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ASSESSING THE ADOPTION OF THE WATER ENERGY FOOD NEXUS APPROACH FOR CLIMATE CHANGE ADAPTATION IN CAMEROON

WATER ENGINEERING

By:

Hermann Fomena TCHINDA

RN: PAUWES/2022/MW06

DIPES II. Env. Geology

BSc. Earth Sciences-Hydrology

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TLEMCEN-ALGERIA

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Declaration

I, **FOMENA TCHINDA HERMANN** hereby declare that this thesis entitled "ASSESSING THE ADOPTION OF THE WATER ENERGY FOOD NEXUS APPROACH FOR CLIMATE CHANGE ADAPTATION IN CAMEROON" represents my personal work, realized to the best of my knowledge. WE also declare that all information, material and results from other works presented here, have been fully cited and referenced in accordance with the academic rules and ethics.

By my signature below, I am submitting this document in partial fulfilment of the requirements for a degree from Pan African University and declare that I have not submitted this document to any other institution for the award of an academic degree, diploma or certificate.

FOMENA TCHINDA HERMANN **Date**: May 06th, 2024

Certification

I, **Dr. FEUMBA Rodrigue Aimé**, hereby certify that this work was carried out by FOMENA TCHINDA Hermann, a student in MSc. Water Engineering at the Pan African University, Institute for Water and Energy Sciences, including Climate Change (PAUWES), under my supervision on the topic "ASSESSING THE ADOPTION OF THE WATER ENERGY FOOD NEXUS APPROACH FOR CLIMATE CHANGE ADAPTATION IN CAMEROON" for the purpose of obtaining the Master of Science degree in Water Sciences, Engineering track and was successfully defended in hybrid mode, and accepted on the 21st of April 2014 in front of a jury constituted as follows:

Prof. Hamid BOUCHELKIA from the PAUWES Institute-Tlemcen, Algeria as Chair person;
Prof. Célestin Defo from the University of Dschang as External examiner
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His document has been reviewed and corrected according to the remarks of the jury. Therefore, I authorize him to reproduce and submit the required number of copies as requested by the PAUWES administration.
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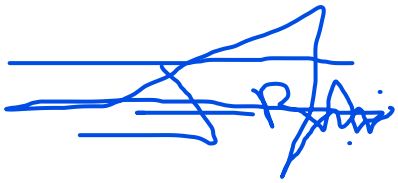

Dr. FEUMBA Rodrigue Aimé Date : 06/05/2024

Dedication:

I dedicate this piece of work to my wife MADIE NZEMBONHON Nelsa who has played an incommensurable role in my life success.

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It has been an exciting experience going through this Master program to this point, with a lot of highs and downs but we have been privileged to achieve exploits. However, this wouldn't have been possible without the help and encouragements of a good number to whom WE would like to express my gratitude.

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List Of Abbreviations:

AMCOW - African Ministers' Council on Water

CSA - Climate-smart agriculture

CTCN - Climate Technology Centre and Network

DWA - Department of Water and Sanitation (South Africa)

FAO - Food and Agriculture Organization (UN)

GDP: Gross Domestic Product

GWP - Global Water Partnership

IWRM - Integrated Water Resources Management

NAPs - National Adaptation Plans

NBWE - Nile Basin Initiative

NDCs - Nationally Determined Contributions

NGOs - Non-governmental organizations

SDGs - Sustainable Development Goals

UNDP - United Nations Development Programme

UNECA - United Nations Economic Commission for Africa

UNECLAC - United Nations Economic Commission for Latin America and the Caribbean

UNEP - United Nations Environment Programme

UNIDO - United Nations Industrial Development Organization

VBA - Volta Basin Authority

WB - World Bank

WEF - Water-Energy-Food (nexus)

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Abstract:

The current was done in the context of the prevailing effects of climate change in ensuring security and sustainability in the resource systems of Water, Energy and Food. It explored the level of adoption of the Water-Energy-Food (WEF) nexus approach for climate change adaptation in Cameroon through a comprehensive analysis. The main objective was to comprehensively assess the current state of art in terms of integrating the WEF nexus approach in the Country. The specific objectives were: to analyse changing patterns of WEF nexus indicators over five years, to examine the evolution of nexus potential in strategic documents, and to assess at the operational level, the nexus potential of projects from relevant ministries integrating the three systems. The methodology employed encompassed linear correlation analysis for the identification of potential synergies and trade-offs; a chronological and comparative examination of strategic documents with respect to some predefined WEF nexus criteria, and the analysis of the WEF nexus potential in some projects. The main results of the study reveal some synergies between Energy-Food and Water-Energy, with Energy and Water exerting the highest influence on the WEF nexus index variation. Moreover, a growing nexus potential is observed in strategic documents over time, particularly in National Determined Contributions (NDCs); and the. Despite some deficiencies in technology involvement and stakeholder consideration, opportunities exist to enhance WEF nexus adoption in adaptation documents. Furthermore, project analysis identifies several initiatives with moderate to high nexus potential is observed from 2005 to 2021, suggesting the feasibility of mainstreaming the Hoff's framework for improved integration. In conclusion, the study highlights the need for updating institutional coordination, capacity building, evidence-based decision-making, policy coherence, and adaptive governance to effectively incorporate WEF nexus considerations into national frameworks, ultimately advancing climate change adaptation efforts and sustainable development goals in Cameroon.

Keywords: **Climate change, WEF-Nexus, policy and project documents, Cameroon.**

Chapter 1. Introduction

1.1. Background:

1.1.1. Climate trends in Cameroon

The climatic changes of Cameroon are complicated, marked by rising temperatures and varying amounts of precipitation in various areas. The Cameroon National Adaptation Plan (NAP) predicts that national temperatures would rise gradually, by 0.2°C on average every ten years (Cameroon NAP, 2015). Temperatures in the upper savanna zone of Guinea are expected to show a brief decline between 2013 and 2019, with a subsequent increase. Data from the World Bank, which indicates a steady rise in the region's average temperature over the previous few decades, supports this pattern (World Bank, 2021). Meanwhile, total precipitation is expected to rise concurrently, while there will likely be a dry spell between 2018 and 2024. Additionally, the NAP shows variations in precipitation amounts, with an anticipated rise in the intensity of rainfall throughout the rainy seasons (Cameroon NAP, 2015). But these changes also bring with them an increased frequency of dry spells, which presents problems for the region's agricultural practices and water resource management. On the other hand, it is anticipated that the soudano-sahelian zone would see steadily rising temperatures in addition to an overall increase in precipitation. By the end of the century, the region is expected to see temperature increases of 1.5°C to 2°C, accompanied by an increase in the intensity of rainfall, according to the Intergovernmental Panel on Climate Change (IPCC, 2021). But the variability in the region's climate is highlighted by outliers and the potential for more deficit years under specific emission scenarios. These patterns highlight the significance of adaptable tactics and sturdy infrastructure in reducing the effects of climate change on agriculture, water resources, and livelihoods in Cameroon's diverse agro-ecological zones.

1.1.2. Climate change and adaptation issues in Cameroon

Cameroon is clearly at risk from climate change, as seen by the varied, recurrent, and growing effects seen throughout the nation. Feumba (2017) uses a study of 450 climate-related catastrophic events such as storms, floods, droughts, landslides, disturbances to seasonal patterns, wildfires, and haze that were recorded between 1960 and 2015 to demonstrate this. In addition to its potential to deplete macroeconomic variables like GDP, these catastrophes have actual observed effects on important sectors like agriculture, water, energy, forests, health, cities, and infrastructure. Lexical study of strategic planning papers from 1961 to 2009 reveals a declining emphasis on adaptation throughout time, despite its significance. While Cameroon

has incorporated adaptation into its strategic planning since the first five-year plan in the 1960s, current planning papers indicate a decreasing focus on adaptation questions, despite the fact that these issues are becoming more and more prominent globally.

Cameroon's efforts to combat climate change are evident through its development of a National Adaptation Plan (NAP) and Nationally Determined Contributions (NDCs). These strategies emphasize community involvement, stakeholder engagement, and the integration of traditional knowledge, highlighting the necessity of a comprehensive approach to adaptation (Cameroon NAP, 2015). While the NDCs set ambitious goals for reducing greenhouse gas emissions and enhancing climate resilience, there remains a gap in effectively addressing the interconnections between water, energy, and food systems (World Bank, 2021). By prioritizing the Water-Energy-Food (WEF) nexus approach, Cameroon can bridge this gap and ensure a more holistic strategy for climate adaptation (Rasul & Sharma, 2016). Integrating WEF nexus considerations into policy and planning processes is crucial for coherence and synergy between mitigation and adaptation measures (Dodds et al., 2018). This entails enhancing institutional coordination and increasing stakeholders' participation to maximize the effectiveness of adaptation efforts (Bizikova et al., 2013). By adopting a more interconnected approach to resource management, Cameroon can better achieve its sustainable development goals and enhance resilience to climate change impacts (Liu et al., 2018).

1.1.3. Clarification of the WEF nexus concepts

According to Allan and Keulertz (2017), the word "nexus" comes from the Latin word "nexus," which means link or bond. It represents the relationships and linkages between the food, energy, and water systems in the framework of the WEF nexus. The idea of the WEF nexus was first publicly presented in the academic and policy literature in the middle of the 2010s, even though many disciplines had previously acknowledged the interconnectivity of these systems. The WEF Nexus idea acknowledges that food, energy, and water are not separate resource systems but rather are intricately linked. It highlights how important it is to view these resources as a whole rather than as separate entities (Hoff, 2011). The nexus method is crucial for resource management and sustainable development because it considers the intricate relationships and feedback loops that exist between various resources. It acknowledges the vital interconnection of the food, energy, and water systems in our world of diminishing resources. Effective management and use of these resources are essential, particularly in view of the problems posed by climate change (Nexus Study Report, 2016).

1.1.3.1.The WEF nexus pillars and sub-pillars

Three main foundations support the WEF nexus hypothesis (Rasul & Sharma, 2016) as seen in the figure1 below:

Water is a vital resource that supports many facets of human existence, such as industry, agriculture, and the creation of electricity. Given that irrigation uses a large amount of water worldwide, it is critical to the production of food. Water scarcity and quality problems are crucial to the WEF nexus because they can directly affect the production of food and energy.

Energy: The energy-water-food nexus refers to the need for energy at different phases of food production, processing, and distribution. For instance, energy inputs are needed for cooking, food refrigeration, and irrigation water pumping. On the other hand, energy generation systems like thermoelectric or hydropower plants may rely heavily on water. Thus, the WEF nexus places a high value on energy efficiency and renewable energy sources.

Food: The nexus's ultimate objective is food, whose production and delivery require energy and water. Global water and energy use is mostly attributed to agriculture. Given the increasing strain on food systems caused by population expansion and shifting eating habits, food security, including having access to enough, safe, and nutritious food is a primary concern of the WEF nexus.

According to Wada et al. (2016) and Simpson et al. (2022), there are multiple sub-pillars that emphasise distinct features of the interconnections within each of the core pillars of the WEF nexus.

Sub-pillars of the water pillar: Water governance, water quality, water availability, and water usage efficiency are a few of them. Water scarcity can result in lower crop yields, while inefficient irrigation can squander water resources. These interactions between the food and water systems are evident in irrigation methods. The production of hydropower and the cooling needs of thermal power plants are clear examples of water-energy connections.

Energy Pillar Sub-Pillars: This category's sub-pillars include renewable energy sources, energy security, and energy efficiency. The cooling systems used in fossil fuel extraction and power generation exhibit strong water-energy interactions. These processes can demand large amounts of water. Food and energy interactions include the energy-intensive operations of transportation, refrigeration, and agricultural machinery.

The sub-pillars of the food pillar consist of sustainable agriculture, food production, and food security. Food-energy interactions can be seen in the energy-intensive procedures required in food production and distribution, while food-water interactions are visible in the water-intensive nature of crop cultivation.

1.1.3.2.The types of interaction between the WEF nexus pillars

In actuality, the WEF nexus method promotes comprehensive planning and decision-making that takes these pillars and sub-pillars' trade-offs and synergies into account.

Trade-offs:

In the WEF nexus, trade-offs are frequently linked to resource allocation choices that give priority to one dimension over others (Bazilian et al., 2011). For instance, the construction of hydropower projects can increase electricity output but could also decrease the amount of water available for agriculture later on, which would affect food production (Rasul & Sharma, 2016). Water supplies may also be strained by water-intensive energy extraction techniques like hydraulic fracturing, or fracking (Gheewala et al., 2019).

Synergies:

In the context of the WEF nexus, synergies are advantageous interactions and favourable results attained by addressing several dimensions at once (Wada et al., 2016). One way to lower energy usage in the water industry is to integrate renewable energy sources with facilities for water pumping and treatment (Wada et al., 2016). While preserving water resources, sustainable soil and water management techniques can increase food production (FAO, 2018).

1.1.4. Significance of the WEF nexus on climate change adaptation

The importance of the WEF Nexus lies in its direct impact on various aspects of human life, including food security, energy access, and water availability (Waughray, 2011). The nexus approach acknowledges that changes in one resource sector can have profound effects on the availability and accessibility of the other resources. For instance, changes in climate patterns can affect water availability for agriculture, which, in turn, can impact food production (Falkenmark & Rockström, 2004). The WEF Nexus approach is instrumental in identifying potential synergies and bottlenecks, making it a valuable tool for evaluating the viability and attractiveness of projects and investments. It highlights the importance of considering cross-sectoral impacts on health and livelihoods (Nexus Study Report, 2016).

1.1.5. Key challenges in managing the WEF nexus on climate change adaptation in Cameroon

The WEF Nexus approach deployment in Cameroon is made difficult due to several reasons as follows:

Resource scarcity: The Sahel zone in Cameroon experiences the highest level of resource scarcity and the competing needs between Agriculture and Energy obstructs a proper management of the resources available (PANGIRE, 2009 and NAP, 2015)

Limited Stakeholder Engagement: Limited stakeholder engagement further complicates WEF nexus management in Cameroon. Despite the emphasis on community involvement in adaptation strategies, there are often gaps in engaging key stakeholders, including local communities, civil society organizations, and private sector actors (Cameroon NAP, 2015).

Climate Change: The disruption in rainfall patterns over the years, and the increasing frequency of extreme weather events that account for climate change and Climate variability in Cameroon have a meaningful impact on several sectors that include but are not limited to Water, Energy and Agriculture (Feumba, 2017). This makes difficult the management of the

1.2. Problem Statement and Justification:

1.2.1. Problem statement:

Cameroon like many other continents, faces a growing challenge in ensuring water, energy, and food security in the context of climate change. The adverse impacts of climate change, including increased temperatures, changing precipitation patterns, and extreme weather events, are exacerbating existing vulnerabilities in the water, energy, and food sectors (IPCC, 2021). These sectors are intricately interconnected within the Water-Energy-Food (WEF) Nexus framework, and addressing the challenges in one sector often has implications for the others (Rasul et al., 2018). Feumba (2017) sought to give an overview of the prevailing impacts of Climate change and Climate variability in Cameroon, providing a detailed presentation of the situation in each of the five climate zones of the country and ways out. The NAP and the NDC of the country produced in 2016 updated NDC of 2021 also address the questions of adaptation, considering the specific needs of each zone, with potential adaptation projects that could help solve the climate crisis. However, the water, energy and food systems are mostly handled with sectoral approaches, which compromises the achievement of WEF nexus security and sustainability in the context of climate change.

Despite the urgent need to enhance climate resilience and sustainable resource management, there is a lack of comprehensive and integrated research at the global level of the African continent as well as localized studies in Cameroon that assess the challenges and opportunities associated with WEF Nexus adoption for climate change adaptation. This involves technologies, encompassing innovations in renewable energy, precision agriculture, and water-efficient systems, have the potential to mitigate climate risks and promote integrated solutions in Africa as a whole and in the Cameroon's context in particular.

1.2.2. Justification:

Effects of Global Climate Change: The water, energy, and food sectors of Africa and Cameroon are significantly impacted by this worldwide phenomenon. Crop yields, water availability, and energy output are being impacted by rising temperatures, unpredictable rainfall patterns, and extreme weather events (IPCC, 2021).

The WEF Nexus approach recognises the interdependence of the food, energy, and water systems as well as the necessity of integrated approaches to meet the challenges posed by climate change (Rasul et al., 2018). Africa is a perfect case study for implementing WEF Nexus principles due to its susceptibility to the effects of climate change.

The use of technology is crucial in improving climate resilience and advancing sustainable resource management, as stated by the UNFCCC (2019). The adoption of precision agriculture, renewable energy, and water-efficient technology can aid Cameroon in its climate change adaptation.

1.2.3. Relevance of the study

Relevance to Policy: The findings of this study are in line with the goals of the Technology Executive Committee (TEC) and the United Nations Framework Convention on Climate Change (UNFCCC). Its goal is to assist in the creation of knowledge products that facilitate the execution of Cameroon's National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs) (UNFCCC, 2020).

Limited Localised Research: There is a lack of localised research that focuses on Cameroon, despite studies being conducted on the WEF Nexus and climate technology. By offering a thorough literature overview for Africa and then focusing it on the Cameroonian setting, this study will close the gap.

Field-Level Findings: Field observations and data gathering in Cameroon will provide insightful information about the prospects and practical challenges associated with WEF Nexus in a real-world context.

1.3. Research Questions and Hypothesis

1.3.1. Research Questions:

For this study, the main research question is:

How does the country consider the interconnectedness nature of Water, Energy and food to ensure security and sustainability?

From this question emerge the three following specific questions:

Question 1. In what ways have the Water-Energy-Food (WEF) nexus metrics evolved in Cameroon over the last five years to reflect growing interdependencies and possible trade-offs?

Question 2. From a WEF nexus viewpoint, how well do Cameroon's strategic documents address the intricate relationships between the food, energy, and water systems, and what gaps are there in the country's climate resilience strategies?

Question 3. How can the use of Hoff's analytical framework help track the interconnectedness of the water, energy and food resource systems for climate change adaptation in Cameroon, and how can these findings guide efforts to promote WEF nexus efficacy and integration?

1.3.2. Research hypothesis:

The main research hypothesis is:

The nexus the country ensures security and sustainability for Climate change adaption but there is still chance to improve it while considering the WEF as interconnected components.

The following specific questions apply:

Hypothesis 1. There is a progressive increase in WEF nexus metrics over the past five years in Cameroon, reflecting increasing interdependencies and potential trade-offs.

Hypothesis 2. The chronological and comparative analysis of Cameroon’s strategic documents shows increasing efforts in achieving resource security in Water, Energy and Food sector while considering Climate issues; but there is still chance to improve their capacity in addressing the

complex interconnections between water, energy, and food systems, leading to gaps in climate resilience strategies.

Hypothesis 3. The Hoff's analytical framework shows a significant potential for promoting synergies and managing trade-offs between the water, energy and food resource systems in Cameroon, highlighting opportunities for enhancing WEF nexus integration and effectiveness.

1.4. Research Objectives

1.4.1. Main Objective:

To assess the challenges and opportunities of integrating the Water-Energy-Food (WEF) nexus for climate change adaptation in Cameroon, with a focus on understanding the dynamics, policies, and projects related to WEF interactions.

1.4.2. Specific Objectives:

Objective 1. To analyse the trends in WEF nexus metrics over the past five years in Cameroon.

Objective 2. To perform a chronological and comparative analysis of the Cameroon's national strategic documents from a WEF nexus perspective, focusing on their alignment with WEF interdependencies and climate resilience goals.

Objective 3. To apply Hoff's analytical framework to assess the effectiveness and implications of a selected climate change adaptation project in Cameroon within the context of the WEF nexus.

1.5. Organisation Of the Study

The current study entitled “ASSESSING THE ADOPTION OF THE WATER ENERGY FOOD NEXUS APPROCAH FOR CLIMATE CHANGE ADAPTATION IN AFRICA: AN INSIGHT ON CAMEROON” is organized around five chapters:

Chapter 1. Introduction

This chapter provides an overview of the whole thesis orientation, stating the background and presenting the problem statement and the research objectives

Chapter 2. Literature review

This chapter sheds light on the WEF nexus situation and sustainable management of resources at the global and specific levels, with an emphasis of results achieved so far

Chapter 3. Materials and methods

This chapter gives information about the how the research was conducted from data collection to results, with the resources used to achieve the objectives

Chapter 4. Results and discussions

In this chapter are presented the results arrived at using the materials and methods deployed

Chapter 5. General conclusion and recommendations

This chapter focuses on the take-home message and present the recommendations relevant for the good integration of the findings arrived at

Chapter 2. Literature Review

2.1. Introduction

The idea of the Water-Energy-Food (WEF) nexus has become well-known throughout the world as a framework for tackling the interrelated problems with food, energy, and water security. The WEF nexus is particularly significant in Africa, where the effects of climate change are already being felt, because it has the potential to improve resilience and strategies for adaptation (Akhtar-Schuster et al., 2018). With a focus on Cameroon specifically, this literature review attempts to evaluate the opportunities and constraints, including trade-offs and synergies, using WEF nexus technology in the context of climate change adaptation.

The WEF nexus was first conceptualised in the late 2000s. Bazilian et al. (2011) suggested using an integrated modelling approach to take into account WEF links in order to evaluate the needs for global resources. Hoff (2011) underlined that in order to coordinate policy across sectors, nexus thinking is essential. He presented the interlinkages between the WEF resource systems as seen in figure1 below. The next step was quantitative analysis of global resource trends. In their analysis of water withdrawals by sector and source, Wada and Bierkens (2014) discovered that 92% of consumptive usage was accounted for by agriculture.

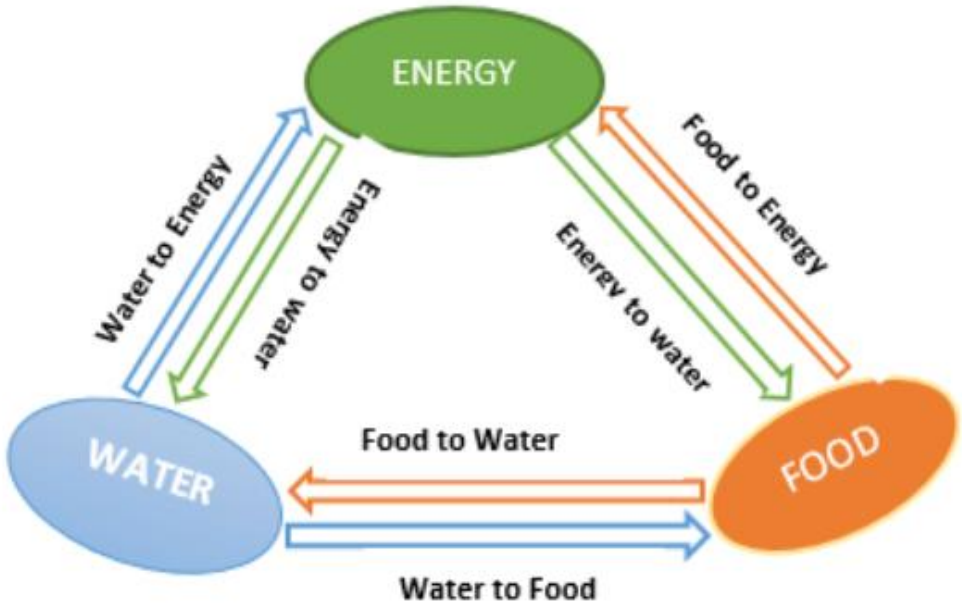


Figure 1: WEF nexus interlinkages diagram (Hoff, 2011)

Future demand projections have been a focus of much research. KC and Lutz (2017) used the Shared Socioeconomic Pathways model to simulate how changes in population and wealth will affect the world's needs for food, water, and energy by 2050. They discovered a 30–70% rise in WEF needs. In a similar vein, Kummu et al. (2018) predicted that if efficiency increases do not keep up, increased global WEF demand and threats of physical scarcity will arise in the next decades.

The UN Sustainable Development Goals have been examined concerning access to the WEF. Weitz et al. (2014) evaluated policy trade-offs and links between targets related to food, energy, water, climate change, and biodiversity. By 2030, Ringler et al. (2013) stressed that integrated solutions are required to satisfy sanitation, water, and nutrition goals concurrently.

One of the main obstacles to WEF security is climate change. Global water and energy systems are impacted by climatic variability and extremes, according to Garrick and Hall's (2014) review. According to Liu et al. (2017), if adaptation is not made, climate change could worsen water stress in more than 80% of the world's population by 2050. In the context of climate uncertainty, basin-scale trade-offs were examined by Varela-Ortega et al. (2016).

Studies on institutional difficulties have been conducted. Integrated planning frameworks were advocated by Bazilian et al. (2011). Gaps were identified by Scott et al. (2015) after reviewing national experiences with WEF governance and policy coherence. Enhancing global hydrological models and data for cooperative management was highlighted by Flörke et al. (2018).

Additionally, technological solutions are heavily featured. Howells et al. (2013) assessed desalination, reusing wastewater, and hydropower as global alternatives. The energy, water, and land nexus of a few chosen technologies was examined by WEF (2016). In areas with limited data, MacDonald et al. (2016) gave priority to growing monitoring networks.

2.2. The National Climate Situation in Cameroon and Technological considerations

The information provided in this section was sourced from the Cameroon Technology plan (MINEPDED, 2022) that sheds light on the political will in the country to mainstream technological benefits to enhance Climate resilience.

2.2.1. Overview of the national technology plan for Climate

The Ministry of Environment published a 153-page national technology plan in November 2022. It functions as a technological action plan customised for certain situations, with a focus on sustainable development and climate technologies. The document was produced with the assistance of the United Nations Industrial Development Organization (UNIDO), the Climate Technology Centre and Network (CTCN), and the Green Climate Fund (GCF); with the cooperative efforts of a number of stakeholders, including government agencies, development partners, academic institutions, businesses, and civil society. It focuses on evaluating technology requirements to the benefit of energy and Agriculture in the context of climate change, for sustainable development. The report incorporates the cooperative feedback from various organisations and stakeholders.

2.2.2. The climate situation in the country as presented in the national technology plan

Key aspects of the climate situation in Cameroon highlight its vulnerability to climate change, similarly to challenges faced by many developing nations, with extreme weather events impeding development progress. Scientific forecasts predict heightened intensity of such events in the future, necessitating urgent action on climate change. Cameroon's active participation in international climate negotiations since the Bali COP in 2007, alongside its ratification of the UNFCCC in 1994, underscores its commitment to addressing climate challenges. Strategic documents such as the National Climate Change Adaptation Plan, National REDD+ Strategy, and NDCs outline the country's priorities in combating climate change and enhancing resilience. Emphasizing the pivotal role of technology in both mitigation and adaptation efforts, the document stresses the importance of stakeholder consultation to identify promising technologies, particularly in the energy and agriculture sectors. These insights underscore Cameroon's climate vulnerabilities, its proactive engagement in global climate initiatives, and the pivotal role of technology in its climate resilience strategies.

2.2.3. The contribution of technology in building resilience as discussed in the national technology plan

The reports emphasizes that technology is essential for reducing greenhouse gas emissions and increasing resistance to the effects of climate change in Cameroon's energy and agricultural sectors. It shows how important it is to find viable solutions through a collaborative process including a variety of stakeholders. The goals of this process are to improve resilience, reduce

emissions, and facilitate low-carbon development planning. The technologies that have been identified hold promise for strengthening efforts to adapt to climate change, enabling the country to more effectively endure the effects of climate change and pursue a sustainable course. A collaborative approach to technology adoption for climate adaptation and mitigation is highlighted by stakeholder involvement in the assessment of technical needs, highlighting the group effort needed to effectively handle climate concerns. The operational and technical parts of technology deployment are further enhanced by support from organisations such as UNIDO, CTCN, and GCF, hence enhancing Cameroon's ability to withstand climate change. These observations underscore the pivotal role that technology plays in bolstering climate resilience, stressing the importance of external support, stakeholder participation, and cooperative engagement as essential components in using technology for sustainable development.

2.3. WEF Nexus Past Studies

The African continent places great priority on the water, energy, and food (WEF) nexus. Numerous studies have examined the regional, national, and local WEF difficulties and connections in Africa. The literature emphasises the growing awareness of integrated WEF challenges as well as the gaps that still need to be filled in order to address them at the global level through coordinated action, planning, and innovation.

Simpson et al. (2022) used a multidimensional scoring scheme to develop and assign values to the WEF nexus pillars and came up with WEF nexus indexes from 2019 to 2022 for the whole world. After reviewing 87 globally available indicators, 21 relevant indicators were selected to construct the WEF Nexus Index (as presented in Figure 2).

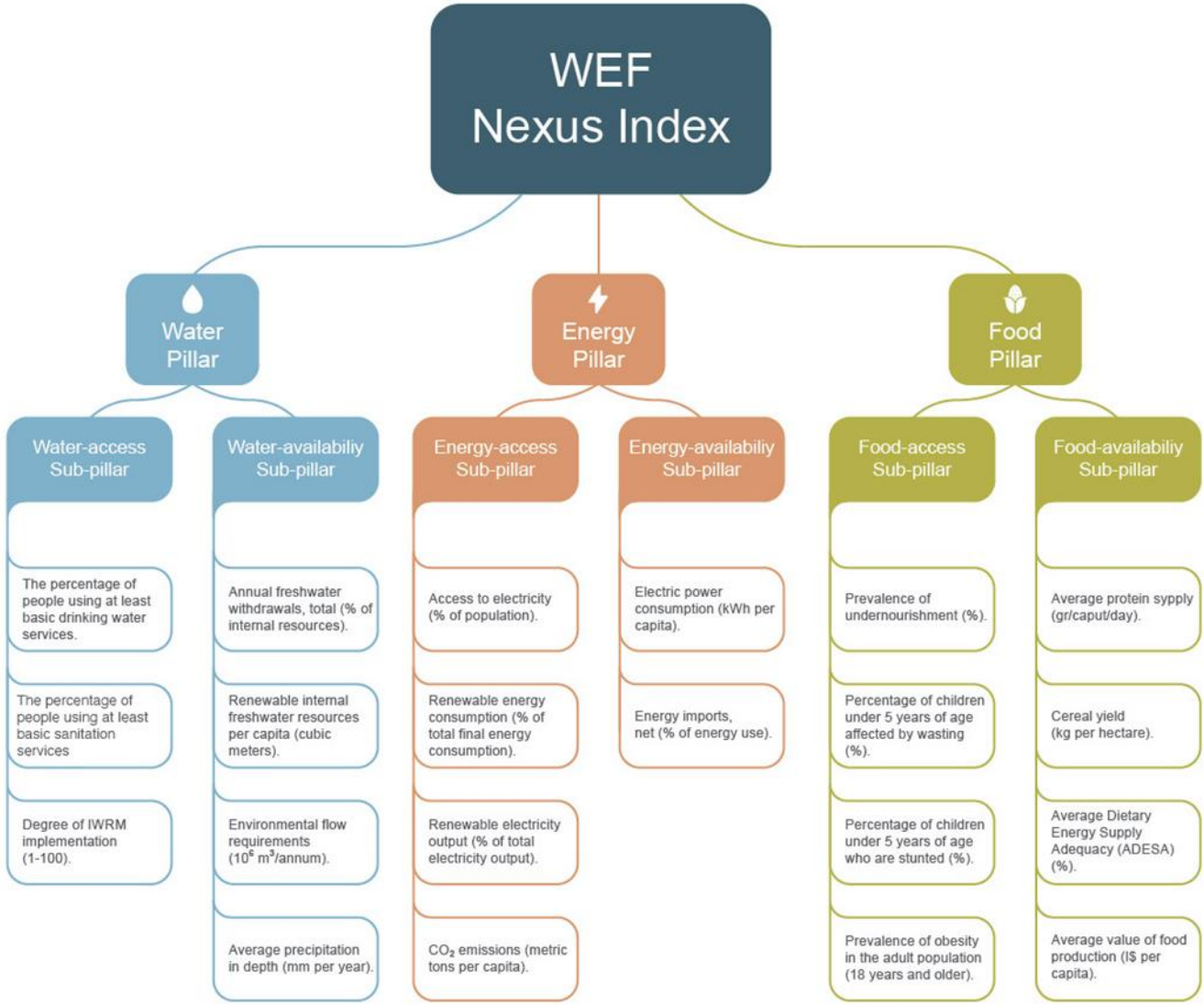


Figure 2: Water energy food nexus pillars and sub-pillars (Source: Simpson et al., 2022)

2.3.1. Studies done in Africa as a whole

Table 1: Past studies in Africa with their results and limitations

Authors and Year	Methods	Main Results	Limitations or Gaps
Simpson et al. (2022)	Multidimensional scoring scheme to develop and assign values to WEF nexus pillars. Pilot analysis conducted on SADC countries.	Developed WEF Nexus Index using 21 indicators. Food pillar was lowest, with food-availability sub-pillar particularly low due to low cereal yields and food production.	Geographic restriction in study; limited replication in sub-Saharan region; pilot analysis focused on SADC countries only.
Hoff et al. (2019)	Developed and applied WEF analytical framework to study 5 projects in MENA region.	Water central across all case studies, highlighting need for increased availability, reduced demand, or increased efficiency. Limited geographic scope restricts generalization to other regions like sub-Saharan Africa.	Geographic restriction to MENA region; limited applicability to sub-Saharan Africa.
Jalilov et al. (2018)	Projected future water demand from food and energy sectors in Africa using modelling at continental scale.	Predicted 60–140% increase in water demand by 2050 due to population and economic expansion.	Lack of consideration for specific regional nuances; reliance on modelling projections.
Hussein et al. (2020)	Examined advancement of WEF objectives in Africa in relation to UN Sustainable Development Agenda.	Highlighted progress in WEF objectives alignment with UN Sustainable Development Agenda in Africa.	Lack of detailed analysis on specific WEF nexus interactions and dynamics.
Ringler et al. (2013)	Studied WEF challenges in Middle East and North Africa using integrated modelling method.	Emphasized need for increased regional collaboration to address WEF challenges.	Limited scope to Middle East and North Africa; lack of focus on sub-Saharan Africa.
Berhe et al. (2020)	Examined risks to food and water security in Eastern Africa under climate change effects using integrated modelling method.	Identified risks to food and water security under climate change effects.	Limited to Eastern Africa; reliance on modelling projections; lack of specific focus on WEF nexus synergies.
Tsegawe (2018)	Analyzed Ethiopia's policies regarding irrigation, climate change, and hydropower using policy analysis.	Identified need for more coordinated long-term planning in Ethiopia.	Limited to analysis of Ethiopia's policies; lack of broader regional perspective.
Gebreegziabher et al. (2018)	Evaluated Tanzania's connections between energy and water using input-output model.	Highlighted interdependencies between energy and water sectors in Tanzania.	Limited to analysis of Tanzania's connections; lack of broader regional perspective.
Mukherjee et al. (2021)	Investigated WEF trade-offs in South Africa's industrial sector using multi-criteria decision analysis.	Demonstrated trade-offs in local maize production due to industrial policy.	Limited to analysis of South Africa's industrial sector; lack of broader regional perspective.
Abdallah and Rosenberg (2020)	Investigated smallholder farmers' opinions on WEF nexus in Kenya using surveys and interviews.	Revealed deficiencies in integrated management and knowledge of WEF relationships among smallholder farmers.	Limited to local context in Kenya; lack of broader regional perspective.
Mare et al. (2021)	Studied community-based WEF control initiatives in Lesotho using qualitative analysis.	Assessed benefits and obstacles of community-based WEF initiatives in Lesotho.	Limited to local context in Lesotho; lack of broader regional perspective.

The studies (See Table 1) provide a thorough summary of the research on the Water-Energy-Food (WEF) nexus, with an emphasis on studies carried out in Africa. Every row denotes a distinct study and includes details about the authors, the year the work was published, the methodology used, the key findings, and any restrictions or gaps in the data.

This analysis reveals several important insights:

Methodological Diversity: There is a broad range in the methodologies used in the studies, from qualitative surveys and interviews to multidimensional scoring schemes and modelling techniques. This variability highlights the intricacy of the WEF nexus and the necessity of interdisciplinary methods to properly comprehend its dynamics.

Principal Findings:

The research' principal findings draw attention to important problems that are made worse by climate change, including food insecurity, energy demand, and water shortage. Central difficulties arise from trade-offs between many sectors, such as the fight for water resources and conflicts between energy production and food security.

Regional and Local Views:

Studies at different sizes are included in the literature review, ranging from local case studies in nations like Kenya and Lesotho to regional analysis of WEF difficulties in the Middle East and North Africa. A more complex understanding of the WEF nexus is made possible by this multi-scale approach, which takes local circumstances and regional patterns into consideration.

Limitations and Gaps:

These studies offer insightful information, but there are still a number of shortcomings and gaps. These include methodological limitations like relying on modelling projections and location restrictions like research that are limited to the MENA region. Furthermore, many studies concentrate on particular nations or local situations rather than taking a more comprehensive regional view.

All things considered, these studies highlight the significance of continued research on the WEF nexus in Africa, with serious climate issues. Researchers can support more effective policies and strategies for sustainable development and climate resilience in the region by addressing

the shortcomings and gaps found in previous studies and using a more integrated and interdisciplinary approach.

2.3.2. Past studies in Cameroon

Table 2: Past studies done in C ameroon and their results and limitations

Authors and Year	Methods	Main Results	Limitations or Gaps
Elong et al. (2021)	Integrated modelling method	Identified trade-offs between hydropower generation and agricultural water usage, emphasizing the need for better cooperation for future food and water security	Limited geographic scope; focused on national-level analysis without considering local variations
Nganje et al. (2020)	Crop and hydrological models	Forecasted the effects of climate change on water resources and maize output until 2050, highlighting threats to food security posed by rising temperatures and shifting precipitation patterns	Lack of consideration for other crops or sectors beyond maize; potential biases in modelling assumptions
Yemefack et al. (2019)	Evaluation of difficulties in the Congo Basin	Examined challenges in transboundary coordination, particularly regarding shared water resources in the Sanaga River, highlighting the importance of regional cooperation	Limited focus on Cameroon-specific issues; generalization of findings to other regions may be challenging
Ndzana et al. (2019)	Surveys and interviews	Investigated smallholder farmers' perceptions of WEF linkages in Northern Cameroon, revealing deficiencies in integrated management and knowledge of relationships between crops, energy, and water	Small sample size; findings may not be representative of the broader population
Kemajou et al. (2021)	Evaluation of community-based water governance projects	Assessed the impact of water governance initiatives around Lake Nyos on local lives, identifying ongoing obstacles and benefits	Lack of longitudinal data; difficulty in quantifying qualitative impacts

The studies summarized in the table 2 offer valuable insights into the complexities of the Water-Energy-Food (WEF) nexus in the context of Cameroon.

Elong et al. (2021) utilized an integrated modelling approach to identify trade-offs between hydropower generation and agricultural water usage at the national level. Their findings underscore the need for improved cooperation to ensure future food and water security. However, the study's geographic focus on a national level may overlook local variations and nuances within Cameroon's diverse regions.

Nganje et al. (2020) employed crop and hydrological models to forecast the impacts of climate change on water resources and maize output until 2050. Their research highlights the significant threats posed by rising temperatures and shifting precipitation patterns to Cameroon's food security. Yet, the study's exclusive focus on maize and the potential biases in modelling assumptions may limit the generalizability of their findings to other crops or sectors.

Yemefack et al. (2019) evaluated challenges in transboundary coordination within the Congo Basin, specifically focusing on shared water resources in the Sanaga River. Their study emphasizes the importance of regional cooperation in managing water resources effectively. However, the research's limited focus on Cameroon-specific issues and the challenges of generalizing findings to other regions may restrict its applicability.

Ndzana et al. (2019) investigated smallholder farmers' perceptions of WEF linkages in Northern Cameroon through surveys and interviews. Their research revealed deficiencies in integrated management and knowledge gaps regarding relationships between crops, energy, and water. Yet, the study's small sample size and potential limitations in representing the broader population raise questions about the generalizability of its findings.

Kemajou et al. (2021) assessed the impact of community-based water governance projects around Lake Nyos on local livelihoods. Their study identified both ongoing obstacles and benefits of these initiatives. However, the lack of longitudinal data and challenges in quantifying qualitative impacts may limit the depth of their analysis.

Overall, these studies collectively contribute to our understanding of the WEF nexus in Cameroon by highlighting key challenges, opportunities, and areas for improvement. However, they also underscore the need for further research that considers local variations, employs robust methodologies, and addresses the limitations identified to develop comprehensive and context-specific strategies for sustainable resource management in Cameroon.

2.3.3. The contribution of strategic documents in WEF nexus studies: NAPs, NDCs and IWRM

2.3.3.1. National determined contributions

One significant channel for mainstreaming nexus-based adaptability is through NDCs. Building resilience across water, energy, food, and interconnected ecosystems is emphasised in many African NDCs. For instance, to increase adaptation capability nationally, Cameroon's NDC (Republic of Cameroon, 2016) places a high priority on climate-smart agriculture, the expansion of renewable energy, and environment protection. Similar to this, as part of a nexus-oriented adaptation approach, Ethiopia's NDC (Federal Democratic Republic of Ethiopia, 2017) places a strong emphasis on integrated water resources management, irrigation development, and climate-resilient infrastructure.

However, research indicates that more collaboration is needed to fully realise the nexus potential of NDCs. After reviewing NDCs from 13 nations, including Senegal and Kenya, Vij et al. (2019) discovered that sectoral silos continue to exist in planning. Mabhaudhwe et al. (2019) highlighted that, considering potential trade-offs, holistic implementation is essential. Additionally, academics support the use of NDCs to scale up creative nexus solutions. In order to access climate funding streams, Njinkeu et al. (2020) suggested bundling adaption projects across national borders, such as hydropower-irrigation programmes. Mateo-Sagasta et al. (2018) examined blended project models that effectively raised funds for WEF initiatives that would benefit both parties.

If coordinated processes address interlinkages and synergies as part of implementation, reflecting each nation's particular cultural context, African NDCs present doors for nexus-informed adaptation planning. Enhancing these procedures may aid in maximising the results related to climate resilience.

2.3.3.2. National adaptation plans

Food, energy, and water security are identified as priority vulnerable areas in the NAPs of many African nations. For instance, coordinated management of inland and coastal water resources is emphasised in Ghana's NAP (Government of Ghana, 2015). In a similar vein, the United Republic of Tanzania (2018) prioritises the expansion of renewable energy sources and climate-resilient agriculture in its NAP. Studies indicate that nexus synergies could be further enhanced by implementing NAP. In their study of South Africa's NAP process, Mabhaudhwe

et al. (2019) discovered that there are still chances to improve cross-sectoral cooperation. In their evaluation of India's NAP, Vij et al. (2019) suggested pooling adaptation measures across ministries in order to garner finance. Adaptation pathways mapping (Harley et al., 2021) is one approach that academics suggest using to sequence NAP measures and optimise co-benefits. Innovative nexus-based projects that harness climate funding could be further scaled up through transboundary cooperation mechanisms (Njinkeu et al., 2020).

Overall, African NAPs offer opportunities for more comprehensive, synergistic climate resilience construction that is representative of each country's distinct cultural context by mainstreaming nexus viewpoints into strategic planning and practical solutions. There may be major co-benefits with improved coordination and regional cooperation.

2.3.3.3. Integrated water resources management (IWRM)

In order to achieve Water-Energy-Food (WEF) nexus security, integrated water resources management (IWRM) is crucial because it provides a comprehensive framework that takes into account how interrelated these vital resources are. IWRM offers a complete framework that enables the coordinated management and development of land, water, and related resources to maximise social and economic welfare while maintaining the sustainability of essential ecosystems, claim Biswas and Tortajada (2018). This is in line with the core tenets of the WEF nexus, which emphasises managing the food, energy, and water systems in a synergistic and interdependent manner to promote sustainability and security (Leach et al., 2019). Policymakers and stakeholders can improve resilience and climate change adaptation by using an IWRM strategy to identify and navigate the complex trade-offs and synergies between the water, energy, and food systems (Dodds et al., 2018). In addition, Nilsson et al. (2012) stress the significance of evidence-based decision-making in IWRM and the necessity of solid data and analytics to support governance and policy reforms in order to effectively solve WEF nexus concerns. The governance frameworks of IWRM are inclusive and flexible, which in turn promotes capacity building and stakeholder engagement—two essential components of attaining WEF nexus security (Folke et al., 2005). When taken as a whole, these viewpoints highlight how crucial IWRM is to the advancement of sustainable management techniques that help achieve the goals of energy, food, and water security while also advancing the larger agenda of sustainable development and climate resilience.

2.4. WEF Nexus in Cameroon

Using an integrated modelling method, Elong et al. (2021) examined the relationships between hydropower generation and agricultural water usage in Cameroon at the national level. They discovered trade-offs between the food and energy sectors that call for better cooperation in order to guarantee food and water security in the future under dynamic circumstances. In a related study, Nganje et al. (2020) used crop and hydrological models to forecast the effects of climate change on Cameroon's water resources and maize output until 2050. Their findings emphasised the threats that rising temperatures and shifting precipitation patterns pose to the country's food security.

The WEF issues facing Cameroon are placed in a larger context by regional analysis. Considering the shared water resources in the Congo Basin, particularly the Sanaga River in Cameroon, Yemefack et al. (2019) evaluated difficulties throughout the basin with a focus on transboundary coordination. Njinkeu et al. (2022) especially looked at Cameroon's hydropower potential as a potential source of regional electrical commerce, and they discovered that this may assist increase food accessibility by boosting agricultural output in nearby nations.

Case studies shed light on the dynamics of the local WEF. Through surveys and interviews, Ndzana et al. (2019) investigated smallholder farmers' perceptions of WEF linkages in Northern Cameroon. Their research showed deficiencies in integrated management as well as knowledge of the relationships between crops, energy, and water. In their evaluation of community-based water governance projects around Lake Nyos and their impact on local lives, Kemajou et al. (2021) noted both ongoing obstacles and benefits.

Considering the country's dependence on hydropower, sensitivity to climate change, and involvement in regional cooperation, Cameroon is vulnerable and interdependent, even though there isn't as much research on the country's WEF nexus as there is in larger African nations.

2.4.1. Some challenges in Cameroon

Central African nation of Cameroon is vulnerable to the effects of climate change, which include more frequent droughts and unpredictable rainfall patterns. The nation's ability to produce food, energy, and water are all directly impacted by these changes (Nkem et al., 2016). Energy access is still a problem, and shocks brought on by climate change might affect the agriculture industry.

2.4.2. Opportunities and synergies in Cameroon

Cameroon has a great deal of opportunity to use WEF Nexus technology to adapt to climate change. The nation has abundant hydropower resources, which can improve water management and energy production (Nkeng et al., 2018). It is possible to increase food security, preserve water resources, and sequester carbon by promoting agroforestry and sustainable land use practices (Tianwe et al., 2021).

2.5. Trade-Offs In Cameroon

2.5.1. Water-Energy-Food Trade-offs

Because of its reliance on hydropower to generate energy, Cameroon may have to make trade-offs with the availability of water for agriculture during dry spells (Nkeng et al., 2018). It is essential to balance water conservation measures with energy needs.

2.5.2. Energy-Food Trade-offs

There are trade-offs between energy and food sustainability since the energy-intensive processes involved in food production and distribution might increase greenhouse gas emissions (Tianwe et al., 2021).

2.6. Conclusion

A viable strategy for tackling the difficulties of climate change adaptation in Africa, and particularly in Cameroon, is the WEF Nexus approach. A good number of prosects can create integrated policies that improve food, energy, and water security while adjusting to climate change by recognising trade-offs and utilising synergies. In order to fully utilise the WEF nexus in Africa and Cameroon and support sustainable development in the area, cooperation between the public and private sectors will be crucial.

Chapter 3. Materials And Methods

The research topic titled " ASSESSING THE ADOPTION OF THE WATER ENERGY FOOD NEXUS APPROACH FOR CLIMATE CHANGE ADAPTATION IN CAMEROON" aims to comprehensively understand the complexities of the WEF nexus in the context of climate change adaptation in Cameroon. This chapter outlines the materials and methods employed to achieve the research objectives. The research activities encompassed two main tasks: a quantitative analysis of the WEF nexus metrics developed by Simpson et al. (2022) related to the water, energy and food pillar over the five past years in Cameroon; and qualitative assessment. The latter is based on the evaluation of Cameroon's strategic papers in a nexus perspective and the application of the Hoff's framework to the analysis of an adaptation project in a highly vulnerable area of Cameroon.

3.1. Description Of the Study Area

3.1.1. Location map

Cameroon, located in Central Africa, stretches from the Gulf of Guinea to Lake Chad, between 2° and 13° North latitude, and between 8° 30' and 16° 10' East longitude (See figure 3). It covers an area of 475,650 km2 with a coastline of 402 km, characterized by a triangular shape with a North-South length of 1,400 km and an East-West width of about 800 km at its maximum. The country is bordered to the South by Congo, Gabon, Equatorial Guinea, and the Atlantic Ocean, to the West by Nigeria, to the North by Lake Chad, and to the East by Chad and the Central African Republic.

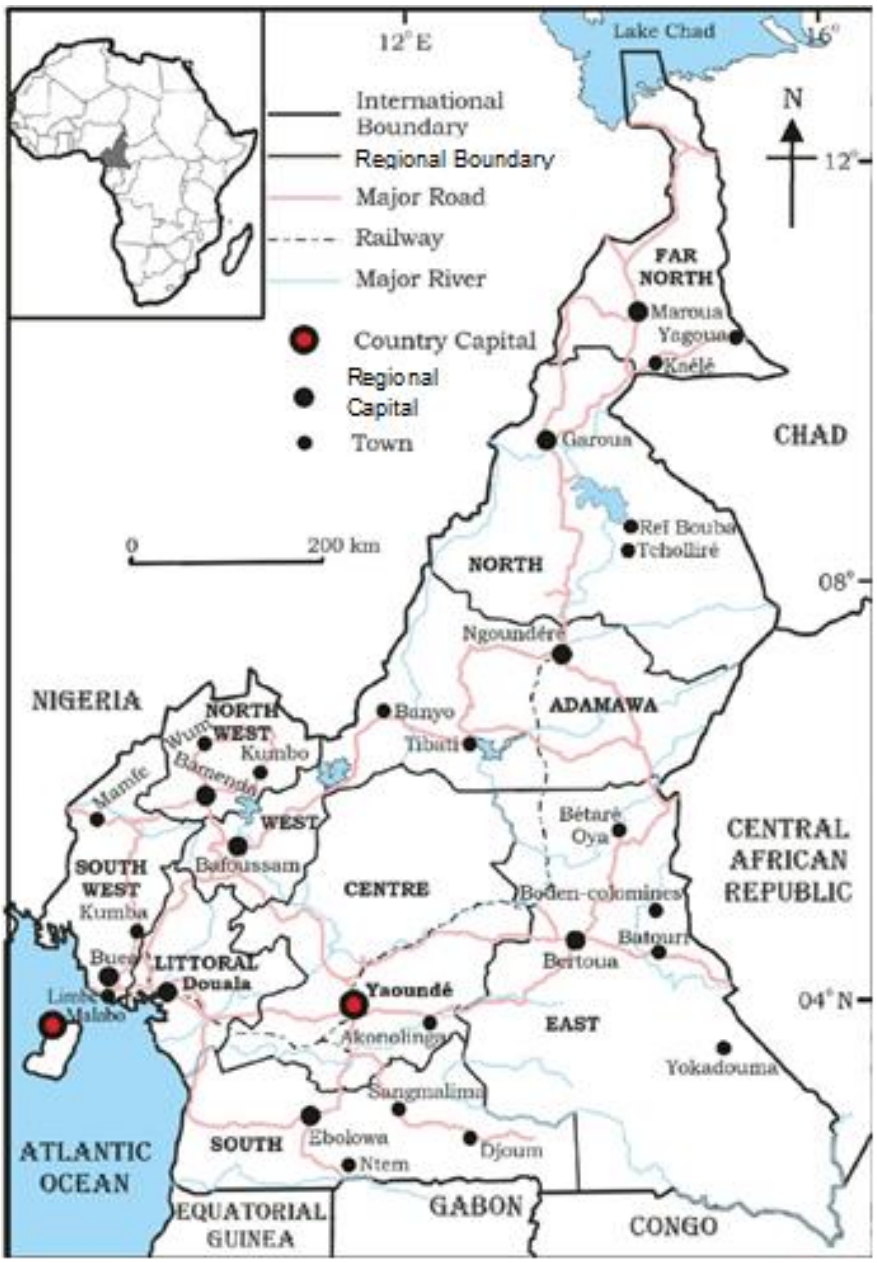


Figure 3: Location map of Cameroon (Modified after Forton et al., 2012)

3.1.2. Physical and socioeconomic environment

3.1.2.1. Relief and Watersheds:

The relief of Cameroon is predominantly mountainous, consisting of 63% mountains, with a hydrographic network divided into 5 major sets. According to the PANGIRE published by MINEE (2009) these sets include the Sanaga basin, coastal river basins, the lake Chad basin, the Niger basin, and the Congo basin (Figure 4).

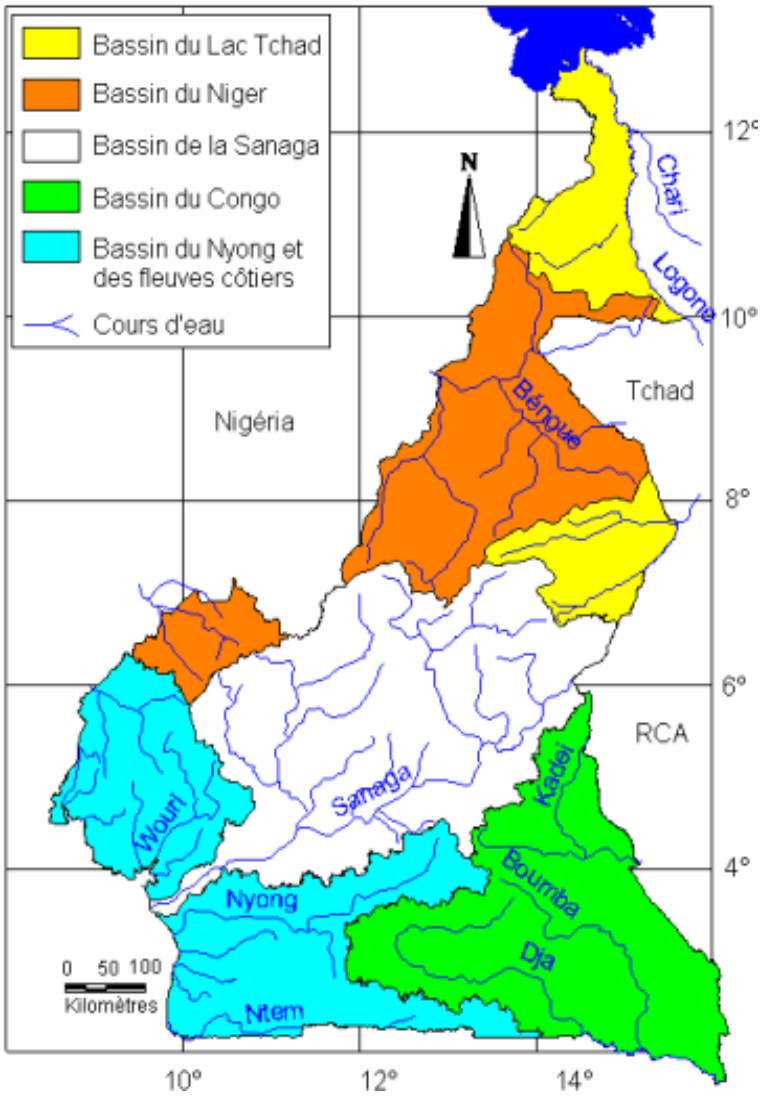


Figure 4: River basins map of Cameroon (Source: MINEE, 2009)

3.1.2.2. Climate and Vegetation:

Cameroon is located in the intertropical zone, with annual temperatures ranging from 20°C to 28°C, increasing from South to North. The country experiences a main rainy season, with precipitation decreasing from the coast to the interior and from South to North. This climatic diversity translates into five agroecological zones, including the Monomodal Forest Zone, Bimodal Forest Zone, Highlands Zone, High Savannah Zone, and Sudano-Sahelian Zone (Cameroon NAP, 2015).

3.1.2.3. Water:

Although considered one of the richest African countries in water resources, Cameroon faces challenges of uneven distribution of these resources. Most water resources are located in the

southern part of the country, and difficulties such as droughts, floods, and water pollution are encountered in all agroecological zones. It has five major river basins of transborder nature (PANGIRE, 2009; Cameroon NAP, 2015).

3.1.2.4. Biodiversity:

Cameroon hosts exceptional biodiversity, with its forests harboring a wide variety of animal and plant species. Cameroonian forests shelter 40% of African animal species, 48% of the continent's mammal species, at least 54% of bird species, 50% of amphibian species, and 30 to 75% of reptile species (Cameroon NAP, 2015).

3.1.2.5. Socioeconomic environment

3.1.2.5.1. Population and Urban Development:

With a population of approximately 27.7 million inhabitants as of 2020, Cameroon has an annual population growth rate of 2.6%, with urban areas experiencing a higher growth rate of 4.3%. The rapid urbanization, with an urbanization rate reaching 52% in 2010, presents challenges in terms of urban development and resource utilization (World Bank, 2020)

3.1.2.5.2. Urban Development:

Anarchic urbanization has become a notable phenomenon in recent years, with approximately 52% of the population residing in urban areas as of 2010, and about half of them living in precarious, often illegal, housing areas (World Bank, 2020).

3.1.2.5.3. Economy:

Cameroon's economy is one of the most diversified in Africa, primarily relying on production sectors such as agriculture, livestock, fishing, forestry, and logging. Agriculture, employing nearly 60% of the population, remains the predominant sector of the national economy, contributing 23% to the GDP. Key commercial crops include cocoa, coffee, tobacco, cotton, bananas, and pepper (World Bank, 2020).

3.1.2.5.4. Energy:

While wood energy dominates the country's energy mix, accounting for 60% of energy consumption, Cameroon also has significant oil reserves. In 2010, about 49% of the population had access to electricity, mainly provided by the country's three main hydroelectric power

plants. However, Cameroon's hydroelectric potential remains largely underutilized (Cameroon NAP, 2015).

3.1.2.5.5. Transportation:

Cameroon's transportation network includes a road network of 12,457 km of rural tracks, 18 national roads, and a railway network covering 1,000 km of main tracks. The country also has three international airports in Douala, Yaoundé, and Garoua, as well as a network of national airports. The autonomous port of Douala, located on the Atlantic coast, handles 95% of the national port traffic and is the main port in Central Africa.

3.2. Data Collection

3.2.1. Data collection for the WEF nexus scores

The data used in this section were retrieved from the database developed by Simpson et al. (2022) and made available on their repository for the period 2019 to 2022. They developed a composite indexation of the WEF nexus metrics for the whole world and the following statement describes the essence of their work:

The WEF Nexus Index has been developed following the methodology developed by the European Commission JRC Competence Centre on Composite Indicators and Scoreboards.

This composite indicator, which utilises the multi-centric WEF nexus as its conceptual framework, and is comprised of the three resource sectors i.e., Water, Energy and Food as equal pillars/sub-indices. Each resource sector is, in turn, made up of “access” and “availability” sub-pillars, which are also weighted equally. Following a review of 87 globally available indicators, 21 relevant indicators were selected to construct the WEF Nexus Index. It can also catalyse, or be utilised in parallel with, complementary quantitative and qualitative nexus assessments.”

3.2.2. Data collection for the chronological and comparative analysis

The documents strategic documents of Cameroon from 2005 to 2021 were collected from the ministries in charges of water, energy and agriculture, and from the ministry of Economy of Cameroun; and their various repositories. The lists of projects with their objectives were collected from the project’s boards of the different ministries in charge and from their various repositories.

An analysis was performed that aimed at assessing their WEF nexus potential and pinpoint the level of adoption of the WEF nexus approach. The analysis was carried out on fourteen documents organised in three sets, namely five general strategic documents, three specific adaptation documents, five sectoral documents in the water, energy and food sectors; and one decentralisation document as presented below:

3.2.2.1. Analysis of the Cameroon’s general strategic documents

Five general strategic documents were used that are presented below:

3.2.2.1.1. The VISION 2035

It is 72-page document titled "Vision 2035," which was released in June 2009, that describes Cameroon's goals for long-term growth. The importance of the Prime Minister and Head of Government in carrying out this goal is emphasised heavily. The Vision lays out a thorough plan for Cameroon's future development, with an emphasis on attaining objectives like decentralised government, economic success, regional and international integration, regulated population increase, and maintaining peace and security.

3.2.2.1.2. DSCE (Growth and Employment Strategy Paper 2010-2020)

The 172-page "Growth and Employment Strategy Paper 2010-2020," which was released in August 2009, outlines Cameroon's coordinated efforts to support the industrial and services sectors. It outlines the government's multipronged approach, which includes steps to strengthen the financial industry, promote an atmosphere that is favourable to business, accelerate infrastructure development, encourage exports and investments, and encourage technical innovation.

3.2.2.1.3. DSDR (Rural Sector Development Strategy Paper)

A thorough 189-page document that was created in 2005, the Rural Sector Development Strategy Paper carefully outlines a strategy framework for promoting rural sector development in Cameroon. There is a preamble, and the text is divided into four main sections: explaining the overall background and issues facing the rural sector, diagnosing the current situation thoroughly, establishing the DSDSR as a fundamental reference work, and suggesting ways to carry out integrated rural development projects and programmes.

3.2.2.1.4. PDSR (Rural Sector Development plan)

January 2016 saw the release of the 160-page Rural Sector Development plan (Second Version), an updated version of the 2005 plan paper. This revised plan is well-positioned to direct the course of growth for Cameroon's rural sector, as it is in line with the country's economic policy framework, which includes Vision 2035, the Document de Strategie pour la Croissance et l'Emploi (DSCE), and the Nouveau Regime Financier de l'Etat (NRFE).

3.2.2.1.5. SND30 (National Development Strategy 2020–2030)

A cornerstone of Cameroon's long-term growth strategy, SND30 (National Development Strategy 2020–2030) is a 261-page document that supports the country's main objective of becoming an emerging, democratic, and cohesive nation by 2035. Covering key contextual factors, methodological tenets, strategy attributes, and constituent parts, SND30 outlines a thorough plan for accomplishing lofty goals.

3.2.2.2. Specific adaptation documents

Three specific adaptation documents were analysed as follows:

3.2.2.2.1. CPDN / (Intended nationally determined contributions) INDC

This brief 17-page document, created in 2015, prior to the Nationally Determined Contributions (NDCs), outlines Cameroon's pledges to reducing greenhouse gas emissions and preparing for its effects. It emphasises how crucial it is to cut greenhouse gas emissions and put comprehensive plans for adaptation and mitigation into effect.

3.2.2.2.2. Nationally Determined Contributions (NDCs)

This 64-page document, which is an updated version of the 2015 original, focuses on assessing the technological requirements for Cameroon's Nationally Determined Contributions (NDCs) implementation. Emphasising the need to battle climate change and promote social and economic growth at the same time, the text goes into great detail about the technology infrastructure that is needed.

3.2.2.2.3. National adaption plan

Cameroon's 154-page National Adaptation Plan, which was released in June 2015, emphasises the necessity of developing an all-encompassing plan to address the effects of climate change. Drawing attention to the increasing frequency of extreme weather events, delayed rainy

seasons, and recurring droughts and floods, the report emphasises that climate change is becoming an urgent social issue rather than a distant worry.

3.2.2.3. Sectoral documents

Documents from the separate sectors of WEF were analysed as follows:

3.2.2.2.1. Agriculture sectoral documents

The document used here was the PNIA (National Agricultural Investment Plan). Delivered in April 2014, the 76-page National Agricultural Investment Plan of Cameroon provides a detailed plan for developing, managing, and improving human resources under the jurisdiction of the Ministry of Economy, Planning, and Regional Development (MINEP).

3.2.2.2.2. Water sectoral documents

The Cameroon's National planning for Integrated Water Resource Management (PANGIRE)

The Cameroon's National planning for Integrated Water Resource Management is a 79 pages document, released in 2009 by the Ministry of Water and Energy, with the technical support of the Global Water Partnership. document talks on the problems and shortcomings in Cameroon's water sector, especially the lack of a national water policy and the institutional framework's shortcomings.

The Cameroon's Water policy

The 148-page Cameroon Water Policy was created with assistance from the Global Water Partnership and was published in November 2019. Its main goal is to position the water sector as a catalyst for broader efforts in sustainable development by offering strategic advice for resolving issues and passing legislation relating to water resource planning, mobilisation, and sustainable development.

3.2.2.2.3. Energy sectoral documents

The document used here was the Long-Term Development Plan for the Electricity Sector with a Horizon of 2030 (PDSE 2030).

Published in July 2006, the 43-page PDSE 2030 (Long-Term Development Plan for the Electricity Sector with a Horizon of 2030) is a crucial document. This carefully thought-out

strategic plan is intended to provide the Ministry of Energy and Water with essential support as it develops the Long-Term Electricity Sector Development Plan for 2030.

3.2.2.4. Decentralization documents

The document used was the Practical Guide to the integration of Climate Change aspects in the Design, Development, Implementation, and Follow-Up of Communal Development plans in Cameroon.

This is a key decentralisation paper that was introduced in December 2013. This 17-page handbook is an essential tool for helping communities incorporate climate change into their council development plans. Functioning in eighteen councils around the country, it provides a thorough framework for incorporating climate change concerns into community development procedures with ease.

3.2.3. Data collection for the VIVA Bénoué project

The documents for the VIVA Bénoué project were collected from the Ministry of Economy and some additional information from the project repository and a focus person working on the project. The selection of this project was done according to the following criteria:

High WEF nexus potential; High level of vulnerability of the project area; Climate adaptative nature of the project; Availability of all relevant data to the project; Status of completion (Ongoing).

3.2. Data Processing, Analysis Procedures, Ethical Considerations

3.2.1. Data processing for the WEF nexus scores

The Excel spreadsheet from Office 365 was used to do perform trend and correlation analysis for the quantitative assessment of the water-energy-food (WEF) nexus indicators in Cameroon. The database created by Simpson et al. (2022) for evaluating the WEF nexus, which includes the WEF index, water pillar, energy pillar, and food pillar, served as the basis for the measurements used. The choice of the linear correlation was done following the studies of Simpson et al. (2022) that applied the same when using the database to analyse the WEF nexus situation in SADC countries. Besides, since the pillars were given equal weight and the sub-pillars as well, it was an assumption from building the scores, that their interaction followed a linear behaviour, that was surely to make the computation less complex.

3.2.1.1. Within the WEF nexus structure, the correlation between pillars can provide various insights:

Interconnectedness: Water, energy, and food systems are interdependent; this may be seen by analysing the correlations between the various pillars. For instance, a high positive correlation between the food and water pillars may suggest that the availability of water affects agricultural productivity.

Trade-offs: A negative connection among the pillars could be a sign of possible conflicts or trade-offs in resource management plans. For example, a negative correlation between the water and energy pillars may indicate that irrigation for agriculture and hydropower generating have competing demands on available water resources.

Synergies: Opportunities for synergistic interventions may be highlighted by positive correlations between the pillars. For example, a positive correlation between the food and energy pillars may suggest that, via mechanisms like effective irrigation systems, advances in energy efficiency can support sustainable food production.

Determining Priorities: It is possible for policymakers to determine priority areas for intervention by examining relationships between the pillars. Policies that address water-food nexus concerns more prominently may be necessary, for instance, if there is a significant association between the water and food pillars but a poor correlation between the energy and water pillars.

Policy Integration: Taking into account the interdependence of the food, energy, and water systems, integrated policy approaches can be informed by correlation analysis. Designing more comprehensive and successful policy solutions can be aided by an understanding of how modifications to one pillar impact others.

3.2.1.2. The following insights can be gained by using Pearson linear correlation analysis between the WEF nexus index and its component pillars (water, energy, and food):

Relationship Strength: The direction and strength of the relationships between each pillar and the WEF nexus index will be shown by the correlation coefficients. Strong positive correlations are shown by coefficients around +1, whereas strong negative correlations are indicated by coefficients near -1.

Relative Importance: The relative contribution of food, energy, and water to the overall WEF nexus situation of a nation can be determined by comparing the correlation coefficients between the WEF nexus index and each pillar.

Related to one another: Improvements or decreases in one pillar typically correspond with improvements or declines in the WEF nexus situation as a whole, according to positive correlations found between the WEF nexus index and individual pillars. On the other hand, negative correlations imply that there can be priorities or trade-offs amongst the pillars.

Implications for Policy: Comprehending the relationships can help policymakers identify potential areas for intervention aimed at improving the WEF nexus situation. For instance, it can suggest that water management policies have a greater impact if there is a strong positive correlation between the WEF nexus index and the water pillar but a lower correlation with the energy or food pillars.

Extended Trends: Monitoring the correlations across time can reveal long-term patterns in the interaction between the WEF nexus index and its component pillars, offering important information for resource management and sustainable development planning.

3.2.2. Data processing for the chronological and comparative analysis

In order to assess the documents and rate them on the same basis, the following grid was developed with six criteria pertinent to the WEF nexus, with climate considerations:

C1: Resource systems involved - This criterion evaluates whether the food, energy, and water systems are taken into account in the document, either directly or indirectly. The significance of taking into account these interrelated resource systems is supported by literature. In order to accomplish sustainable development goals, for instance, Rasul and Sharma (2016) stress the necessity of integrated approaches that address the food, energy, and water systems concurrently.

C2: The resource systems' interconnectedness: This criterion assesses if the paper takes into account how the food, energy, and water systems are interconnected. The importance of identifying and resolving the interdependencies between various systems is highlighted by research. For example, in order to attain resilience and sustainability, Bates et al. (2018) recommend taking into account the interconnections between the food, energy, and water

systems. Hoff (2011) and Hoff et al. (2019) also insisted on the interconnectedness of the WEF resource systems.

C3: Climate consideration: This criterion looks at how specifically climate change issues are addressed in the document. Strategies for adaptation and efficient resource management must take climate change into account. Dodds et al. (2018) emphasise that in order to effectively handle the problems presented by climate change, resource management policies must incorporate climate considerations. Feumba (2017) also mentioned climate change and climate variability as a major threat to achieving security in the sector of water, energy and agriculture.

C4: Coherence of policy - This criterion evaluates how well the text fits in with other governance instruments and guidelines. Maintaining policy coherence is crucial to the efficient execution and synchronisation of resource management endeavours. Liu et al. (2018) stress that in order to handle complicated sustainability concerns across many sectors, policy consistency is necessary.

C5: Stakeholder consideration - This criterion assesses whether the paper outlines the obligations and duties of stakeholders in sustainability and resource management. Involving stakeholders is essential to the adoption and effective execution of projects and policies. The significance of stakeholder engagement in attaining sustainable resource management results is examined by Partzsch et al. (2017). Hoff et al. (2019) also emphasized this point in developing their analytical framework of the WEF nexus approach.

C6: technology consideration: This criterion evaluates if the text takes into account innovations and technology requirements to achieve resource security and sustainability. Making the most of technology is essential to improving resource management's resilience and efficiency. Nilsson et al. (2012) emphasise the function of technology in advancing sustainable development and tackling resource-related issues. The CTCN also emphasizes on the role of technology in tackling climate related questions (CTCN, 2022a, 2022b).

The following questions guided our analysis:

Question 1) Which of the resource systems of Water, Energy and Food are considered in the document? (Is their consideration explicit or implicit?)/ 3*2 points

1 resource system = 1 point; Explicit consideration = 1 point; Implicit consideration 0 point

Question 2) If applicable, are they considered as separate or interconnected? / 6 points

Three resources whether explicitly or implicitly involved = 3 points if not considered as interconnected systems

Three resources whether explicitly or implicitly involved = 6 points if considered as interconnected systems

Question 3) Is the climate question considered? (If yes, is it explicit or implicit)

Climate change being the major threat to resource security;

Explicit Consideration of climate issues = 4 points

Implicit consideration = 2 points; No consideration = 0 points

Question 4) Is the document in line with other regulation tools or policies? (Policy coherence)/ 2points

Strong policy coherence = 2 points

Weak policy coherence = 1 point; No policy coherence = 0 points

Question 5) If applicable, does the document define the roles and responsibilities of the stakeholders?

Strong stakeholders' consideration = 2 points

Weak Strong stakeholders' consideration = 1 point

No consideration of stakeholders = 0 points

Question 6) Is there any consideration of technological aspect regarding water, energy, food and or Climate?

Strong technological considerations = 2 points

Weak technological consideration = 1 point; No technological consideration = 0 points

The overall score on 22 points was then converted to a score of 100 representing the WEF nexus potential of these documents following the evaluation grid set.

In order to assess the level of integration of the WEF nexus at the operational level, a set of thirty-eight recently completed and ongoing projects were identified; of which 10 at the

Ministry of Agriculture, 12 at the ministry of Water and Energy and, 16 at the ministry of Economy. They were then evaluated with regard to the resource systems they involve. The nexus potential was assessed as low for projects and programs aimed at achieving security only in one of the resource systems, while those involving two resource systems were identified as moderate nexus potential and those touching to the three resource systems considered as high nexus potential.

3.2.3. Data processing for the VIVA Bénoué project study

The Hoff's WEF nexus analytical framework was used to analyse the VIVA Bénoué adaptation project in Cameroon. Hoff (2011) and Hoff et al. (2019) created this framework, which offers a methodical way to comprehend the trade-offs and interdependencies between the food, energy, and water systems in the context of adaptation initiatives.

The interdependence of the food, energy, and water systems is highlighted by Hoff's framework, which acknowledges that modifications to one system can have an impact on the others. We sought to evaluate an adaption project efficacy in tackling the intricate problems of food, energy, and water security in the area by using this analytical framework to it. Numerous studies have proved the application of Hoff's approach in the assessment of adaption initiatives. For instance, Schulte et al. (2018) evaluated the sustainability of agricultural water management initiatives in Ethiopia using Hoff's approach, emphasising the significance of taking interconnections between the food, energy, and water systems into account.

Also were identified the project's goals, actions, and results regarding food, energy, and water security through analysis conducted by going over project documents, reports, pertinent literature and interview of the project’s board members. Afterwards, the project's effects on each WEF nexus component were methodically evaluated, taking into account both direct and indirect effects, using Hoff's approach. This approach precisely involves six steps of which the Nexus framing, Nexus opportunities, Technical and economic nexus solutions, Stakeholders involved, Framework conditions, Monitoring, evaluation, and next steps (See table1 below).

Table 3: Hoff's WEF nexus analytical framework (Hoff et al.,2019)

STEPS	DESCRIPTION
1) Nexus framing	Create a common understanding of key issues from a nexus perspective. Explore interlinkages between different sectors and resources, identifying synergies and trade-offs relevant to the case study.
2) Nexus opportunities	Identify how a nexus approach can add value in the context, such as improving cross-resource productivity, reducing resource and environmental degradation, increasing climate resilience, and reducing human insecurities, poverty, or unemployment.
3) Technical and economic nexus solutions	Assess and quantify potential benefits from nexus approaches or "nexus savings" in the case study. Evaluate multi-functional production systems, municipalities or landscapes, and cross-resource and cross-sector recycling initiatives.
4) Stakeholders involved	Specify types and levels of stakeholders involved, including public and private sectors and civil society. Define their roles and requirements for success in implementing nexus solutions.
5) Framework conditions	Address relevant conditions and context factors for implementing nexus approaches, including technical and policy solutions, scale and level of implementation, institutionalization, cooperation between sectors and institutions, and policy coherence.
6) Monitoring, evaluation, and next steps	Define indicators and data for monitoring and evaluation of nexus implementation. Incorporate self-reflexive mechanisms for institutional and multi-loop learning. Provide outlook for replication and upscaling of the case study.

Table 4: Synthetic table of the materials and methods per objective

Objective	Data Collection and sources	Nature of Data	Data Processing
Objective 1: WEF Nexus Scores analysis	- Data retrieved from Simpson et al. (2022) database for the period 2019-2022 providing a composite indexation of WEF nexus metrics based on European Commission JRC methodology	Secondary Composite index	- Excel spreadsheet analysis using Office 365 - Trend and correlation analysis for quantitative assessment of WEF nexus indicators - Pearson linear correlation analysis between WEF nexus index and its component pillars (water, energy, food)
Objective 2: Chronological and Comparative Analysis of strategic documents	- Documents from ministries of water, energy, agriculture, and economy of Cameroon - Project boards' lists of projects and objectives - Strategic documents and adaptation plans - VIVA Bénoué Project documents - Focus person input and interviews	Primary and Secondary Qualitative data	- Development of evaluation grid with six criteria pertinent to WEF nexus and climate considerations - Scoring and conversion to represent WEF nexus potential - Evaluation of projects based on resource system involvement - Use of Hoff's WEF nexus analytical framework for VIVA Bénoué project analysis
Objective 3: WEF nexus analysi of the VIVA Bénoué Project	- Documents from Ministry of Economy and project repo - Focus person input and interviews	Primary and Secondary Qualitative data	- Utilization of Hoff's WEF nexus analytical framework for project analysis - Identification of project goals, actions, and results regarding food, energy, and water security - Evaluation of project effects on each WEF nexus component - Analysis of direct and indirect effects using Hoff's approach

3.3. Integration Of Findings

Following the application of the methodology as summarized per objective (See table 4), qualitative and quantitative findings were integrated to develop a comprehensive understanding of the WEF nexus dynamics in Cameroon. Confrontation of data from multiple sources facilitated the assessment of the level of adoption of the WEF nexus approach for climate change adaptation in the country. This integrated approach ensured robust and evidence-based conclusions.

Chapter 4. Results And Discussions

This chapter explores the findings and debates from the studies done on the water-energy-food (WEF) nexus in Cameroon, after outlining the extensive materials and methodologies used. A thorough summary of the quantitative analysis of WEF nexus index and pillars, the qualitative evaluation of Cameroon's strategic papers from 2005 to 2021, and the application of Hoff's WEF nexus analytical framework to the VIVA Bénoué project in North Cameroon may be found in the parts that preceded this one. Presenting the results of these studies, we address research concerns about the incorporation of the WEF nexus approach in adaptation techniques, uncover patterns, and synthesise important insights in this chapter's discussions. This chapter provides a comprehensive knowledge of the complex dynamics affecting food, energy, and water security in Cameroon despite climate change problems through an analysis of both quantitative trends and qualitative evaluations. It also offers a forum for discussion and introspection on the efficacy of adaption strategies and the chances to improve sustainability and resilience in the area.

4.1. Results of the Analysis of the WEF Nexus Indicators in Cameroon from 2019 To 2022

4.1.1. WEF Nexus Metrics Trend Analysis

4.1.1.1. WEF index

The WEF nexus Index trend was analysed for the past five years in Cameroon, from 2019 to 2023 as seen in Figure2a. The lowest index appears to be that of the year 2020 with a value of 57.6; while the highest index of 57.6 was observed in 2022. The overall trend line shows a positive slope which reveals an increase in the index. But the spread (difference between the highest and the lowest value) of 2.2 is not meaningful, so the index value remains around 50.

4.1.1.2. Water pillar

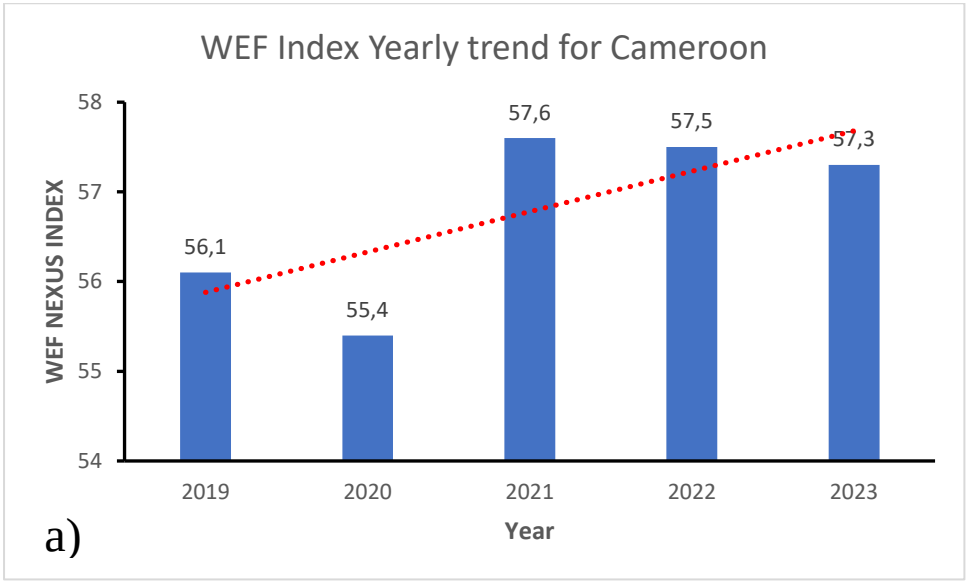
The Figure2b shows an analysis of the Water pillar score trend in Cameroon over the last five years, from 2019 to 2023. With a score of 50.7, the index from 2020 appears to be the lowest, while the index from 2022 has the greatest value of 55.1. An increase in the score is indicated by the positive slope of the overall trend line as shown in the figure. However, the score value stays around 50 with a moderate spread of 4.4.

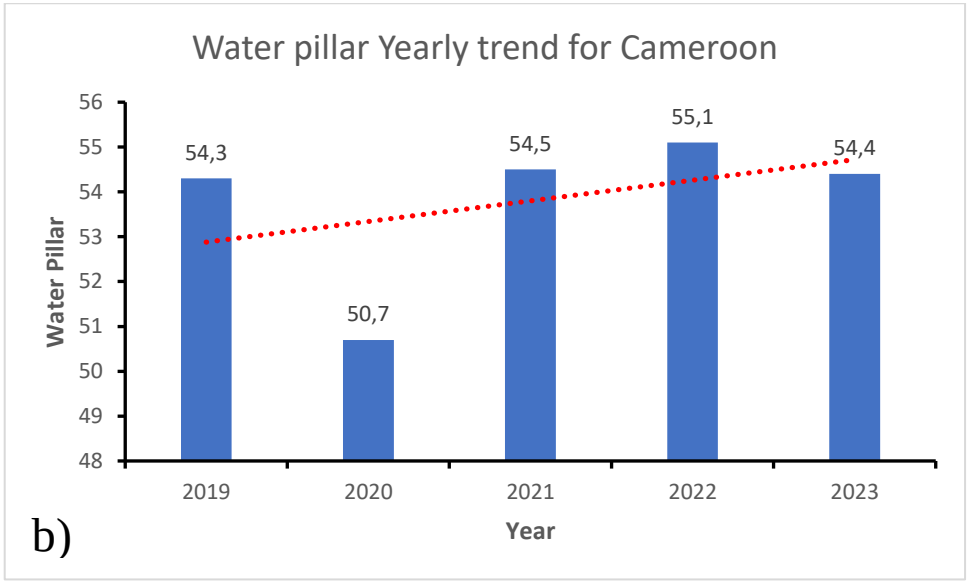
4.1.1.3. Energy pillar

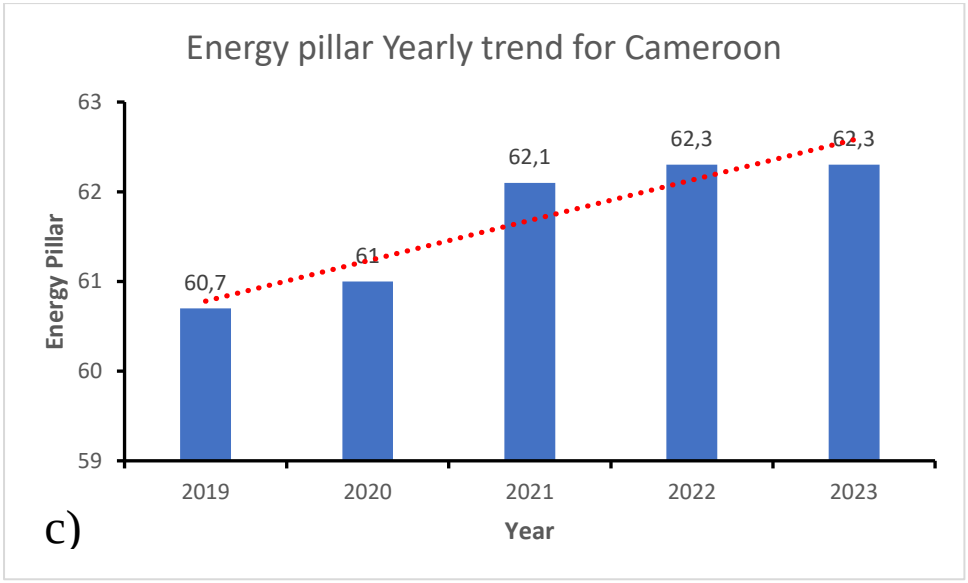
As can be seen in Figure2c, the Energy score trend in Cameroon was examined for the five years between 2019 and 2023. 2019 appeared to have the lowest score, with a value of 60.7, while 2022 had the highest score of 62.3. The total trend line exhibits a positive slope, indicating that the index has increased from an overall perspective. However, the spread is poor, with a value of 1.6 which implies that the score stays at roughly 60.

4.1.1.4. Food pillar

The Figure2d shows the analysis of the Food pillar score trend for the five years in Cameroon, from 2019 to 2023. It looks that the year 2019 had the lowest index, at 53.2, while the year 2021 had the highest index with a value of 56. A rise in the index is shown by the overall trend line's positive slope. In spite of this, the index value stays close to 50 because the spread of 2.8 is not significant.







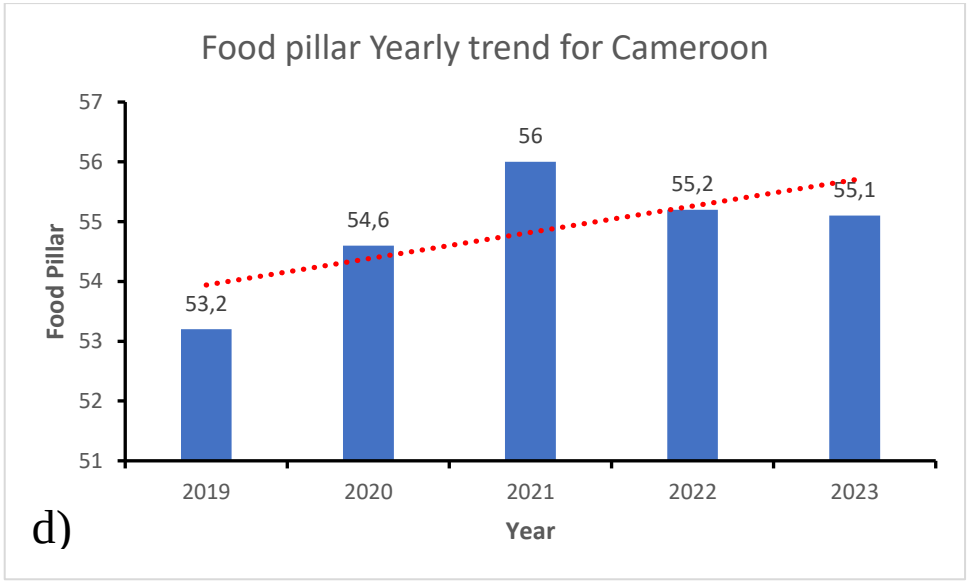


Figure 5: WEF nexus metrics analysis for the period 2019-2023

4.1.2. Correlation analysis

4.1.2.1. Between the WEF nexus index and pillars

The Pearson linear correlation analysis was conducted on the WEF nexus index and their descriptive variables that are WEF nexus pillar scores representing Water, Energy and Food availability and accessibility.

In Figure4a, the WEF nexus Index was correlated with the Food pillar scores for the past five years, from 2019 to 2023. It shows that there is a moderate positive correlation between the two variables, since the determination coefficient r^2 is of 0.47. This means the WEF nexus index is moderately supported by the Food pillar in the specific case of Cameroon. Therefore, the latter pillar has a poor contribution to the current WEF nexus situation.

The correlation analysis between the Energy pillar scores and the WEF nexus Index for the previous five years, from 2019 to 2023, is displayed in the Figure4b. A strong positive correlation between the two variables may be deduced from the determination coefficient (r^2) of 0.81. This suggests that the Energy pillar contributes highly to the WEF nexus index in Cameroon. Therefore, the latter pillar has a significant impact on the current WEF nexus condition.

The Figure4c shows the correlation between the Water pillar scores and the WEF nexus Index for the last five years, spanning from 2019 to 2023. Given that the determination coefficient (r^2) is 0.69, it may be inferred that there is a positive correlation between the two variables. This indicates that, in the particular instance of Cameroon, the Food pillar has a significant contribution to the WEF nexus index. As a result, the latter pillar's influence on the current WEF nexus scenario is meaningful.

The correlation between the gross domestic product (GDP) values and the WEF nexus Index for the previous five years in Cameroon, from 2019 to 2023, is displayed in the Figure4d. A strong positive correlation between the two variables may be deduced from the determination coefficient (r^2) of 0.84. This suggests that the GDP contributes substantially to the WEF nexus index in the specific case of Cameroon. Therefore, the latter has a significant impact on the current WEF nexus condition in the country.

4.1.2.2. Between pillars

Between 2019 and 2023, there appears to be a moderately positive correlation (r^2) 0.32 between the water and energy pillar scores in Cameroon (Figure5a). This suggests that throughout the given period, changes in the energy pillar scores are somewhat correlated with changes in the water pillar scores. It suggests that there may be a link, though a weak one, between the nation's energy production or consumption and the availability or management of water resources. This emphasises the interdependence of water and energy systems, underscoring the possibility of common obstacles and prospects in tackling problems pertaining to both domains. Insights for policymakers and stakeholders looking to improve resource management plans and strengthen the resilience of the water and energy systems in the face of changing environmental and socioeconomic circumstances could be gained from more research into the precise factors causing this correlation.

The water and food pillar ratings in Cameroon from 2019 to 2023 show a weakly positive correlation, as indicated by the determination coefficient (r^2) of 0.034 as presented in Figure5b. This implies that within the given period, changes in the food pillar scores have only a weak correlation with changes in the water pillar scores. This suggests that differences in the availability or management of water may not have a substantial direct impact on the nation's food production or security. This does not, however, negate the possibility of unintended consequences or intricate relationships between water supplies and agricultural techniques, such as irrigation or land use patterns, which can call for more research. Comprehending the determinants of this correlation can facilitate focused interventions aimed at fortifying food security protocols and reducing any hazards that may emerge from water-related difficulties in farming systems. This situation can also owe its explanation to the fact that imports represent a major determinant of food security in the country, and people in the country produce what they don’t consume while consuming what they don’t produce.

The energy and food pillar ratings in Cameroon from 2019 to 2023 show a high positive link, as indicated by the determination coefficient (r^2) of 0.68 (SeeFigure5c). This shows that within the given period, changes in the food pillar scores are closely correlated with changes in the energy pillar ones. The strong association suggests that there are important interdependencies between the nation's food production, processing, and distribution activities and the energy supply, distribution, or consumption patterns. These discoveries underscore the complex interrelationships among energy accessibility, cost, and availability, as well as their effects on

food processing, distribution networks, and agricultural output. Developing integrated strategies that support sustainable resource management, improve the resilience of the food system, and handle the changing challenges brought about by population expansion, climate change, and socioeconomic development goals requires an understanding of these interconnections.

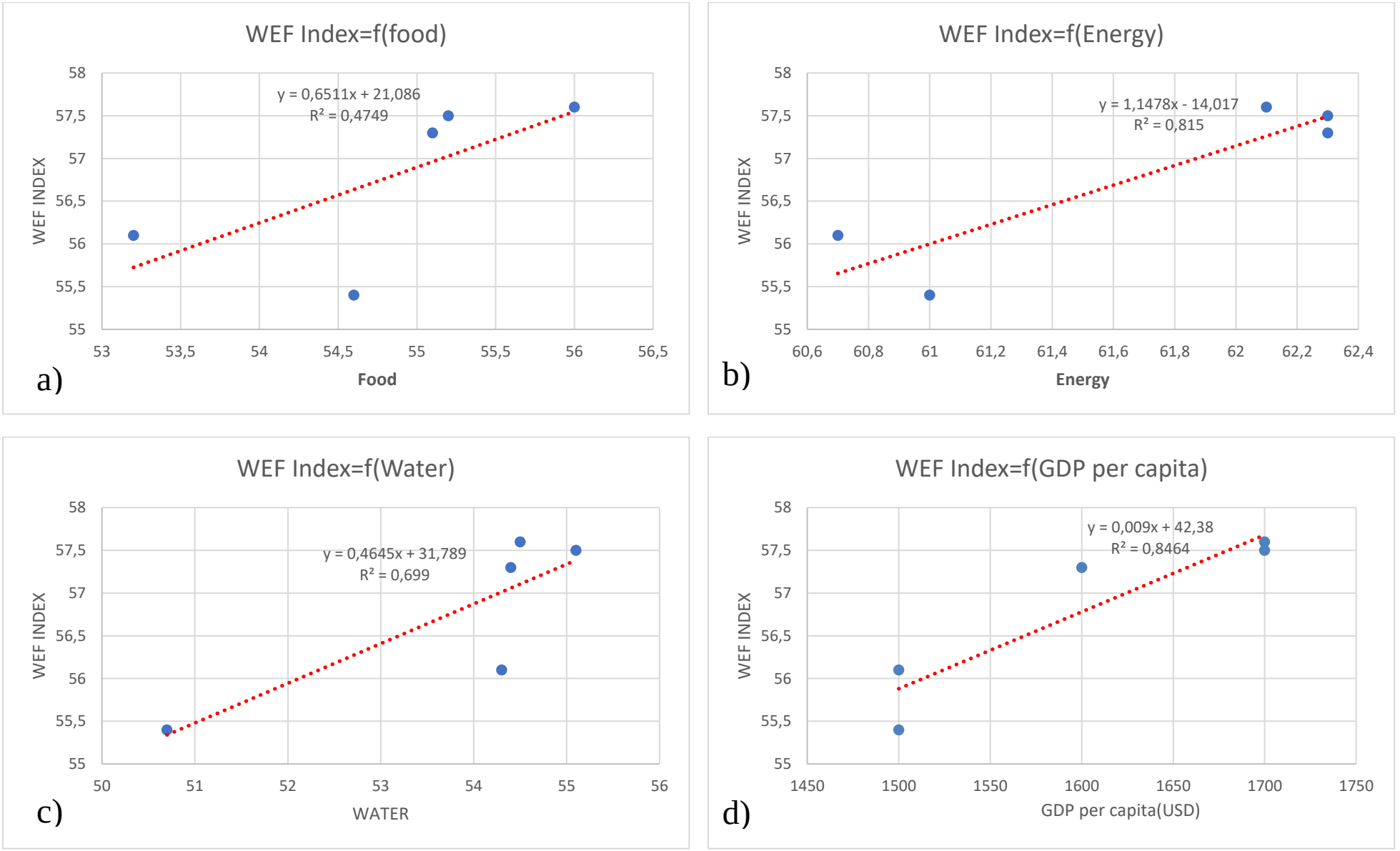


Figure 6: WEF nexus metrics correlation analysis for the period 2019-2023

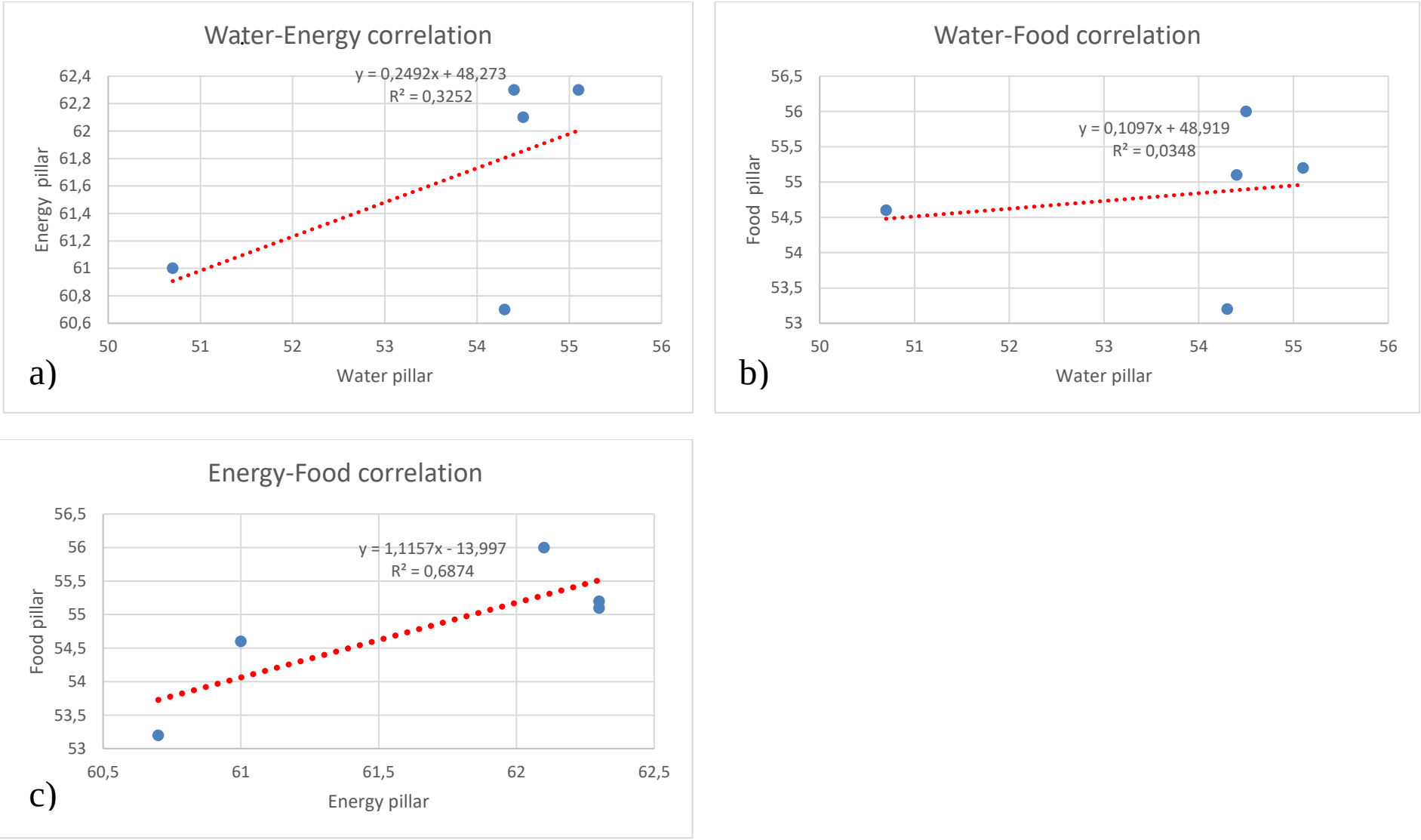


Figure 7: WEF nexus pillar correlation analysis for the period 2019-2023

4.2. Results of the Evaluation of Strategic Documents and Projects in Cameroon

4.2.1. Evaluation of the WEF nexus potential of strategic documents from 2005 to 2021 in Cameroon

The fourteen strategic documents rated in a WEF nexus perspective for climate change adaptation were documented below (Table).

Table 5: Synthetic table of WEF nexus potential ratings of strategic documents following six predefined criteria

	Document	Year	C1	C2	C3	C4	C5	C6	W.N.P
General strategic planning documents	VISION 2035	2009	3	3	4	0	0	2	55
	DSCE	2009	5	3	2	2	1	0	59
	DSDR 1	2005	4	4	2	2	0	0	55
	DSDR 2	2016	4	4	4	2	0	0	64
	SND30	2020	3	3	4	2	0	0	55
Specific adaptation documents	CPDN	2015	5	3	4	2	0	0	64
	PNA	2015	3	3	4	2	2	0	64
	CDN	2021	5	3	4	2	0	2	73
Food, Water and Energy sectoral documents	PANIA	2014	4	4	2	2	0	0	55
	PANGIRE	2009	2	2	4	2	2	0	55
	Water P	2019	4	6	2	2	2	2	82
	PDSE	2006	4	4	2	2	2	2	73
Decentralisation documents	PDC	2013	3	3	2	2	2	2	64

Key: C1: Resource systems involved; C2: Interconnectedness of the resource systems; C3: Climate consideration; C4: Policy coherence; C5: Stakeholders' consideration; C6: Technological consideration; W.N.P: WEF nexus potential/100 computed from the total score (22 points ⬌ 100). W.N.P = (number of points*100)/22

Variations in the potential for a given document's Water-Energy-Food (WEF) nexus are shown by reviewing generic strategic planning documents. Both the SND30 and VISION 2035, which prioritised economic growth, received a score of 55, suggesting a moderate understanding and integration of WEF interdependencies. Comparably, the DSDR documents, which concentrated on agriculturally based rural development, likewise received a score of 55, indicating a consistent methodology over editions. The revised DSDR 2 scored higher, at 64, though, suggesting that WEF nexus integration has improved over time in the agriculturally enhanced rural development strategies. On the other hand, certain documents related to climate adaptation demonstrated higher WEF nexus scores, indicating a higher priority placed on addressing interconnections. Planning for climate adaptation has taken WEF interdependencies into significant account, as evidenced by the CPDN and PNA's 64 score. With a score of 73, the upgraded CDN was even better, indicating more improvement in WEF nexus integration. The

PANIA and PANGIRE sectoral documents received scores of 55, suggesting that the WEF nexus is moderately taken into account in the agriculture and water sectors, respectively. Interestingly, the Water Policy document received a far better score of 82, demonstrating a strong integration of WEF issues. Comparably, the energy sector's PDSE scored 73, indicating a significant emphasis on resolving WEF interdependencies. The PDC, which represents decentralisation documents, received a score of 64, demonstrating regular local examination of the WEF nexus. Overall, the study shows how different kinds of strategic documents integrate the WEF nexus to varying degrees, indicating areas for improvement in the coherence and integration of policies to address Cameroon's climate change adaptation challenges.

A prevalent constraint observed in the majority of texts is the absence of express considerations of the interdependence of the food, energy, and water systems. This neglect creates obstacles to a thorough comprehension of the many relationships and possible trade-offs, which makes climate change adaptation more difficult. Furthermore, a lack of clearly defined roles and duties for stakeholders is evident in numerous papers, suggesting a deficiency in stakeholder coordination and engagement. This restriction hinders the cooperative efforts required to address WEF nexus concerns. Moreover, most documents don't go far enough in addressing technology issues pertaining to food, energy, and water systems, as well as climate resilience. This omission signifies a lost chance to improve WEF nexus integration and resilience-building initiatives by utilising technology. In spite of these obstacles, the analysis also points up a number of ways to promote the WEF nexus approach's implementation. Interestingly, revised versions of some documents like the CDN and DSDR 2 show how WEF nexus integration has improved over time and point to the possibility of learning and adaptation. Moreover, strategic documents like the Water Policy and PDSE, which have higher WEF nexus ratings, are good examples of how to integrate WEF issues in an effective manner. These publications provide insightful information on how to successfully handle the interrelated problems of food, energy, and water security in the context of climate change. Cameroon's resilience to climate change can be strengthened by implementing the WEF nexus strategy, which will ultimately improve policy coherence and integration by addressing the limits that have been identified and taking use of the opportunities that now exist.

The chronological trend of the WEF nexus potential in strategic documents shows a slightly increasing pattern (Figure6), which reveal a growing global interest to achieving resource security in the Country. This result is in line with the WEF nexus metrics developed by Simpson et al., (2022).

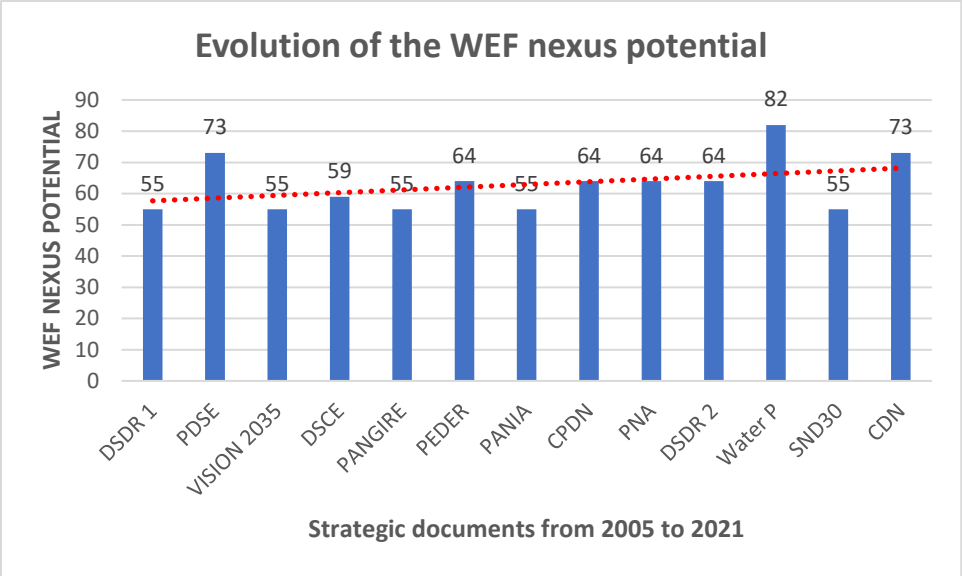


Figure 8: Chronological evolution of the WEF nexus potential in strategic documents

4.2.2. Assessing the operationalization of the WEF nexus in projects related to water, energy and food in Cameroon

After analysing the thirty-eight identified projects, the following results emerged:

All the ten projects from the Ministry of Agriculture presented a low WEF nexus potential, which means they basically apply the sectoral approach in their projects and programs, and thus neglect the interconnectedness of the food resource systems with other systems.

Among the twelve projects from the Ministry of water, eight presented a moderate WEF nexus potential (Table 4); essentially the Water-Energy nexus potential. This is simply due to the fact that the same institution manages both resource systems of Water and Energy, and part of the Energy produced in the country is of hydroelectric nature. From this result, it is clear that the integrated management of all the resource systems by the same institution offers more WEF nexus opportunities compared to sectoral silos management.

At the ministry of Economy, out of the sixteen projects identified, eight presented high WEF nexus potential (Table 5). This suggests a higher consideration of the WEF interconnections in projects focusing on the global growth of the country. This means higher opportunities exist at the operational level for integrating the WEF nexus approach in development projects in Cameroon in comparison to sectoral institutions managing separately the water, food and energy sectors.

Table 6: Recently completed and ongoing projects at the Ministry of water and energy with WEF nexus potential

	Projects/Programs	Description	Objective	Resource System(s)	Completion Status	Nexus Potential
1	Lom-Pangar Dam	Multipurpose dam for hydroelectric power generation	To regulate water flow and generate electricity	Water, Energy	Completed	Moderate
2	Memve'ele Hydroelectric Project	Construction of a hydroelectric dam	To increase energy production	Water, Energy	Completed	Moderate
3	Memve'ele Hydroelectric Project	Construction of a hydroelectric dam	To increase energy production	Water, Energy	Completed	Moderate
4	Mékin Hydroelectric Dam	Hydroelectric dam project	To provide clean energy and regulate water flow	Water, Energy	Ongoing	Moderate
5	Sanaga Hydroelectric Dam	Hydroelectric dam construction	To increase energy production	Water, Energy	Ongoing	Moderate
6	Menchum Hydroelectric Power Plant	Hydroelectric power generation	To generate electricity from water resources	Water, Energy	Completed	Moderate
7	PforR Payment for Results	Payment for Results project	To incentivize sustainable land and forest management	Energy, Food	Ongoing	Moderate
8	PIRECT Integrated Electrification	Integrated rural electrification and climate project	To provide electricity and address climate challenges	Energy, Water	Ongoing	Moderate

Table 7: Recently completed and ongoing projects at the Ministry of Economy with WEF nexus potential

	Projects/Programs	Description	Objective	Resource System(s)	Completion Status	Nexus Potential
1	Integrated Rural Development Project Charwe Logone (PDRI-CL)	Focuses on rural development in the Charwe Logone region	To promote integrated rural development, improve livelihoods, and enhance socio-economic conditions in the Charwe Logone region	Water, Energy, Food	Ongoing	High
2	Integrated Community Development Programme of the Atlantic (PDICA)	Targets community development in the Atlantic region	To facilitate integrated community development, enhance livelihoods, and promote socio-economic 3growth in the Atlantic region	Water, Energy, Food	Completed	High
3	Integrated Development and Land Use Project in the Dja Mining Loop and Adjacent Border Zone (PADI-Dja)	Focuses on development and land use in the Dja Mining Loop and adjacent border zone	To promote integrated development and sustainable land use practices in the Dja Mining Loop and adjacent areas	Water, Energy, Food	Completed	High
4	Study Mission for the Development and Planning of the Northern Region (MEADEN)	Conducts a study for the development and planning of the Northern Region	To conduct a comprehensive study for the development and planning of the Northern Region	Water, Energy, Food	Ongoing	High
5	Integrated Development Mission of the Mandara Mountains (MIDIMA)	Focuses on integrated development in the Mandara Mountains region	To promote integrated development, improve livelihoods, and enhance socio-economic conditions in the Mandara Mountains region	Water, Energy, Food	Completed	High
6	Regional Project for the Revival and Development of Lake Chad (PROLAC)	Aims to revive and develop the Lake Chad region	To revive the Lake Chad region, promote sustainable development, and enhance livelihoods	Water, Energy, Food	Ongoing	High
7	Project for the Development and Valorization of Investments in the Bénoué Valley (VIVA-Bénoué)	Focuses on development and valorization of investments in the Bénoué Valley	To develop and valorize investments, promote sustainable development, and enhance socio-economic conditions in the Bénoué Valley	Water, Energy, Food	Ongoing	High
8	Project for the Development and Valorization of Investments in the Logone Valley (VIVA-Logone)	Focuses on development and valorization of investments in the Logone Valley	To develop and valorize investments, promote sustainable development, and enhance socio-economic conditions in the Logone Valley	Water, Energy, Food	Ongoing	High

4.2.3. Mainstreaming the Hoff's WEF nexus analytical framework

One the projects studied was selected and the Hoff's framework was applied to it. The selected project was the VIVA Bénoué project.

4.2.3.1. Pertinence of the selected project

First of all, the North Cameroon region is one of the most climatically susceptible regions, with serious issues with energy access, food security, and water scarcity. Thus, addressing the pressing needs of vulnerable communities in this region requires concentrating on adaptation activities. Second, the VIVA Bénoué project demonstrates remarkable nexus potential since it incorporates the food, energy, and water systems into its structure, which is in complete accordance with the determinants of the WEF nexus strategy. Thirdly, because the project is still in progress, it is possible to evaluate and analyse its implementation and results in real time, which offers insightful information about how the WEF nexus principles may be used practically in the context of climate change adaptation. The accessibility of the information and data required for carrying out thorough analyses and evaluations is further facilitated by the availability of all pertinent materials and an interactive web platform for connection with the project board team. All things considered, the VIVA Bénoué project offers a rare chance to investigate the trade-offs and synergies involved in integrating the WEF nexus into a real-world adaption situation in North Cameroon with a high prospect of scalability.

4.2.3.2. Resources used in the analysis of the project

Five main sources were used to gather necessary information on the VIVA-Bénoué project ahead of conducting the Hoff's analysis:

The Resettlement Action Plan (RAP) Lagdo I' Perimeter - Rehabilitation 1000 ha,

Resettlement Action Plan developed as part of the Lagdo WE perimeter on the right bank of the Benue River (5,000ha) and the Lagdo IWE perimeter on the left bank (5,000 ha),

The EMERGENCY FLOOD CONTROL PROJECT,

And the completion of the detailed environmental and social study of the Lagdo perimeters, Right bank rehabilitation (1000ha), Right bank-extension 5000ha and left bank extension (5000ha)

And the interactive web platform of the projects that provides insights on the progress of the project and gives possibility to interact with the project board members. (Au cœur de l'action du Projet VIVA BENOUE : les infrastructures d'irrigation et de drainage)

4.2.3.3. Overview of the project

The World Bank's financial support for the VIVA Bénoué project, which is being provided to the Cameroonian government, is an indication of the organization's strong commitment to tackling the complex issues that the Bénoué Valley region faces. The goal of this programme is to restore the 1,000-hectare Lagdo I' perimeter and build the 10,000-hectare Lagdo WE and Lagdo IWE irrigation perimeters. With an estimated 100,000 indirect beneficiaries and 26,000 direct farmers, the project has the potential to benefit millions of people by reducing flood risk along the Benue River, which could improve agricultural productivity, socioeconomic development, and environmental sustainability in the area while ensuring clean power generation.

Within the intricate web of water, energy, and food systems, the VIVA project officially named Valorisation Intégrée de la Vallée de la Bénoué pour l'Agriculture Durable operates. The sectoral approach applied in conducting such projects and their inability to effectively mainstream existing national governing tools makes it difficult to apprehend the system holistically and to handle their components successfully. In order the achieve sustainability and security across the three resource systems involved in such project, an extensive holistic analytical framework is necessary to evaluate and manage the project's components in a coordinated way that provides at every level an overall view of the performance of each area of interest. The Hoff's framework is unique in that it emphasises the interdependent dynamics and trade-offs present in WEF systems in a comprehensive manner.

We will examine the goals, interventions, and anticipated results of the VIVA project using Hoff's framework in order to comprehend its significance for the WEF nexus. This analysis will look at how the project affects energy generation and use, water availability, agricultural productivity, and socioeconomic well-being with the goal of finding trade-offs and opportunities for collaboration and creating plans for maximising results.

For the Lagdo irrigation perimeter projects, extensive technical studies and environmental and social impact assessments (ESIAs) have been conducted to make sure that the environmental and social safeguards required by the World Bank are followed. Resettlement Action Plans

(RAPs), which emphasise the project's dedication to sustainable and inclusive development, are also being produced to handle land compensation and resettlement difficulties.

With the help of this research, we hope to shed light on the advantages and disadvantages of the VIVA project, assisting in the region of the Bénoué Valley's sustainable development and decision-making. The following steps are involved in the Hoff's analytical process:

4.2.4. Implementing the Hoff's framework to the VIVA Bénoué project

4.2.4.1. Problem Identification and Nexus Framing:

4.2.4.1.1. Problem identification

Problem identification is the first phase in the Hoff's analytical framework for the VIVA Benoue project. The goal of this step is to pinpoint the main obstacles and possibilities in the food, energy, and water systems of the project area, the Bénoué Valley region.

Water difficulties:

The Bénoué Valley region is vulnerable to climate change-induced unpredictability and has a number of water-related difficulties, such as water scarcity and ineffective water management techniques. A lack of dependable irrigation water supplies limits agricultural productivity, and a lack of effective flood control infrastructure increases the likelihood of water-related calamities.

Energy-related issues:

Availability and price of energy are major issues in the area. Inadequate availability of contemporary energy services impedes agricultural mechanisation and processing, impacting output and value addition along the food value chain. The use of traditional biomass fuels for cooking and heating has a negative impact on environmental sustainability and public health due to indoor air pollution and deforestation.

Food system constraints:

In the Bénoué Valley, agricultural productivity and food security continue to be major issues. The predominant farming practice is subsistence farming, which is typified by low-yield rainfed cropping patterns and restricted access to markets, inputs, and extension services. Food losses

are a result of inadequate post-harvest processing and storage facilities, and food insecurity and rural poverty are made worse by climate extremes.

Socio-economic factors:

Water, energy, and food difficulties interact with socio-economic imbalances, such as poverty, unemployment, and gender inequality, to impact local populations' resilience and susceptibility. Inadequate availability of social services, healthcare, and education exacerbates poverty and reduces prospects for employment in the area.

Environmental Concerns:

The Bénoué Valley's ecological integrity is in jeopardy due to environmental degradation, which includes soil erosion, deforestation, and biodiversity loss. In addition to the effects of climate change, unsustainable land use practices also put ecosystem services, water quality, and natural resource management at risk. This exacerbates already existing vulnerabilities and undermines long-term sustainability.

Determining these interrelated problems offers a thorough grasp of the intricate processes forming the water-energy-food nexus in the Bénoué Valley area. In the context of the VIVA Bénoué project, this knowledge forms the basis for further analysis and intervention planning using Hoff's analytical approach.

4.2.4.1.2. Nexus framing

A comprehensive effort to address the intricate relationships between food security, energy, and water in the Benoue River Basin of Cameroon is represented by the VIVA Bénoué project. By using a nexus method, we may investigate the trade-offs and synergies present in the project's implementation and gain a deeper understanding of how the interventions are interconnected.

Food, Energy, and Water Interactions:

Water: The project's main goal is to enhance water management by expanding and renovating irrigation infrastructure, especially in the Lagdo Dam area. In order to do this, agricultural water consumption must be optimised while maintaining the sustainability of water supplies for irrigation and hydroelectric power production.

Energy: The Lagdo Dam generates hydropower in addition to serving as a source of irrigation water. The project intends to minimise possible effects on downstream water availability for

irrigation and other applications while maximising the efficiency and dependability of hydropower output.

Food: The initiative aims to improve agricultural output and food security in the area by expanding availability to water for irrigation. To improve food production and livelihoods for local communities, it supports livestock and fishing practices, as well as the growth of staple crops like rice, maize, and sorghum.

Synergies

Better Water Management: Restoring and growing irrigation infrastructure makes more water available for farming, which raises food production and sustains local lives. Improved water management techniques can also result in greater water security and climate variability resilience.

Sustainable Energy Production: By maximising the Lagdo Dam's functioning, the project not only improves the availability of water for agriculture but also guarantees consistent hydropower production, thereby promoting energy security and lowering dependency on fossil fuels.

Enhanced Food Security: By lowering reliance on food imports and lowering the danger of hunger and malnutrition among the local people, the project's focus on raising agricultural production and diversifying food crops can improve food security outcomes.

Trade-offs:

Water Allocation: Conflicts over water allocation can arise from competition for resources among hydropower generation, irrigation, and other users, particularly during dry spells or low water levels. A major difficulty is providing fair access to water resources while balancing the needs of various sectors.

Environmental Impact: Although hydropower is a sustainable energy source, building and maintaining dams can have negative effects on the environment, such as changing habitats, causing sedimentation, and upsetting aquatic ecosystems. It is crucial to minimise these effects while optimising the advantages of developing water infrastructure.

Land Use Change: Increasing agricultural land through irrigation development may result in ecosystem degradation and changes to land use, which could have an impact on soil fertility,

biodiversity, and carbon sequestration. Incorporating sustainable land use principles into project planning is crucial to mitigate adverse environmental effects.

The VIVA Bénoué initiative functions at a multifaceted intersection of the food, energy, and water systems, where decisions made in one area can have a significant impact on others. Through acknowledgement and resolution of the mutual benefits and compromises present in these connections, the project may maximise its influence on agricultural output, water and energy sovereignty, and the socio-economic advancement of the Benoue River Basin. Maximising the project's potential benefits for local communities and the environment, as well as attaining sustainable outcomes, would require effective stakeholder participation, integrated planning, and adaptive management approaches.

4.2.4.1.3. System Boundaries Definition

The VIVA Bénoué project's analytical methodology requires a thorough definition of system boundaries that includes the many parameters impacted by the Lagdo Dam's technical capabilities. The operations of the dam, which include flood control, irrigation infrastructure, water regulation, hydroelectric power generation, and environmental concerns, are intricately linked to the project's dynamics.

Water Storage and Regulation:

A key component of water storage and regulation along the Bénoué River is the Lagdo Dam. Its storage capacity has a significant impact on downstream water availability, which affects a number of industries and sectors including domestic use, industry, and agriculture. Because of this, the system limits encompass the complex web of stakeholders and water users who depend on the controlled flow of the river.

Hydroelectric Power Generation:

The dam makes a substantial contribution to the local energy system with its 72 MW of hydroelectric power. This feature expands the bounds of the system to include not just water-related elements but also the complex interactions between energy generation and its socio-economic effects.

Flood Control:

By regulating river flows during times of heavy rainfall, the dam plays a crucial part in reducing the risk of flooding. Therefore, the boundaries extend to include community well-being, resilient infrastructure, and patterns of land use in both the immediate project area and downstream regions.

Infrastructure for Irrigation:

One of the dam's primary purposes is to facilitate irrigation plans. Within the system boundaries, its technical capabilities such as irrigation canal networks and water release mechanisms become essential elements. This entails a thorough examination of the ways in which different irrigation systems affect agricultural output and practices.

Environmental Considerations:

Using the dam will have an impact on the environment through altered sedimentation patterns, altered downstream hydrology, and altered aquatic ecosystems. The boundaries of the system are further complicated by these environmental factors, which calls for a study of ecological dynamics and conservation efforts of biodiversity.

To summarise, the bounds of the VIVA Bénoué project system encompasses the complex relationships that exist between the technological capabilities of the Lagdo Dam and the wider socio-economic, environmental, and infrastructure factors. Water management, energy generation, flood resilience, agriculture, and environmental sustainability are interconnected and should be considered as a foundation for a comprehensive analysis that stays within those stated limitations.

4.2.4.2. Nexus Opportunities

There are many chances to use a nexus strategy to create value in the unique setting of the Bénoué Valley region thanks to the VIVA Bénoué project. Through the adoption of an integrated water-energy-food (WEF) nexus paradigm, stakeholders can effectively leverage synergies and concurrently tackle various concerns. The following are some interesting findings on nexus potential found in the project:

4.2.4.2.1. Enhanced Productivity of Resources:

The project intends to raise the Bénoué Valley's agricultural, energy, and water resources' productivity and efficiency. The initiative can optimise water usage and increase crop yields by encouraging sustainable irrigation practices including the System of Rice Intensification (SRI) and gravitation-based irrigation systems. Furthermore, the region's energy productivity can be raised by investments in energy infrastructure, such as the Lagdo Dam, which can improve hydropower generation capacity.

4.2.4.2.2. Mitigation of Environmental Degradation:

The project can lessen the effects of land degradation and wasteful water use on the environment by renovating and modernising irrigation infrastructure. The project can lessen soil erosion, water pollution, and habitat loss by supporting sustainable land and water management techniques, such as integrated pest control and soil conservation measures. This will maintain the ecological integrity of the Bénoué Valley environment.

4.2.4.2.3. Increasing Climate Resilience:

To lessen the effects of climate change on the water, energy, and food systems, the initiative uses climate-resilient techniques. Through the construction of the Lagdo Dam and the promotion of climate-smart agricultural techniques like agroforestry systems and drought-resistant crop types, the project can increase the ability of the surrounding populations to withstand extreme weather events like floods and droughts.

4.2.4.2.4. Resolving socio-economic issues:

The initiative can help the Bénoué Valley region deal with socio-economic issues including unemployment and poverty by encouraging inclusive and sustainable development. The project has the potential to enhance the quality of life and promote economic development, especially in rural areas, by generating employment opportunities in the construction, agriculture, and energy sectors. Furthermore, empowering local populations to actively participate in and profit from project operations can be achieved through investments in education, training, and capacity building.

Overall, the VIVA Bénoué project may accomplish a number of goals at once, such as improving resource productivity, reducing environmental degradation, strengthening climate

resilience, and solving socioeconomic issues, by identifying and seizing nexus possibilities. By using an integrated approach, the Bénoué Valley region's development is ensured to be sustainable, and the future generations' quality of life is enhanced.

4.2.4.3. Technical and Economic Nexus Solutions

The third phase of the VIVA Bénoué project entails finding and assessing technical and economic nexus solutions that maximise resource utilisation and improve sustainability in the food, energy, and water industries. Key points to think about and possible remedies are as follows:

4.2.4.3.1. Production Systems with Multiple Functions:

Combining agroecological and agroforestry practices: By producing fruits, lumber, and feed, agroforestry techniques like alley cropping and intercropping increase biodiversity, soil fertility, and water retention. They also create extra revenue streams.

4.2.4.3.2. Systems diversification in agriculture:

Encouraging crop diversity increases resistance to climate change and market swings, enhancing food security and generating money for farmers. This includes growing high-value, drought-resistant crops alongside staples like rice and sorghum.

4.2.4.3.3. Initiatives for Cross-Sectoral Recycling:

Reusing and recycling water: Decentralised wastewater treatment systems minimise nutrient runoff, minimise freshwater demand, and increase agricultural production, especially in dry seasons, when treated effluent is used for irrigation.

Recycling organic waste: Creating composting sites and biogas digesters to turn trash into nutrient-rich compost and clean energy promotes the ideas of the circular economy, lowers greenhouse gas emissions, and enhances agricultural yields and soil health.

4.2.4.3.4. Development of Integrated Infrastructure:

Systems of irrigation powered by renewable energy: By reducing reliance on fossil fuels, reducing greenhouse gas emissions, and improving energy availability for rural populations, investments in solar-powered pumps and micro-hydropower irrigation systems increase agricultural output and incomes.

Intelligent water management technologies: Utilising drip irrigation systems, precision farming methods, and sensor-based irrigation scheduling maximises crop yields, reduces water loss, and optimises water consumption, all of which contribute to cost savings and environmental sustainability.

4.2.4.3.5. Market connections and value-added services:

Establishing incubators for agribusiness and farmer cooperatives: Smallholder farmers and entrepreneurs are empowered when they have easier access to capital, technical support, and market connections. This encourages rural entrepreneurship and inclusive economic growth along the agricultural value chain.

Encouraging eco-labelling and climate-smart certification programmes: Promoting the use of eco-friendly products and sustainable farming methods increases market competitiveness, boosts product quality, and satisfies consumer demand for products made with ethical materials and minimal environmental impact.

Stakeholders can find ways to maximise resource utilisation, enhance lives, and accomplish sustainable development goals in the Bénoué Valley region by assessing these technological and economic nexus solutions. In the end, implementing these integrated approaches will increase the resilience and prosperity of local communities by requiring cooperation, creativity, and investment across sectors.

4.2.4.4. Stakeholders' Involvement

Stakeholder analysis is the second phase in Hoff's analytical approach for the VIVA Bénoué project. In order to comprehend the interests, priorities, and power dynamics of the relevant stakeholders in the water, energy, and food sectors, this step focuses on identifying and engaging them. The project can improve coordination, collaboration, and ownership by incorporating a variety of stakeholders, such as government agencies, local communities, civil society organisations, and commercial sector actors. This will ultimately improve the effectiveness and sustainability of interventions.

4.2.4.4.1. Governmental Organisations:

The Ministry of Water and Energy (MINEE), which is in charge of managing water resources and developing energy infrastructure, and the Ministry of Agriculture and Rural Development (MINADER), which is in charge of agricultural policy and extension services, are important

government stakeholders. In addition, the technical expertise is assured by the public companies such as the Société d'Expansion et de Modernisation de la Riziculture de Yagoua (SEMRY) in the Far North and the Mission d'Études pour l'Aménagement et le Développement de la Région du Nord (MEADEN) in the North. By working with these organisations, compliance with national development agendas and legal frameworks is ensured.

4.2.4.4.2. Local Communities:

The VIVA Benoue project's main stakeholders are the local communities, who comprise pastoralists, smallholder farmers, and fishermen. Their involvement is critical to recognising context-specific issues, collaborating on the creation of interventions, and promoting resilience and social inclusion. Enhancing project ownership and sustainability can be achieved by empowering local populations through capacity building and participatory decision-making processes. The 1000ha concerned by the rehabilitation are distributed in the villages in four villages, namely Gounougou, Ouro-Doukoudgé, Bessoun and Dingale. The left river bank where it is foreseen to establish 3500ha of irrigated perimeter and 1496ha of Agribusiness infrastructures, touches the Tcheboa subdivision, involving two villages that are Ouro Labbo1 and Kerawa for a total of 230 users. The other seven villages impacted by this component, namely Bamsi, Napanla, Bame, Djoulol-bocki, Ouro labbo 2, Harande Bame, and Kouroungou are located in the Lagdo subdivision for a total of 1416 users. For the right river bank that concerns the development of 4350 ha of perimeters irrigated for peasants, four villages are impacted in the Lagdo subdivision that are OURO BOBOWA, Djanga1, Djanga2 and Riao; for a total of 1023 users.

4.2.4.4.3. Civil Society Organisations (CSOs):

CSOs are essential in supporting environmental protection, empowering communities through mobilisation, and fighting for the rights and interests of underrepresented groups. Working together with CSOs guarantees that project interventions are sensitive to local needs and aspirations, increases social accountability, and improves transparency.

4.2.4.4.4. Private Sector Players:

Two major consulting firms represent the private sector in this project, namely the companies **IDEA CONSEIL GROUPE STUDI**, and **ANDAL & SYNERGY ENGINEERING** that conducted the feasibility and environmental studies, as well as the population resettlement

action plan for the affected areas. Within the water-energy-food nexus, the involvement of the private sector, such as agribusinesses, irrigation suppliers, and financial institutions, can spur investment, innovation, and market connections. Public-private partnerships (PPPs) open up economic opportunities and support sustainable agri-food systems by facilitating technology transfer, financing access, and value chain development.

4.2.4.4.5. Research and Academic Institutions:

The Agricultural College of Lagdo and the University of Maroua represent are the main Institutions involved here. By offering evidence-based perspectives and technical assistance for project design, monitoring, and assessment, academic institutions and research organisations contribute their experience in agronomy, hydrology, energy systems, and socio-economic analysis. Working together with research partners promotes evidence-based decision-making and adaptive management by strengthening information sharing, capacity building, and innovation diffusion.

4.2.4.4.6. Development Partners:

To support integrated water, energy, and food programmes, multilateral and bilateral development partners such as the World Bank offer financial resources, technical help, and forums for policy discourse. Let’s recall that in this project the World Bank is the one proving funding. Enhancing policy coherence, knowledge sharing, and resource mobilisation through collaborations with development agencies strengthens the project's impact and sustainability over time.

The VIVA Bénoué project can promote multi-stakeholder involvement, synergy, and resilience-building throughout the water-energy-food nexus by carrying out a thorough stakeholder analysis, thereby enhancing equitable and sustainable development outcomes in the Bénoué Valley region

Table 8: Comprehensive analysis of the stakeholders involved in the VIVA Bénoué project

Stakeholder Group	Description	Interests and Concerns	Influence and Power	Importance
Governmental Organizations	- Ministry of Water and Energy (MINEE): Responsible for managing water resources and developing energy infrastructure. - Ministry of Agriculture and Rural Development (MINADER): In charge of agricultural policy and extension services. - Société d'Expansion et de Modernisation de la Riziculture de Yagoua (SEMRY) : Provides technical expertise in rice cultivation. - Mission d'Études pour l'Aménagement et le Développement de la Région du Nord (MEADEN) : Responsible for regional development and infrastructure projects.	- Ensuring sustainable management of water resources and energy infrastructure. - Enhancing agricultural productivity and rural development. - Promoting economic growth and livelihood improvement in the region.	High influence and power due to their regulatory and decision-making authority in their respective domains.	Critical stakeholders due to their role in policy formulation, resource allocation, and project implementation.
Local Communities	- Pastoralists, smallholder farmers, and fishermen residing in villages impacted by the project. - Total of 1416 users in Lagdo subdivision and 230 users in Tcheboa subdivision.	- Access to reliable water sources for irrigation and livestock. - Protection of traditional livelihoods and land rights. - Mitigation of environmental impacts on local ecosystems.	Limited influence and power at the institutional level but significant influence on project outcomes at the local community level.	High importance as primary beneficiaries and directly impacted stakeholders.
Civil Society Organizations	- Organizations supporting environmental protection, community empowerment, and advocacy for underrepresented groups.	- Ensuring community participation and social inclusion in project decision-making processes. - Advocating for environmental conservation and sustainable development practices. - Promoting transparency and accountability in project implementation.	Moderate to high influence and power depending on their level of organization, advocacy capacity, and community support.	Significant importance in advocating for marginalized groups and ensuring project accountability and transparency.
Private Sector Players	- Consulting firms like IDEA CONSEIL GROUPE STUDWE and ANDAL & SYNERGY ENGINEERING. - Agribusinesses, irrigation suppliers, and financial institutions involved in project implementation.	- Business opportunities in project implementation and infrastructure development. - Access to markets and financing for agribusiness ventures. - Compliance with environmental and social standards in project activities.	Variable influence and power depending on their level of investment, expertise, and contractual arrangements with project stakeholders.	High importance in providing technical expertise, financing, and market linkages for project implementation.
Research and Academic Institutions	- Academic and research bodies such as the Agricultural College of Lagdo and the University of Maroua offering evidence-based perspectives and technical assistance in agronomy, hydrology, energy systems, and socio-economic analysis.	- Contributing knowledge and technical expertise to inform project design and implementation. - Advancing research on sustainable water, energy, and food systems in the region.	Moderate influence and power in providing technical advice and research support to project stakeholders.	Moderate importance in providing evidence-based insights and technical assistance for project planning and implementation.
Development Partners	- Multilateral and bilateral development partners such as the World Bank providing financial resources, technical assistance, and policy support.	- Supporting integrated water, energy, and food programmes for sustainable development. - Ensuring compliance with international development standards and best practices. - Facilitating policy dialogue and knowledge exchange among stakeholders.	High influence and power due to their financial and technical support, as well as their role in setting development agendas and priorities.	Critical importance as primary funders and technical partners in project implementation.

4.2.4.5. Framework Conditions

Examining the framework conditions required for the successful deployment of nexus approaches across the water, energy, and food sectors is the fifth stage in the VIVA Bénoué project. These are important things to think about and ways to deal with them:

4.2.4.5.1. Creating platforms with multiple stakeholders:

Establishing forums for communication and cooperation between government departments, regional communities, civil society organisations, businesses, and development partners promotes the formation of consensus, the exchange of knowledge, and coordinated action towards shared objectives.

4.2.4.5.2. Integrating Nexus concepts into plans and policies:

Decision-making processes pertaining to water, energy, and food security can be made to systematically address cross-cutting concerns by incorporating nexus thinking into sectoral policies, local land-use plans, and national development strategies.

Connecting mechanisms with nexus organisations:

4.2.4.5.3. Boosting inter-agency coordination:

Improving the coordination systems between pertinent ministries, departments, and agencies in charge of managing water resources, developing agriculture, and providing energy contributes to better policy coherence, less effort duplication, and more effective resource allocation.

4.2.4.5.4. Putting in place specific nexus institutions:

Cross-sectoral planning, implementation, and monitoring of nexus interventions are facilitated by the establishment of specialised organisations or task forces devoted to nexus concerns, such as integrated resource management boards or commissioners on water, energy, and food security.

4.2.4.5.6. Dimensions and degree of execution:

Targeting interventions at different scales:

By putting nexus solutions into practice at different scales such as farm, community, and watershed, it is possible to make sure that the interventions are scalable for greater impact, responsive to a range of demands, and suited to local settings.

4.2.4.5.7. Implementing the IWRM, NDC, NAP and SDGs together:

A noticeable incoherence with existing policies is deplored that has to be fixed for more effective results. The alignment of nexus efforts with the integrated water resource management (IWRM), Nationally Determined Contributions (NDCs), National Adaptation Plan (NAP) and the Sustainable Development Goals (SDGs) improves policy coherence, maximises synergies between development objectives, and fortifies the ability of vulnerable populations to withstand the impacts of climate change.

4.2.4.5.8. Entrepreneurship and Innovation:

Encouraging innovation ecosystems:

In the water, energy, and agricultural sectors, funding innovation hubs, incubators, and entrepreneurship programmes across the local community, involving students and pupils from the University of Maroua and the Agricultural College of Lagdo will go a long way in encouraging technological breakthroughs, creative business models, and knowledge sharing, which propels sustainable development and economic expansion.

Establishing favourable regulatory environments:

Simplifying regulations, offering rewards for private sector investment, and safeguarding intellectual property rights encourage entrepreneurship, draw capital, and hasten the adoption of creative solutions to related problems.

The institutionalisation, scalability, and innovative potential of nexus approaches can be improved by stakeholders by addressing these framework requirements. This will improve policy coherence, advance sustainable development goals, and promote inclusive growth in the Bénoué Valley region.

4.2.4.6. Monitoring, Evaluation, And Next Steps:

Monitoring, assessment, and next actions are essential in the context of the VIVA Bénoué project to guarantee the successful use of nexus techniques and optimise the project's impact. For this stage, keep the following points in mind:

4.2.4.6.1. Monitoring and evaluation indicators:

Water-Energy-Food Nexus Indicators:

Creating metrics, such as water use efficiency, energy consumption for irrigation, agricultural productivity, and food security outcomes, to evaluate the integration and synergy between the water, energy, and food sectors is of high necessity.

Environmental and Social Indicators:

Monitor social and environmental results (e.g., improved livelihoods and gender empowerment in a society where women and girls are still seen as just house helps) to make that project interventions are inclusive and sustainable. Examples of these outcomes include changes in land usage and water quality.

Metrics for Economic Performance:

Calculate the financial gains, such as the return on investment from infrastructure improvements, the cost-effectiveness of nexus interventions, and the contributions to the local and national economies.

4.2.4.6.2. Information needs:

Data gathering and Management:

To obtain baseline data and monitor changes over time, create reliable data gathering methods. To record the temporal and spatial dynamics of nexus interactions, make use of participative methods, geographic information systems (GIS), and remote sensing.

Stakeholders' engagement

Involve stakeholders in the data gathering process to guarantee that local viewpoints and expertise are taken into account during the monitoring and assessment phases. To improve the availability and quality of data, cultivate alliances with educational institutions, research centres, and neighbourhood associations.

4.2.4.6.3. Mechanisms of institutional learning:

Adaptive Management Framework:

Use an approach to adaptive management that enables feedback loops, iterative learning, and course modifications in response to monitoring and assessment results. Create recurring review processes to evaluate project performance, spot new issues, and modify plans of action as necessary.

Platforms for exchanging knowledge:

Encourage stakeholders in the project to share expertise and learn from one another through online forums, workshops, and seminars. Promote cross-sector communication and cooperation to take advantage of best practices, knowledge gained, and creative solutions.

4.2.4.6.4. Upscaling and replication:

Extending Effective Interventions:

Determine efficacious nexus interventions that have favourable results and the possibility of replication. To facilitate the replication of these interventions in other geographic contexts or comparable Agro-ecological zones, provide guidelines, toolkits, and capacity-building initiatives.

Policy Advocacy and Stakeholder Engagement:

Encourage the mainstreaming of nexus approaches into national policies, sectoral strategies, and development agendas through policy advocacy and stakeholder engagement. Involve international organisations, donors, and legislators in order to raise funds, garner political backing, and spur efforts at replication and upscaling.

Stakeholders can improve accountability, transparency, and adaptive management in the VIVA Bénoué project by integrating strong monitoring, evaluation, and learning mechanisms. This will ultimately optimise the project's contribution to resilience and sustainable development in the Bénoué Valley region.

4.3. Discussions Of the Results

4.3.3. The statistical analysis of the WEF nexus scores

The trend analysis of WEF Nexus Metrics over the five-year period reveals overall improvements in both the WEF Nexus Index and individual pillar scores, with continuous positive slopes observed across all pillars. However, the narrow range of index values suggests

a plateau at the midpoint, indicating potential obstacles to substantial progress in the WEF Nexus field (Liu et al., 2018). This trend underscores the intricate and interdependent relationships between water, energy, and food systems, highlighting the need for transformative change and cross-sector synergies (Dodds et al., 2018).

Correlation analysis further elucidates the connections between WEF Nexus pillars and their impact on the overall WEF Nexus Index. Strong positive correlations between the WEF Nexus Index and the Energy pillar emphasize the critical role of energy availability and management in determining the overall nexus situation (Rasul & Sharma, 2016). Similarly, moderate correlations between the Water and Food pillars underscore their significant contributions to the WEF Nexus (Bates et al., 2018). These findings emphasize the importance of integrated resource management strategies that consider trade-offs and interdependencies between different sectors, enabling policymakers to devise focused actions that maximize co-benefits and minimize unintended consequences (Nilsson et al., 2012).

While the statistical study sheds light on the dynamics of the WEF nexus in Cameroon, it is challenging to directly confront the metrics with observable facts in the field due to their composite nature and complexity to track. To fully comprehend the fundamental causes and ramifications of WEF nexus interactions in the nation, further investigation and analysis are necessary to provide meaningful information corresponding to accessible realities in the field (Bizikova et al., 2013). This underscores the ongoing need for scientific inquiry and evidence-based research to inform effective policy and decision-making processes related to the WEF nexus.

4.3.2. The chronological and comparative analysis of strategic papers and projects

The observed trends underscore the critical importance of incorporating WEF (water-energy-food) interconnections into climate change adaptation plans. SND30 and VISION 2035, documents prioritizing economic growth, exhibit limited integration of WEF nexus principles (Bizikova et al., 2013) and this also supports the increasing neglecfulness of the state over time in factoring adaptation questions in the planning strategy of the country as discussed by Feumba (2017). This highlights the need for greater coherence in addressing climate concerns within these frameworks. Conversely, documents focusing on climate adaptation, such as CPDN and PNA, demonstrate higher WEF nexus scores, indicating a stronger emphasis on fostering resilience and addressing interdependencies (Dodds et al., 2018).

The study reveals common weaknesses across all documents, including a lack of explicit discussion on WEF interconnectedness, poor stakeholder participation, and insufficient focus on technological elements (Liu et al., 2018). Overcoming these obstacles is essential from a scientific perspective to enhance the coherence and efficacy of policies aimed at addressing climate change adaptation challenges. Identifying areas requiring development underscores the importance of approaching resource management and resilience-building programs holistically.

Moreover, the report identifies opportunities to improve WEF nexus integration, drawing inspiration from successful models like the Water Policy and PDSE, and learning from updated document versions like CDN and DSDR 2 (Rasul & Sharma, 2016). Leveraging these opportunities can enhance Cameroon's policy coherence and integration while strengthening its resilience to climate change.

In terms of operationalization, the evaluation of food, energy, and water initiatives clarifies the implementation of the WEF nexus strategy in Cameroon. The varying levels of WEF nexus potential displayed by projects from different ministries reflect the degree of integration across sectors. Projects managed by the Ministry of Agriculture primarily adopt a sectoral approach, overlooking WEF links (Bates et al., 2018). Conversely, initiatives by the Ministry of Water show moderate potential for a WEF nexus, benefiting from integrated resource management for both water and energy. Similarly, projects by the Ministry of Economy demonstrate a strong potential for WEF nexus integration, reflecting a comprehensive approach to development (Nilsson et al., 2012).

Overall, the results underscore the importance of integrated resource management and institutional cooperation in maximizing WEF nexus prospects. Scientifically informed approaches can enhance resilience, optimize resource utilization, and support Cameroon's sustainable development goals.

4.3.3. The integration of the Hoff's framework

The application of Hoff's WEF nexus analytical framework to the VIVA Bénoué project provides valuable insights into the complex interrelationships between the food, energy, and water systems in the Bénoué Valley region. These insights can be used to improve the effectiveness of climate change adaptation initiatives in Cameroon. Bates et al. (2018) and Dodds et al. (2018) provide valuable context for the comprehensive problem identification phase, which highlights the framework's holistic approach by highlighting interconnected

challenges across disciplines. Liu et al. (2018) point out that Hoff's emphasis on comprehending opportunities and trade-offs within the WEF nexus is consistent with recommendations for integrated solutions to sustainability concerns. Integrated methods to water, energy, and food management are supported by identifying nexus opportunities, such as resource productivity enhancement and climate resilience improvement, as noted by Bizikova et al. (2013) and IPCC (2014). In line with the aims of the United Nations (2015), highlighting synergistic solutions highlights possible cross-sector co-benefits and advances sustainable development objectives. Additionally, as suggested by Rasul and Sharma (2016), the identification of technical and financial solutions highlights the significance of creative resource management strategies. Strategies that are integrated, such as irrigation powered by renewable energy and sustainable land management, support resilience and resource efficiency by adhering to Nilsson et al. (2012)'s nexus thinking. According to Partzsch et al. (2017) and Leach et al. (2019), stakeholder involvement guarantees participatory governance principles, promoting socially and contextually appropriate solutions for improved project ownership and sustainability. Furthermore, as Folke et al. (2005) argue, identifying system boundaries reflects the interdisciplinary nature of the WEF nexus and enables a thorough knowledge of interrelated elements influenced by the project. The project's efficacy is increased by taking into account water storage, hydroelectric power generation, flood control, irrigation infrastructure, and environmental implications. These factors highlight the intricate interactions within the project's scope.

Chapter 5. Conclusion And Recommendations

5.1. Conclusion

We have investigated the adoption of the Water-Energy-Food (WEF) nexus approach for climate change adaptation in Cameroon in this study. We have learned a great deal about the challenges of addressing interconnected water, energy, and food systems in the context of climate change through a thorough analysis of WEF nexus metrics, an assessment of Cameroon's national strategic documents, and the application of Hoff's analytical framework to a climate change adaptation project. The study's conclusions highlight how WEF nexus dynamics are changing in Cameroon, which has important ramifications for plans for coping with climate change. There are noticeable gaps on stakeholders and technological involvement in the national strategic documents concerning the complex interrelationships between the food, energy, and water systems, despite the overall increase of their nexus potential over the years. However, opportunities exist to mainstream the WEF nexus approach in climate adaptation documents like NDCs that depict a growing WEF nexus potential. Furthermore, the utilisation of Hoff's framework has exposed the complexity of climate change adaptation initiatives, emphasising chances to improve the efficacy and integration of the WEF nexus. Following the results arrived at, recommendations were done on two main aspects, precisely the policy and governance aspect and the technological aspect.

5.2. Recommendations

5.2.1. Recommendations on research and data collection

Resources must be set aside for research and data collection to improve knowledge of WEF nexus links in order to enable evidence-based policies. It is critical to include the WEF nexus approach into national policy frameworks in order to fully comprehend and address the issues presented by the intricate interrelationships between the food, energy, and water systems in Cameroon. By doing this, Cameroon can guarantee the sustainability and resilience of its agricultural, energy, and water sectors in addition to prioritising economic growth. To promote cross-sector synergies and avoid trade-offs, this integration should be complemented by enhanced institutional collaboration and coordination. Furthermore, for stakeholders and policymakers to make well-informed decisions, it is imperative that they become more knowledgeable about the WEF nexus idea and develop their competence in doing so. Cameroon may successfully manage the dynamic nature of WEF nexus concerns and strive towards

achieving sustainable development goals by implementing flexible governance mechanisms, prioritising and incorporating WEF aspects into decision-making processes.

5.2.2. Recommendations On Policy and Governance Reforms

The national strategy papers of Cameroon are very important in determining the direction of programmes and policies pertaining to sustainable development and climate resilience. Strategic planning frameworks must incorporate climate-smart agricultural practices, agrivoltaic technology, and rainwater harvesting methods to guarantee alignment with WEF interdependencies and climate resilience targets (CTCN, 2022a, 2022b). These methods support sustainable water management, renewable energy generation, and increased agricultural productivity and flexibility. Cameroon can improve its climate resilience and encourage integrated solutions across sectors by utilising the Climate Technology Centre and Network (CTCN) to facilitate technology transfer and looking into opportunities for incorporating nexus-oriented technologies into strategic planning and project implementation.

5.2.3. Recommendations on the Nexus Frameworks and technology integration

Using cutting-edge strategies and tools that support resilient development and sustainable resource management is essential for evaluating the efficacy and implications of climate change adaptation programmes in the framework of the WEF nexus. Climate-smart agricultural techniques, such integrated water harvesting and management and soil fertility management, present chances to increase agricultural productivity while adjusting to changes brought on by climate change. Comparably, agrivoltaic systems combine the production of solar energy with agricultural methods to improve agricultural yields and offer co-location advantages. Furthermore, rainwater gathering techniques support sustainable food and water security and lessen the strain on water resources. Cameroon may encourage integrated solutions that maximise cross-sector co-benefits and strengthen its climate resilience by including these techniques into strategic planning frameworks and project implementation.

Chapter 6. References

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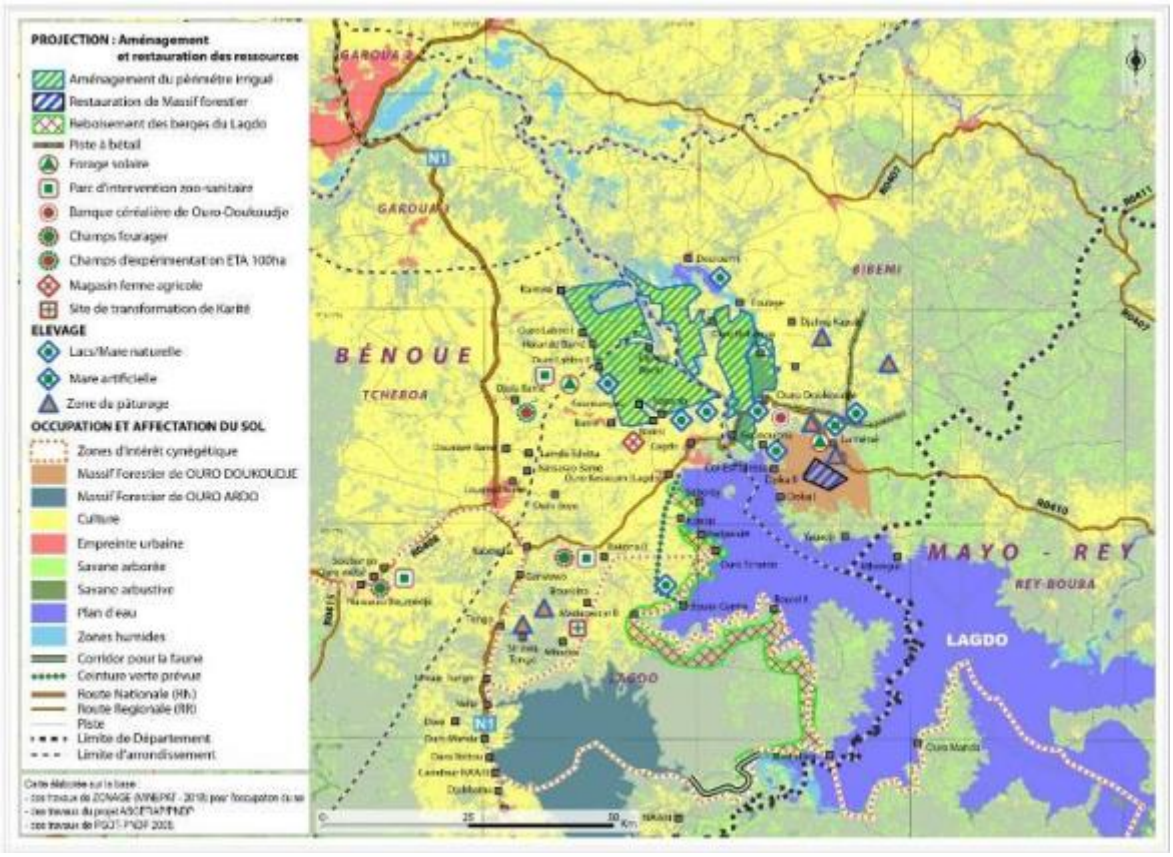
Chapter 7: Appendix

Appendix1: Table 2: WEF nexus performance metrics for Cameroon (2019 to 2023)

Year	WEF Index	Water pillar	Energy pillar	Food pillar	GDP
2019	56,1	54,3	60,7	53,2	1500
2020	55,4	50,7	61	54,6	1500
2021	57,6	54,5	62,1	56	1700
2022	57,5	55,1	62,3	55,2	1700
2023	57,3	54,4	62,3	55,1	1600

WEF index = (WP + EP + FP)/3; Where WP = Water pillar score, EP = Energy pillar score and FP = Food pillar score.

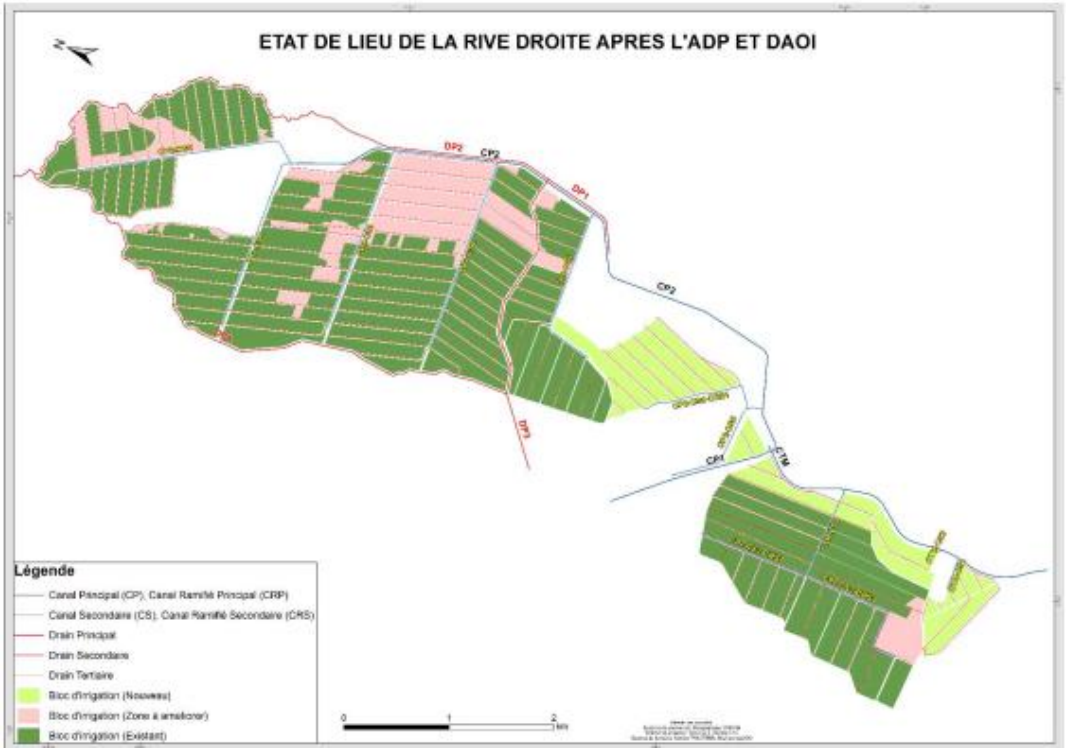
Source: Simpson et al., 2022



Appendix 2: Zonal map of the Viva Bénoué project

Source: Viva Bénoué database repository: https://vivabenoue.org/nos-offres/ consulted on May 04th 2014

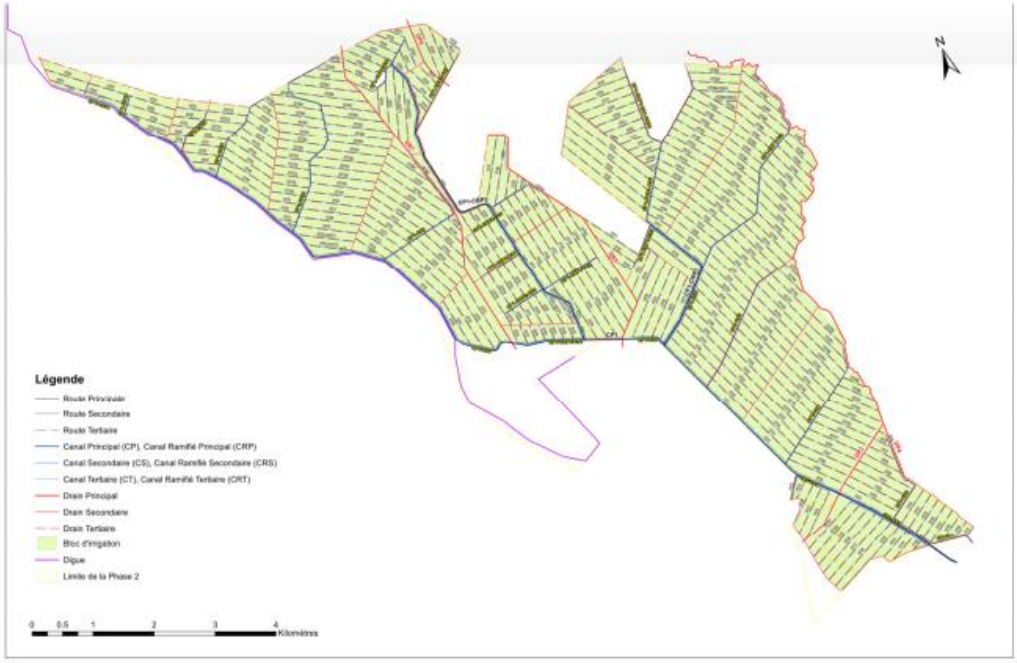
Resource person: Mr. Mahamat Habibou



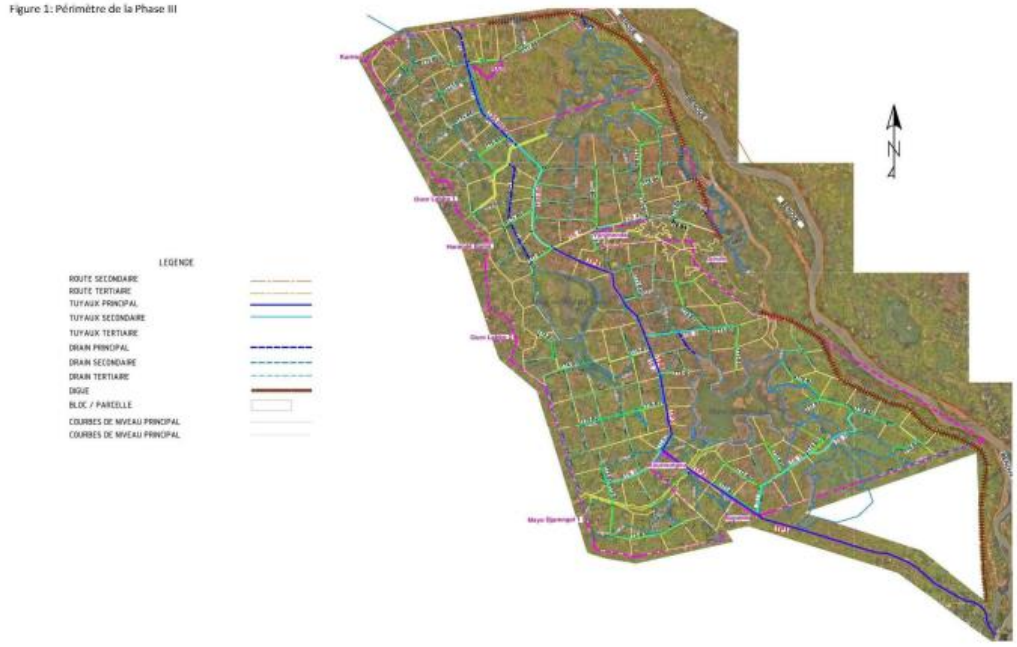
Appendix 3: Map of the rehabilitation perimeter in the VIVA Bénoué project

Source: Viva Bénoué database repository: https://vivabenoue.org/nos-offres/ consulted on May 04th 2014

Resource person: Mr. Mahamat Habibou



Appendix 4: Map of the 5000ha to be developed on the right river bank of the Bénoué Source: Viva Bénoué database repository: https://vivabenoue.org/nos-offres/ consulted on May 04th 2014 Resource person: Mr. Mahamat Habibou



Appendix 5: Map of the 5000ha to be developed on the left river Bénoué Bank

Source: Viva Bénoué database repository: https://vivabenoue.org/nos-offres/ consulted on May 04th 2014

Resource person: Mr. Mahamat Habibou

Appendix 6: Projects from the Ministry of Water and Energy in Cameroon

	Project/ Programme	Description	Objective
1	**Natchigal Hydroelectric Project**	Construction of a hydroelectric dam	To increase energy production
2	**Lom-Pangar Dam**	Multipurpose dam for hydroelectric power generation	To regulate water flow and generate electricity
3	**Chollet Hydroelectric Plant**	Rehabilitation and expansion of hydroelectric plant	To enhance energy production and distribution
4	**Memve'ele Hydroelectric Project**	Construction of a hydroelectric dam	To increase energy production
5	**Mékin Hydroelectric Dam**	Hydroelectric dam project	To provide clean energy and regulate water flow
6	**Sanaga Hydroelectric Dam**	Hydroelectric dam construction	To increase energy production
7	**Menchum Hydroelectric Power Plant**	Hydroelectric power generation	To generate electricity from water resources
8	**PUERTEM Energy Infrastructure**	Energy infrastructure development project	To improve energy access and efficiency
9	**PERACE Rural Electrification**	Rural electrification and renewable energy project	To provide electricity to rural areas
10	**PSCOFE Power Sector Efficiency**	Power sector efficiency improvement project	To enhance the efficiency and reliability of power
11	**PforR Payment for Results**	Payment for Results project	To incentivize sustainable land and forest management
12	**PIRECT Integrated Electrification**	Integrated rural electrification and climate project	To provide electricity and address climate challenges

Source: https://minee.cm/projets/ consulted May 04th 2024

Appendix 7: Projects from the Ministry of Agriculture and Rural development in Cameroon

	Project/Program	Description	Objectives
1	PNVRSA (Project for Food Security Monitoring and Reinforcement)	Monitoring and enhancing food security in Cameroon.	- Monitor food security indicators - Strengthen food security measures and interventions
2	PADRT (Project for Root and Tuber Crop Development Support)	Supporting the development of root and tuber crops in Cameroon.	- Promote the cultivation of root and tuber crops - Improve production techniques and yields of root and tuber crops
3	PADMIR (Project for Rural Microfinance Development Support)	Supporting the development of rural microfinance in Cameroon.	- Enhance access to financial services for rural populations - Promote entrepreneurship and economic activities in rural areas
4	PAIJA (Project for Young Farmers and Vulnerable Individuals Establishment Support)	Facilitating the establishment of young farmers and vulnerable individuals.	- Facilitate the establishment of young farmers and vulnerable individuals in agriculture - Provide training and support to enhance agricultural skills and livelihoods
5	PNDCF (National Fruit Crop Development Project)	Focused on the development of fruit crops in Cameroon.	- Promote the cultivation and commercialization of fruit crops - Enhance productivity and quality of fruit crops
6	PNDPHH (National Oil Palm and Rubber Development Project)	Supporting the development of oil palm and rubber in Cameroon.	- Support the cultivation and processing of oil palm and rubber - Improve the yield and quality of oil palm and rubber products
7	PNAPCM (National Vegetable Crop Production Improvement Project)	Improving vegetable crop production in Cameroon.	- Enhance production techniques and practices for vegetable crops - Increase the availability and accessibility of fresh vegetables
8	AMO (Rural Sector Administration Capacity Building Program)	Supporting the capacity building of rural sector administrations in Cameroon.	- Strengthen the capacity of rural sector administrations - Improve governance and service delivery in rural areas
9	PCRD (Decentralized Rural Credit Project)	Providing decentralized rural credit in Cameroon.	- Provide access to decentralized credit facilities for rural populations - Support rural economic activities and development initiatives
10	PFRIA-C (Pilot Irrigated Rice Farming Project, Avangane, Center Region)	Establishing a pilot rice cultivation farm in Avangane, Center Region, Cameroon.	- Establish a pilot rice cultivation farm - Promote irrigation-based rice farming techniques and technologies
11	CATAC (Cameroon Agricultural Technology Application Center Project)	Focused on the application of agricultural technologies in Cameroon.	- Facilitate the application and dissemination of agricultural technologies - Improve agricultural productivity and efficiency through technology adoption
12	NCA (National Cocoa Academy)	Enhancing cocoa production and processing in Cameroon.	- Provide training and technical support for cocoa farmers - Improve cocoa production techniques and post-harvest processing
13	PADFC (Edible Mushroom Sector	Supporting the development of the	- Promote the cultivation and commercialization of edible

	Development Support Project)	edible mushroom sector in Cameroon.	mushrooms - Enhance the capacity and skills of mushroom farmers

Source: https://www.minader.cm/index.php/nos-institutions/projets-et-programmes/ consulted May 04th 2024.

Appendix 8: Projects and programs from the Ministry of Economy in Cameroon

	Project/Program	**Description**	**Objective**
1	National Participatory Development Programme (PNDP)	A program aimed at decentralizing development initiatives, engaging local communities, and enhancing participation in decision-making processes.	To empower local communities and promote participatory development.
2	Integrated Rural Development Project Chari Logone (PDRI-CL)	A project focused on comprehensive rural development in the Chari Logone region, aiming to improve livelihoods, infrastructure, and social services.	To enhance rural livelihoods and socio-economic development in the Chari Logone region.
3	Rehabilitation and Strengthening Programme for Socio-Ecological Systems of the Lake Chad Basin (PRESIBALT)	A program designed to rehabilitate and strengthen socio-ecological systems within the Lake Chad Basin, enhancing resilience to environmental challenges.	To rehabilitate and strengthen socio-ecological systems in the Lake Chad Basin region.
4	Integrated Community Development Programme of the Atlantic (PDICA)	A program aimed at promoting integrated community development along the Atlantic coast, focusing on socio-5economic e6mpowerment and inf7rastructure dev8elopment.	To promote integrated community development and socio-economic empowerment along the Atlantic coast.
5	Support Programme for the Production of National Strategic Instruments (PAPRINS)	A pr9ogram supporting the production of national strategic instruments to enhance economic planning and policy formulation.	To support the production of national strategic instruments for effective economic planning and policy formulation.
5	Integrated Development and Land Use Project in the Dja Mining Loop and Adjacent Border Zone (PADI-Dja)	A project focused on integrated development and land use planning in the Dja Mining Loop and adjacent border zone.	To promote integrated development and sustainable land use planning in the Dja Mining Loop and adjacent border zone.
6	HIMO Project (High-Intensity Labor Approach)	A project implementing the High-Intensity Labor Approach to create employment opportunities and improve infrastructure.	To create employment opportunities and improve infrastructure through the High-Intensity Labor Approach.
7	Study Mission for the Development and Planning of the Northern Region (MEADEN)	A mission focused on studying and planning development initiatives in the Northern Region of Cameroon.	To study and plan development initiatives for the Northern Region of Cameroon.
8	Integrated Development Mission of the Mandara Mountains (MIDIMA)	A mission aimed at integrated development in the Mandara Mountains region, focusing on socio-economic empowerment and infrastructure development.	To promote integrated development, socio-economic empowerment, and infrastructure development in the Mandara Mountains region.
9	Ocean Development Mission (MEAO)	A mission focused on studying and planning development initiatives in the oceanic region of Cameroon.	To study and plan development initiatives for the oceanic region of Cameroon.
10	Social Safety Nets Project (PFS)	A project aimed at implementing social safety nets to alleviate poverty and support vulnerable populations.	To implement social safety nets to alleviate poverty and support vulnerable populations.
11	Project for the Improvement of Agricultural	A project aimed at improving agricultural competitiveness through	To improve agricultural competitiveness through

	Competitiveness in Cameroon (PACA)	modernization, innovation, and capacity building.	modernization, innovation, and capacity building.
12	AGROPOLES Programme (PA)	A program focused on developing agro-industrial clusters (Agropoles) to enhance agricultural production, processing, and marketing.	To develop agro-industrial clusters (Agropoles) to enhance agricultural production, processing, and marketing.
13	Regional Project for the Revival and Development of Lake Chad (PROLAC)	A regional project aimed at revitalizing and developing the Lake Chad region, focusing on environmental sustainability and socio-economic development.	To revitalize and develop the Lake Chad region, focusing on environmental sustainability and socio-economic development.
14	Project for the Development and Valorization of Investments in the Bénoué Valley (VIVA-Bénoué)	A project focused on development and valorization of investments in the Bénoué Valley, enhancing agricultural productivity and livelihoods.	To develop and valorize investments in the Bénoué Valley, enhancing agricultural productivity and livelihoods.
15	Project for the Development and Valorization of Investments in the Logone Valley (VIVA-Logone)	A project focused on development and valorization of investments in the Logone Valley, enhancing agricultural productivity and livelihoods.	To develop and valorize investments in the Logone Valley, enhancing agricultural productivity and livelihoods.
16	Integrated Programme for Valorization and Transformation of Agricultural and Agri-Food Products (TRANSFAGRI)	A program aimed at promoting value addition and transformation of agricultural and agri-food products, enhancing market competitiveness.	To promote value addition and transformation of agricultural and agri-food products, enhancing market competitiveness.

Source: https://minepat.gov.cm/fr/projets-et-programmes-economie/ consulted May 04th 2024

Resource person: Mr. Engelbert Anouna

Appendix 9: Projects and programs from the Ministry of Environment in Cameroon

	Project/Programme	**Description**	**Objective**
1	Green Sahel Operation (Opération Sahel Vert)	A project aimed at promoting sustainable agriculture and combating desertification in the Sahel region through reforestation and land restoration efforts.	To promote sustainable agriculture, combat desertification, and restore land in the Sahel region.
2	APA/GIZ Regional Support to COMIFAC	A project providing regional support to the Central African Forests Commission (COMIFAC) through the African Parks Association (APA) and GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit).	To provide regional support to COMIFAC in forest conservation and management efforts.
3	OZONE Project	A project focused on ozone layer protection and environmental conservation.	To protect the ozone layer and promote environmental conservation.
4	Minamata on Mercury Project	A project addressing mercury contamination and pollution in the environment.	To mitigate mercury pollution and contamination in the environment.
5	Bamboo Project (Projet Banbou)	A project promoting the cultivation and sustainable use of bamboo resources.	To promote bamboo cultivation and sustainable utilization of bamboo resources.
6	PCB Reduction in Cameroon through Local Expertise and National Capacity Development Project	A project aimed at reducing polychlorinated biphenyl (PCB) contamination in Cameroon by	To reduce PCB contamination in Cameroon through local expertise and capacity building.

		utilizing local expertise and enhancing national capacities.	
7	Improving Population Resilience to the Effects of Climate Change (REPECC)	A project focused on enhancing community resilience to climate change impacts through adaptation measures and capacity building.	To improve community resilience to the effects of climate change through adaptation and capacity building.
8	Reduction of Greenhouse Gas (GHG) Emissions from Deforestation, Forest Degradation, Conservation, Sustainable Forest Management, and Carbon Stock Enhancement (REDD+)	A project aimed at reducing greenhouse gas emissions from deforestation, forest degradation, conservation, sustainable forest management, and carbon stock enhancement.	To reduce greenhouse gas emissions from deforestation, forest degradation, and promote conservation and sustainable forest management.
9	Participatory Integrated Ecosystem Service Management Plans for Bakassi Post Conflict Ecosystems (PINESMAP-BPCE)	A project focused on developing participatory integrated ecosystem service management plans for the Bakassi Post Conflict Ecosystems.	To develop participatory integrated ecosystem service management plans for the Bakassi Post Conflict Ecosystems.
10	Sustainable Farming and Critical Habitat Conservation to Achieve Biodiversity Mainstreaming and Protected Areas Management Effectiveness in Western Region (SUFACCHAC)	A project promoting sustainable farming practices, critical habitat conservation, biodiversity mainstreaming, and effectiveness of protected areas management in the Western Region.	To promote sustainable farming practices, habitat conservation, biodiversity mainstreaming, and effectiveness of protected areas management in the Western Region.

Source: https://minepded.gov.cm/fr/projets-et-programmes/projets/projets-en-cours/ consulted May 04th 2024