenure and catchment management practices as they are crucial for efficient water use and management in agriculture. Secure land rights encourage farmers to invest in water-saving technologies, while catchment management practices like afforestation and soil conservation maintain water availability. Water harvesting techniques like rainwater harvesting and small-scale reservoirs increase water availability during dry periods. These practices also contribute to energy efficiency by reducing the need for energy-intensive irrigation methods and water pumping. Improved water and land productivity lead to increased food production and improved food security, while enhancing farmers' resilience to climate variability.
- Food Security and Productivity: The NIP aims to improve food security and agriculture production by expanding irrigation coverage and improving crop yields, prioritizing smallholder irrigation schemes, and promoting climate-resilient cropping systems for better nutrition outcomes.

  "…identify areas with potential for irrigated agriculture… rehabilitate infrastructure for irrigation…e*ncourage smallholder farmers to grow non-traditional crops…"* (NIP, 2016).

  The NIP emphasizes WEF nexus thinking in agriculture, focusing on identifying potential irrigation areas, and addressing factors like soil quality, topography, and climate resilience. It aims to improve water use efficiency and energy efficiency through the rehabilitation of irrigation infrastructure, modern technologies, and long-term maintenance plans. It encourages smallholder farmers to grow non-traditional crops, considering water and energy requirements, market demand, and climate suitability.

4.5.5 Malawi's Farm Input Subsidy Program (2005)

Since 2005, the Malawi Farm Input Subsidy Program (FISP) has been a crucial part of the country's agricultural policy, aiming to enhance smallholder farmers' access to agricultural inputs like fertilizers and seeds, and has undergone reforms to align with broader development objectives. The FISP aims to improve agricultural productivity, increase maize production, and boost household food security by reducing fertilizer costs and improving maize seed for poor farmers.

Despite national projections of considerable maize output and productivity increases in Malawi during the FISP, research has revealed only modest increases in maize production and yields on the farm level (Lunduka et al., 2013). Real maize prices continue to increase, and Malawi continues to import maize. Better-off households gained more than poorer ones, casting doubt on the FISP's effectiveness in combating food insecurity and poverty.

4.5.6 National Water Policy (2005)

The National Water Policy (NWP) tackles all elements of water management, including water resource development and service delivery following current global and regional trends and requirements reflected in the Millennium Development Goals and Sustainable Development Goals. The NWP is the country's third water policy, and it aims to provide a strong framework outlining the guidelines for water management practices, promoting efficient water resource use and equitable access to water for various sectors, including agriculture and energy. It was a reform of the 2000 policy, which was regarded as overly ambiguous and verbose, and attempted to improve water resource management. The initial water policy (200) prioritized water service delivery without explicitly defining institutions' roles, duties, and jurisdiction. The main policy goal and specific goal relating to WEF nexus thinking in the agriculture sector include;

- *"…new water sector vision of 'Water and Sanitation for All, Always.'… promoting efficient and effective utilization, conservation and protection of water resources for sustainable agriculture and irrigation, fisheries, navigation, eco-tourism, forestry, hydropower and disaster management and environmental protection…"*(NWP, 2005).

The NWP vision statement aims to ensure water for all sectors, focusing on the efficient utilization and conservation of water resources in various sectors, including agriculture. It emphasizes the importance of water resources for sustainable agriculture and irrigation to contribute to food security in the country. The policy also acknowledges the interdependency of water resources with other sectors, such as energy, agriculture, and environmental protection. This holistic approach highlights the need for coordinated management to balance competing demands while safeguarding ecosystem services. The policy also emphasizes disaster management and environmental protection, emphasizing the importance of water resilience and ecosystem health. Sustainable water management practices can mitigate risks of water-related disasters while protecting ecosystems and biodiversity. Environmental protection measures like watershed management contribute to the sustainability of water resources and agricultural landscapes.

4.5.7 Water Resources Act (2013)

The Water Resources Act (WRA) in Malawi is a crucial legislative framework for managing and regulating water resources. The regulations apply to any policies, plans, programs, and activities that are covered by the Act. It has 176 regulations which are organised into fifteen parts. While the Act primarily focuses on water management, its provisions have implications for the integration of the WEF nexus concept within the agriculture sector. The objectives of the act concerning WEF nexus include;

"…allow for the orderly development and use of water resources for all purposes including domestic use, the watering of stock, irrigation, and agriculture…. generation of hydroelectric or geothermal energy….in ways which minimize harmful effects to the environment…" (WRA, 2013).

The WRA recognizes the interconnectedness with sectors like agriculture, energy, and food security. It establishes the Water Resources Authority to coordinate and regulate water use across sectors in Malawi, addressing challenges and optimizing water allocation for agricultural activities. The Act also provides provisions for water allocation for irrigation, ensuring sustainable water supply for food production and enhancing productivity. It also mentions hydroelectric and geothermal energy generation signifies a commitment to renewable energy sources, aligning with sustainability objectives. These energy sources can meet agricultural energy needs while reducing

fossil fuel reliance. It incorporates environmental considerations, prohibiting activities that may pollute or degrade water resources, and preserving water quality for agricultural purposes. The Act also mandates climate change adaptation measures, mandating the development of water management plans that consider climate variability and change. This promotes climate-resilient water management practices, supporting agricultural adaptation strategies and ensuring the resilience of the agriculture sector to climate-related risks within the water-energy-food nexus.

4.5.8 Water Resources Regulation (2018)

The Water Resources Regulation (WRR) in Malawi governs water resource management and utilization, providing a legal framework for sustainable development, allocation, and conservation across sectors like agriculture, under the Water Resources Act. The objectives of the regulation concerning WEF nexus thinking include;

"…when allocating water for irrigation, the Authority shall give priority to smallholder irrigation…considering aggregate water demand for smallholder irrigation, the Authority may declare by public notification for each catchment area or part thereof an upper limit for the allocation of water either in aggregate or for any one permit where the allocation is shared among more than one household. …" (WRR, 2018)

The WRR statement prioritizes smallholder farmers in the sector of agriculture in Malawi, ensuring just access to water resources for these smallholder farmers. It acknowledges the interconnectedness of WEF systems within the sector, assessing total water demand for smallholder irrigation. This approach ensures sustainable and efficient management of water resources, meeting the needs of both smallholder farmers and the broader agricultural sector, while addressing energy use and food security.

4.5.9 Malawi tax incentives (2022)

The government of Malawi offers a variety of tax incentives to encourage development, increase productivity, and provide job opportunities. These incentives are classified as Customs & Excise Taxes and Domestic Taxes. Customs and Excise Tax is also divided into incentives, which include both general and specific. General applies to all Malawian taxpayers who import products, whereas

specific are those who have been permitted to operate in a specific sector under agreed-upon conditions. These incentives contribute to the country's social and economic development.

The 2022 tax incentives aim to boost investment and innovation in key agriculture sectors, focusing on sustainable technologies, renewable energy, water-efficient irrigation systems, and diversified food crops, addressing the WEF nexus thinking. The taxes and incentives that apply to recent advancement specifically the WEF nexus concept in the agriculture sector in Malawi are as follows:

"…Solar products are imported duty-free while VAT remains payable at 16.5 percent Examples of such solar products include solar batteries and solar energy lamps…import duty, import excise, and VAT free on importation of the following goods for direct use in irrigation…. d*uty-free and VAT free importation of agricultural good and importation of agricultural equipment…"* (MERA, 2022).

The above statement demonstrates the Malawi government's recognition of the interdependency between WEF systems in the agriculture sector. The government has introduced tax incentives to encourage sustainable agriculture practices. The 2022 tax incentive promotes renewable energy through import duty-free status for solar products, reducing reliance on fossil fuels and mitigating environmental impacts. It also encourages investment in water-efficient technologies and infrastructure for irrigation equipment, supporting sustainable water management practices and water conservation. The duty-free importation of agricultural goods and equipment lowers financial barriers to accessing essential inputs, enhancing agricultural productivity and food security. These tax incentives demonstrate the interdependency between WEF systems in the agriculture sector, aiming to enhance sustainability, resilience, and productivity. Tax holidays and reduced import duties are also offered to agro-processing industries to add value to agricultural products. These incentives have accelerated the embracing of sustainable agriculture practices, with preliminary assessments showing increased investments in renewable energy and water-efficient technologies (Leone, 2021).

4.5.10 The Malawi Energy Policy (2018)

The Energy Policy (EP) intends to increase Malawians' access to affordable, dependable, sustainable, efficient, and modern-day energy services. The government prioritizes the energy

sector in its National Development Agenda due to its crucial role in industrial and socio-economic development. The 2003 energy policy has been revised to guide stakeholders in implementing energy interventions, aiming to spur development as outlined in the Malawi Vision 2020, Malawi Growth and Development Strategy III, and the Sustainable Energy for All Initiative and Sustainable Development Goals (SDGs). The revision was driven by several factors, including the Millennium Development Goals, the adoption of Energy Sector Reforms, Malawi's commitment to the Sustainable Energy for All Initiative, and the Public Sector Reform Programme aimed at ensuring efficiency, transparency, and accountability in public service delivery, including energy services.

The EP includes an Implementation Plan and a Monitoring and Evaluation Plan with time-bound deliverables, outlining updated goals, objectives, strategies, and priority actions. The EP promotes renewable energy, sustainable agriculture, cross-sector coordination, and stakeholder engagement in the water, energy, and food sectors. It aims to promote sustainable development, energy access, and food security in Malawi by addressing interdependencies between these systems. The policy goals and specific objectives that apply to recent advancement specifically the water, energy, and food nexus thinking in the agriculture sector in Malawi are as follows;

"…developing the sites for power generation from Hydro, Coal, Geothermal, Natural Gas, Solar, Wind, agricultural waste… biomass (firewood, charcoal, agricultural and industrial wastes), which account for 80% of the total primary energy supply… GoM has recognized that biomass remains an important source of energy for the foreseeable future. To this end, GoM is promoting sustainable production and efficient use of biomass…. set a target to roll out 2 million efficient cookstoves by 2020 to reduce biomass consumption…"

The EP is a crucial tool in addressing the WEF nexus in the agricultural sector. It promotes renewable energy sources like solar, and hydroelectric power, reducing dependence on fossil fuels and minimizing greenhouse gas emissions. The GoM's commitment to sustainable biomass management aligns with the principles of the WEF nexus concept, ensuring long-term energy security and supporting agricultural productivity. The GoM's target to roll out 2 million efficient cookstoves by 2020 aims to reduce biomass consumption and address environmental and health concerns associated with traditional cooking methods. Efficient cookstoves not only minimize biomass consumption but also reduce indoor air pollution, improving the health and well-being of

rural communities, particularly women and children. Access to electricity in rural areas can facilitate modern agricultural technologies, improve water management, and enhance food processing and storage capabilities, contributing to food security and rural development. The policy emphasizes cross-sectoral coordination and integration in energy planning and implementation, fostering collaboration between the energy and agriculture sectors. It also recognizes the role of energy in building climate resilience in agriculture, promoting climate-smart energy solutions and renewable energy technologies. Stakeholder engagement and participation are also crucial in energy planning and decision-making processes, ensuring the water, energy, and food nexus is effectively mainstreamed into agricultural development strategies.

4.6 Conflicts or gaps in the policy supporting the WEF Nexus thinking in the agriculture sector in Malawi

The following are policy conflicts or gaps within the policy landscape governing the accommodation of recent advancement, specifically, the WEF concept in Malawi's agriculture sector, highlighting inconsistencies and conflicts within existing frameworks that hinder the effective implementation of integrated WEF nexus approaches for sustainable development.

4.6.1 Lack of coordinated sectoral policies

In Malawi, there is a notable absence of harmonized interests, incentives, and sustainability considerations across different sectors of water, energy, and food. For instance, agriculture, water, and energy incentives are administered separately, often without due consideration for their implications on water resources.

- The ASWAp's introduction of the Green Belt Initiative has the potential to improve food security in Malawi by expanding water access and addressing the interconnectedness of water, energy, and food systems. However, irrigation initiatives around Lake Malawi and the Shire River may reduce water levels, limiting hydropower generation and resulting in energy insecurity (Bhave et al., 2021). Additionally, the GBI involves village relocation for irrigation projects near Lake Malawi, raising social and environmental concerns. The incentives may improve water access but also pose ecological impacts. The policy lacks measures to mitigate conflicts and ensure equitable outcomes.
- The Farm Input Subsidy Program (FISP) has the potential to increase maize production and improve food security but does not address the water-related implications of intensified

agricultural practices (Bhave et al., 2021; Mangisoni et al., 2021). Increased fertilizer usage, facilitated by FISP, can contribute to water pollution through runoff, leading to the eutrophication of water bodies and compromising water quality. The Jwaideh et al. (2022) study found that the excessive use of nitrogen and phosphorus fertilizers on agricultural land has led to eutrophication in water bodies. This oversight indicates a lack of consideration for the water-food nexus and potential trade-offs between agricultural productivity and water quality. Furthermore, FISP highlights gender biases in beneficiary targeting and access to subsidized fertilizers, particularly for female-headed households. This disparity may affect water and food security, and the lack of gender-sensitive policies in agricultural programs exacerbates these inequalities.

- The energy policies in Malawi mentioned focus on power sector reforms, rural electrification, and renewable energy, however, they lack explicit integration of water, energy, and food sectors, especially in agriculture. There is no mention of initiatives for water use efficiency or sustainable irrigation practices. Furthermore, Malawi's heavy reliance on biomass fuels, such as firewood and charcoal for cooking energy, poses significant challenges to the WEF nexus. The depletion of forests due to increased demand for biomass fuels has adverse impacts on soil fertility, erosion, and river siltation, directly affecting agricultural productivity and food security. The emphasis on promoting alternative energy by the Malawi government is a positive step, but more comprehensive strategies integrating energy, water, and food considerations are needed to address this issue effectively.
- Malawi's agriculture sector faces challenges due to the weak integration of land administration and water regulation, leading to conflicting regulations and ineffective practices. The unequal land distribution among smallholder farmers, accounting for 84% of agricultural value-added, is exacerbated by population growth and customary tenure, resulting in land sub-divisions among family members. This fragmentation has led to a decrease in per capita land ownership from 1.53 hectares in 1968 to 0.8 hectares in 2000 (E. W. Chirwa, 2008). This unequal land distribution hinders optimal yields and reduces food security, resulting in limited access to modern irrigation technologies and energy-efficient practices. The fragmentation also complicates the implementation of sustainable water management practices. Socioeconomic disparities in rural communities in Malawi

further exacerbate these issues, as farmers face barriers to essential services like electricity or clean cooking fuels. The fragmentation also contributes to ecosystem degradation and water quality concerns, undermining the sustainability of agricultural practices and compromising water availability and quality for food production.

4.6.2 Competing interests and policy frameworks

Malawi's agricultural sector experiences conflict between different interests and policies, complicating the establishment of effective WEF governance structures. For example, while exemptions on solar equipment imports have spurred individual farmers to adopt solar-powered boreholes, this has raised concerns over water over-abstraction. Moreover, agricultural subsidies, such as fertilizer support, while beneficial for agricultural productivity, may pose challenges to water quality regulation due to minimal enforcement measures.

- The Malawi Energy Policy of 2018 faces challenges in balancing agricultural development with energy production, particularly in water usage. The policy does not adequately consider the interconnectedness of water, energy, and food systems, leading to disjointed approaches and missed opportunities. It also does not recognize the interdependencies between these systems and lacks mechanisms for holistic trade-offs. Inadequate support for implementing integrated approaches to managing the water-energy-food nexus is also lacking. For example, Malawi's tax incentives for solar equipment imports are a reflection of competing interests in the water, energy, and food nexus concept in the agriculture sector. These incentives are promoting smallholder farmers in Malawi to adopt renewable solar-powered irrigation. However, rapid agricultural expansion may lead to deforestation, soil degradation, and groundwater over-abstraction, impacting long-term sustainability. The short-term benefits of solar technology adoption must be balanced with long-term goals of sustainable resource management. Malawi's agricultural policy frameworks should integrate energy policies with agricultural development strategies to support sustainable practices.
- Another example is FISP which primarily provides subsidized agricultural inputs to smallholder farmers. However, the program faces limitations and gaps in accommodating the water, energy, and food nexus concept within the agriculture sector. The program's focus on fertilizers and seeds neglects other crucial inputs, leading to inefficient resource

allocation and potential conflicts between stakeholders. The policy framework of the FISP does not adequately address the interconnections between water, energy, and food systems, leading to fragmented approaches to addressing challenges. The program lacks integrated approaches to agriculture and does not recognize the interdependencies between water, energy, and food systems, making it difficult to implement across different ministries responsible for agriculture, water resources, and energy.

4.6.3 Lack of integrated governance

The governance structures responsible for managing water, energy, and food resources in Malawi are fragmented, with different agencies and ministries overseeing each sector independently. The lack of a comprehensive framework for cross-sectoral coordination in water, energy, and agriculture governance, causes policies to be developed and implemented in isolation without considering their interdependencies. The existing polycentric governance systems suffer from limited integration and coordination, hindering effective management of cross-cutting issues like water and sanitation, land rehabilitation, and green infrastructure initiatives.

- For example, Malawi has different regulatory bodies: The Natural Water Resources Authority (NWRA) for water resource protection and the Malawi Energy Regulatory Body (MERA) for energy sector regulation (Chunga, 2019; Kachaje et al., 2017). The absence of a single regulator for the water, energy, and food nexus poses challenges in implementing sustainable agricultural practices requiring coordinated resource management. This lack of coordination makes it challenging to address the interconnections between water, energy, and food systems, leading to inefficient resource use, environmental degradation, and food insecurity. Additionally, the lack of coordination hinders the implementation of innovative solutions, such as green infrastructure initiatives promoting sustainable water management practices.

4.6.4 Lack of stakeholder engagement

Effective implementation of policy accommodating the water-energy-food nexus requires active engagement of stakeholders from various sectors. If the regulation or policy fails to involve stakeholders such as farmers, energy producers, and policymakers, it may not adequately address their needs and priorities. Smallholder farmers, who make up the majority of agricultural

producers, do not have a significant voice in policy discussions. There is a gap in stakeholder engagement and participation in the formulation and implementation of the policy in Malawi, leading to a lack of diverse perspectives and expertise in addressing the water, energy, and food nexus. For instance, Cohen (2020) study revealed a lack of stakeholder engagement in energy policy formulation in Malawi. The study showed that MERA hired a policy consultant who copied the Kenyan Feed in Tarif policy without making necessary modifications to suit Malawi's socio-economic conditions, causing frustration for the policy initiative. Cohen's 2020 study revealed Malawi's lack of stakeholder engagement in energy policy formulation, with MERA hiring a consultant who copied the Kenyan Feed in Tarif policy without adjusting it to suit the socio-economic conditions of Malawi.

4.6.5 Climate change impacts

Malawi's vulnerability to climate extremes is posing challenges in managing integrated resource systems, including water, energy, and agriculture. Climate change exacerbates water-energy-food nexus issues, disrupting agricultural activities and affecting water availability, energy production, and crop yields. Water management is a major issue, with erratic rainfall patterns, water scarcity, and inefficient irrigation practices. Additionally, seasonal water scarcity in Malawi threatens food security and intensifies conflicts over water usage.

4.6.6 Chapter conclusion

In conclusion, this chapter examines the Water, Energy, and Food (WEF) nexus concept, focusing on solar-powered irrigation systems in Malawi's agricultural sector. These systems can address food insecurity, water scarcity, and unreliable energy supplies, improving water management, fostering economic development, and empowering marginalized groups. Despite the benefits, the implementation of the WEF nexus faces challenges such as poor irrigation infrastructure development, inadequate catchment conservation efforts, technical barriers, socio-economic constraints, and policy and regulatory issues. Existing policies in Malawi were also analyzed in line with the WEF nexus thinking. Key issues include a lack of coordinated sectoral policies, competing interests, poor governance, inadequate stakeholder engagement, and climate change impacts on resource management. A holistic approach is needed, including coherent policies, stakeholder collaboration, capacity building, and investment in infrastructure and technology. This

approach can lead to a more sustainable, resilient, and equitable agricultural sector, contributing to Malawi's long-term development goals.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Chapter Overview

The main objective of this study is to examine the conflicts in agriculture policies in accommodating recent advancements in the agricultural sector in Malawi, specifically using the WEF Nexus concept and technologies as a case study. Specifically, this research aims to understand the recent advancement or new concept in the agricultural sector in Africa, particularly in Malawi, to identify one recent advancement and assess the opportunities and challenges of this advancement when compared to the traditional form of agriculture in Malawi, to analyze the agricultural policy in Malawi and identify gaps or conflicts arising in accommodating the recent advancement, and propose policy recommendations on how to better accommodate the recent advancement in Malawi. This chapter provides a synopsis of the main discoveries made under each research objective, along with conclusions drawn and recommendations for policy adjustments.

5.2 Conclusion

The study involved representatives from the water, energy, and food sectors to contribute to the study objectives. However, due to interviews based on willingness, knowledge, and availability, male domination was observed. This was not considered significant as the information was aimed at facilitating agriculture policy reforms. The validity and reliability of responses were determined by the experts' years of experience in the sector, while farmers were based on the number of years in farming. Experts' education level also played a role in their familiarity with the context and the aptness of their suggestions.

The study finds out that recent advancements such as the Water, Energy, and Food (WEF) nexus concept, specifically through the adoption of solar-powered irrigation systems in Malawi, present a significant shift from traditional agricultural practices towards more sustainable, efficient, and resilient farming methods. This shift has numerous benefits, including increasing crop yields, diversifying cropping patterns, and extending the growing season beyond traditional rain-fed cycles. Higher productivity and reduced labor costs contribute to rural development, creating job opportunities and fostering entrepreneurship in Malawi. Socially, solar irrigation offers women farmers in Malawi a pathway to empowerment and greater involvement in the agricultural sector, despite prevailing land rights and gender norms.

The study finds out that the implementation of the WEF Nexus concept in the agriculture sector in Malawi faces numerous challenges, including poor irrigation development, poor catchment conservation, technical, socioeconomic, and policy and regulatory. These issues hinder the effective adoption and utilization of WEF nexus technologies such as solar irrigation systems in the agricultural sector. Poor irrigation infrastructure, catchment conservation, technical issues, and socio-economic barriers limit the potential of solar-powered irrigation to enhance agricultural productivity. The lack of skilled labor for system installation and maintenance further complicates the situation for rural communities. Socioeconomic barriers, such as high upfront costs and lack of community ownership, limit the accessibility and sustainability of these systems. Policy and regulatory challenges highlight the need for cohesive governance structures to integrate the WEF Nexus approach into Malawi's agricultural practices.

Lastly, the study has examined the policy landscape of Malawi in accommodating recent advancements, focusing on the water, energy, and food (WEF) nexus in the agricultural sector. The study has revealed inconsistencies and conflicts within existing policy frameworks, hindering the effective implementation of integrated WEF approaches for sustainable development. Key issues include lack of coordinated sectoral policies, competing interests, poor governance, inadequate stakeholder engagement, and the impact of climate change on resource management. Despite the significant progress of the Malawi government in developing sector-specific policies, a holistic, integrated approach is needed to address the interconnected nature of the WEF nexus, ensuring the nation's long-term sustainability goals.

5.3 Recommendations

In line with the study findings, the following recommendations are made to address conflicts in Malawi's agriculture policies and align with recent advancements in the agriculture sector:

- The government should establish a coordinated policy framework that accommodates recent advancements such Water, energy, and food nexus concept and harmonizes water, energy, and food sectorial policies.

- Governments and international development agencies should review subsidy programs for solar products to prevent the over-abstraction of groundwater resources and ensure equitable access to resources, particularly for smallholder farmers.
- The government should strengthen technical support systems by developing a comprehensive training program for farmers and local technicians on the installation, operation, and maintenance of solar-powered irrigation systems to ensure sustainability and maximize benefits.
- The government should incorporate agriculture's recent advancements such as the WEF nexus concept into Universities, secondary, and primary school curriculums to promote research and understanding among scholars of recent advancements in Malawi.
- The government should introduce a database concerning recent advancements in the agriculture sector in Malawi, specifically targeting water, energy, and food nexus concepts and technologies in Malawi.
- The government should increase its budget allocation towards recent advancements in the agriculture sector in Malawi specifically targeting the WEF nexus approaches and technologies.
- The government should support research and innovation to enhance the sustainability of the WEF nexus, fostering partnerships between government, academia, and the private sector.

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7 APPENDIX

APPENDIX 1: INFORMED CONSENT FORM

1. Introduction

Dear Participant,

I am Chikondi Chizu, a Master of Science in Water Policy Student from Pan African University Institute of Water and Energy Sciences (including Climate Change) (PAUWES), Tlemcen, Algeria carrying out key informant interviews for a research project looking at conflict in agricultural policies in accommodating recent advancements in the agricultural sector in Africa: a case of Malawi. This research is conducted as partial fulfilment for a Master's degree in Water Policy.

2. Aim of the study

The study examines the conflict in agricultural policies in accommodating recent advancements, specifically the Water, Energy, and Food Nexus approaches and technologies in the agricultural sector in Malawi.

3. Participation Benefits

There will be no immediate benefit for you, but your involvement in this research will shed light on the conflict in agricultural policies in accommodating recent advancements, specifically the Water, Energy, and Food Nexus approaches and technologies in the agricultural sector in Malawi. Your cooperation would be much appreciated.

4. Right to Refuse or Withdraw

Your participation in this study is entirely voluntary. You may withdraw your consent and stop answering these questions at any time. I will offer you the opportunity to evaluate your statements after the interview/discussion, and you may request that sections of them be modified or removed if you disagree with my notes or if I did not understand you correctly.

5. Confidentiality

This study is done anonymously. This means that any information that may lead to you will be anonymized. As a result, a researcher who utilizes the data will never be able to identify you unless

you explicitly permit them. Your anonymous responses will only be used for this research and the final thesis. Any scientific publication will only include anonymized data.

6. Contact Information

If you have any queries, please ask them now or later. If you believe you have been treated unfairly or have any questions or concerns, please contact Chikondi Chizu, Pan African University Institute for Water and Energy Sciences (incl. Climate Change) – PAUWES, C/O Tlemcen University, B.P. 119 |Pôle Chetouane, Tlemcen 13000, Algeria. Phone/WhatsApp: +265882148544. Email: chikondi.chizu@student.pauwes.dz.

7. Consent

The previous statement was read to me/ I read it myself, and the researcher explained its meaning. I accept to participate in this study. I acknowledge that I can withdraw my participation at any moment and that the research staff/contact person will respond to any queries that occur throughout the survey.

☐ Yes, I agree to participate.

☐ No, I do not wish to participate.

Participant Name: …….

Participant Signature: ……. Date:...…….

Researcher Signature: ……. Date:…….