L'Institut Agro Rennes-Angers
☐ **Site d'Angers** ■ **Site de Rennes**

Année universitaire : 2022-2023 **Spécialité** : Transition in Environmental and Agri-food system Management (TEAM-actors) **Spécialisation** : Génie de l'environnement (GE) **Option** : Agriculture durable et Développement Territorial (ADT)	**Mémoire de fin d'études** ☐ d'ingénieur de l'Institut Agro Rennes-Angers (Institut national d'enseignement supérieur pour l'agriculture, l'alimentation et l'environnement) ■ de master de l'Institut Agro Rennes-Angers (Institut national d'enseignement supérieur pour l'agriculture, l'alimentation et l'environnement) ☐ de l'Institut Agro Montpellier (étudiant arrivé en M2) ☐ d'un autre établissement (étudiant arrivé en M2)

Democratization of climate knowledge : Assessing co-creation of knowledge via Climate Field Lab activities in Senegal

Par : Bright LITTLE-TETTEH

Mural © NUTRiGREEN, 2021

Soutenu à Rennes le 21 septembre 2023

Devant le jury composé de :

Président : Jean- Eudes BEURET

Maître de stage : Dr. Silke STÖBER

Enseignant référent : Phillipe BOUDES

Autres membres du jury :

Guy DURAND (Professeur honoraire)

ACKNOWLEDGMENTS

I'd like to begin by thanking the funders and partners of the NUTRIGREEN project for their contribution to addressing climate change and food security in West Africa, which made this master's thesis possible.

My sincere thanks go to Dr. Silke Stöber, my tutor, who trusted me with this study and supported me throughout so that we could achieve our goals. I would also like to thank M. Philippe Boudes, my supervisor, who did everything in his power to ensure the smooth running of my internship. They both supervised my work from France, Berlin, and Senegal and gave me the confidence to be an actor for change and to take action.

Thanks to the farmers' group in Senegal, all the staff of APAF, the students and professors of UCAD and SLE, who welcomed me as a member of their family and shared their knowledge with me.

Thank you to my two translators and friends, Mame Cheikh and Thiélème Diouf, who assisted me in the field data collection in Senegal. Thanks to Islem Heraghi for the peer-review and comments on my work.

My loudest gratitude goes to Martin Kuntze-Fescher, Eugenia Covernton, Charlotte Liborio-Cornet, Emma Aidoo, and many others too numerous to mention, who saw the potential in me and supported me since my departure from Ghana to my arrival and through my studies in France.

LIST OF ABBREVIATIONS

ACMAD	African Center for Meteorological Application and Development
ADB	African Development Bank
AGRHYMET	Agriculture-Hydrology-Meteorology regional center
ANACIM	Agence Nationale de l'Aviation Civile et de la Météorologie
APAF	L'Association pour la Promotion de l'Agroforesterie et de la Foresterie
APFG	L'Association pour la Promotion Féminine de Gaoua
CCAFS	Climate Change Agriculture Food Security
CFL	Climate Field Lab
CFS	Climate Field School
CGIAR	Consultative Group for International Agricultural Research
CINSERE	Climate Information Services for Increased Resilience and Productivity project
ClimDEV-Africa	Climate for Development in Africa
COMNACC	Comité National sur les Changement Climatiques
COMRECC	Comité Régionaux sur les Changement Climatiques
CRAIIP	Climate Resilience Agriculture Investigation and Innovation Project
CS	Conveniece Sampling
CTA	Conseiller Technique Agroforesterie
CVA	Comité Villageois d'Agroforesterie
ENACT	Enhancing Nature-based Solutions for an Accelerated Climate Transformation
FFS	Farmer Field School
FGD	Focus Group Discussion
FONRID	Fonds National de la Recherche et de L'Innovation pour le Développement
GE	Groupement d'interêt Économique
GFCS	Global Framework for Climate Services
GPF	Groupement de Promotion Féminine
INDC	Intended Nationally Determined Contribution
IRI	International Research Institute for Climate and Society
IRSS	L'Institut de Recherche en Sciences de la Santé
ITCZ	Inter-Tropical Convergence Zone
MEDD	Ministère de l'Environnement et du Développement Durable
MWG	Multidisciplinary Working Group
NAP	National Adaptation Plan
NAPA	National Adaptation Programmes of Action
NBA	Niger Basin Authority
NGO	Non-Governmental Organization
PAR	Participatory Action Research
PRESAO	Prévision Saisonnières pour l'Afrique de l'Ouest
PSE	Plan Sénégal Émergent
RCOF	Regional Climate Outlook Forums
SDG	Sustainable Development Goal

SLE	Center for Rural Development (Humboldt-Universität zu Berlin)
SLU	Swedish University of Agricultural Sciences
SNDES	Stratégie Nationale de Développement Économique et Sociale
SNMO	Stratégie Nationale Initiale de Mise en œuvre de la Convention Cadre des Nations Unies sur les Changements Climatiques
SRS	Simple Random Sampling
UCAD	Université Cheikh Anta Diop
UJKZ	Université Joseph Ki-Zerbo Ouagadougou
UNFCCC	United Nations Framework Convention on Climate Change
USAID	The United States Agency for International Development
WARCOF	West African Regional Climate Outlook Forums
WMO	World Meteorological Organization
WP	Work Package

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

1. INTRODUCTION

1.1. Background

The climate change-food security nexus

The population of humans on earth reached 8 billion in November 2022, according to the United Nations Department of Economic and Social Affairs in their World Population Prospects 2022 report (UN DESA, 2022). The rapid growth of the human population, combined with climate change, biodiversity loss, and extreme hunger are some of the threats that the global world is currently facing. These threats are interlinked and driven by several factors, of which the current food system is a part. Agriculture is both a contributor to climate change and, at the same time, affected by it. For a global temperature increase of 2 ^{0}C or more, yields are expected to decrease for most staple crops (Torquebiau, 2015). The numerous factors affecting food systems, food security and access to healthy diets range from disruptions in the global food value chain, inflation and soaring food prices to structural inequalities and slow economic growth in developing countries (FAO, 2022). According to a report from the World Economic Forum held in Davos, prices for food, fertilizer and energy are at record highs, with climate change intensifying and the global food system failing (WEF, 2023). Globally, 2.3 billion people are moderately or severely food insecure, 3.1 billion people are unable to afford healthy diets, 149.2 million children under age 5 are stunted, 45.4 million children suffer from child wasting, and 38.9 million children are overweight (FAO, 2022). Climate change alone contributes to high levels of acute food insecurity for 222 million people around the world and could cause more than 216 million people to migrate within or out of their own countries by 2050 (Clement et al., 2021) (FAO, 2022). The FAO has defined food security to exist when all people always have physical, social, and economic access to sufficient, safe, and nutritious foods to meet their dietary needs and food preferences for a healthy and active life (Peng and Berry, 2019). This definition of food security has been strongly linked to the Sustainable Development Goal (SDG 2) which aims to end hunger, achieve food security, improve nutrition, and the promotion of sustainable agriculture by 2030 (Braun et al., 2021). Subsequently, the time left to unravel these negative effects of climate change, ensure global food security, end hunger, and eradicate poverty by 2030 is limited, making the achievement of the agenda 2030 for Sustainable Development slip further out of reach.

The climate jeopardy in Sahel and West Africa

Every country is subject to the direct and indirect consequences of climate change. However, sub-Saharan African countries, particularly those in West Africa are of particular interest to this study because of their immense vulnerability to the adverse effects of climate change. Population growth and rapid urbanization, land and water management challenges, gender disparity to resource use, conflicts, youth disengagement from agriculture, and political challenges across the region are some of the additional pressing challenges in West Africa (FAO, 2023). These phenomena make West Africa, especially the Sudan savannah zone, very sensitive to climate change (Callo-Concha, 2018). Analyzing climate data from 1950 to date, Sanoussi observed a historic trend of climate variability in West Africa with emphasis on the year between 1970 and 1980 where the region experienced severe droughts in duration and extent, apparently one of the most severe in the world (Sanoussi et al., 2015). In addition, sub-Saharan Africa is expected to experience a continuous population growth until 2100, contributing to more than half of the growth of global world population by 2050 (UN DESA, 2022). The agricultural sector in West Africa is often made up of subsistence livestock rearing, fisheries, crop production mainly rainfed and a significant contributor to the economy (Sanoussi et al., 2015). The perils described are surpassing the ability and capacity for sensitive rural communities in these areas to grow food in a sustainable way and to secure their livelihoods. Rural populations already living below the poverty line are being pushed further down the line, and as a result, facing intense destructive impacts (IFAD, 2020). Urgent climate action is therefore needed to support vulnerable populations through inclusive climate adaptation strategies.

Clamor for climate action

The call for immediate climate action as a response to the proliferating concerns about vulnerable African rural households to extreme climate variations and changes have unlocked investments in the development of climate services to enhance local farmers' adaptation capacities (Roudier et al., 2014). The NUTRiGREEN project, which aims to promote green nutrition in the Sahel region, is one such investment worth mentioning. The project materialized with joint financial support from the FOSC ERA-Net (European Research Area Network) Cofund on Food systems and Climate under the European Union's Horizon 2020 research and innovation program, FORMAS in Sweden, the Federal Ministry of Food and Agriculture in Germany, *Ministere de L'Enseignement Supérieur de la Recherche et de L'Innovation in Senegal and the Fonds National de la Recherche et de L'Innovation pour le Développement* (FONRID) in Burkina Faso. Thus, a research consortium was formed involving international partners (i.e., Center for Rural Development SLE at *Humboldt-Universität zu Berlin*, the Swedish University of Agricultural Sciences SLU) in Sweden), and national partners (i.e, Université Cheikh Anta Diop UCAD in Senegal, *L'Institut de Recherche en sciences de la santé* (IRSS), Université Joseph Ki-Zerbo Ouagadougou UJKZ both in Burkina Faso) along with grassroot organizations (i.e, *L'Association pour la Promotion de l'Agroforesterie et de la Foresterie* APAF and *L'Association pour la Promotion Féminine de Gaoua* APFG from Senegal and Burkina Faso respectively). Exploring and improving the value chain of healthy and sustainable traditional plants, integrating them in diets and incomes of rural households in Burkina Faso and Senegal, has been the overall objective of the project. Designing the adaptation strategies to be inclusive, collaborative and a transparent process can accelerate impacts of climate mitigation, facilitate adaptation measures, while ensuring resilience in rural communities (Mfitumukiza et al., 2020). The NUTRiGREEN project therefore pursues a knowledge co-creation or co-research approach whereby smallholder farmers in rural areas are not just passive beneficiaries but become empowered to take up center-stage in the knowledge creation process and to lead the dialogues (Stöber et al., 2022).

Nurturing stakeholder synergies

Smallholder farmers are a source of local knowledge and an insight into the community dynamics of rural areas. Farmers actively cooperate with nature and weather instabilities, especially those dependent on rainfed agriculture, and have accumulated knowledge over the years, making them local experts (Stöber et al., 2022). Local and traditional knowledge provides valuable information on rural community climatic systems, household vulnerabilities and adaptation measures (Roudier et al., 2014). However, access to climate information and links with practitioners and local communities remain weak or non-existent, while scientific knowledge of climate science and its findings remains with several researchers (Stöber et al., 2022). The lack of integration of the two knowledge systems, local and scientific, is due to an incomplete understanding of local knowledge and social dynamics, including the lack of adequate tools to integrate both (Callo-Concha, 2018). Given the diversity of livelihood systems among rural West Africans communities, emphasis should be placed on a more comprehensive and informed strategy adapted to local contexts (Tall et al., 2018) (Leal Filho et al., 2022). Financial, technological, and knowledge gaps are the most common adaptation gaps holding back rural areas, and different stakeholders such as researchers, practitioners, local communities, and decision-makers have a key role to play in bridging these gaps and strengthening adaptive capacity (Stöber et al., 2022). Therefore, addressing this weak link between researchers/practitioners and local farmers in terms of climate knowledge and exchange can enhance rural adaptation measures. As Alvar-Beltrán states, improving access to climate knowledge through the provision of climate services can yield positive impacts that aid smallholder farmers in their decision-making process (Alvar-Beltrán et al., 2020). The benefits, however, can go beyond improved decision-making skills at the farm-scale level to nurturing valuable off-farm leadership skills among smallholder farmers (Bremer et al., 2019). Yet, Bremer highlights the existence of important barriers to the effective and reliable transformation of climate data into usable climate services (Bremer et al., 2019). To enable effective adaptation, climate information should be salient, provided in a timely and tailored manner to ensure that it is appropriate and usable (Vincent et al., 2018). Some scholars argue that the delivery approach of climate information has not always rendered effective adaptation and calls for changes in the way in which the production of climate science is conceptualized, suggesting a shift from “*dominant supply-driven modes of science ‘push’ to a post-normal approach in which demand is ‘pull’* ” (Vincent et al., 2018) (Roudier et al., 2014) (Amegnaglo et al., 2017) (Tarchiani et al., 2018). The World Meteorological Organization (WMO) identifies bridging this knowledge gap between climate information provided by scientists/stakeholders and smallholder farmers (end-users) through climate services (Leal Filho et al., 2022). Bridging this knowledge gap involves establishing and strengthening partnerships between local farmers and a range of stakeholders at different levels (Mfitumukiza et al., 2020).

Merging the knowledge systems

Climate Field Schools (CFS) provide a common ground where scientific research findings meet with agricultural practices through various social interactions between farmer groups and stakeholders. Popularly referred to as “schools without walls”, CFS aims to build local capacity on climate risks, foster knowledge sharing of climate information through climate services, promote agroecological practices and contribute to improving household livelihoods (WMO, 2013). The CFS, through the space it provides for problem-solving dialogue and agrometeorological learning, is one of the essential elements of the Climate Field Lab (CFL) approach (Stöber et al., 2022). Other elements within the CFL approach include Climate-friendly farming, where the promotion of agroecological practices and principles is key, and the Climate adaptation co-research element, where the core principle is to empower farmers through evidence-based advocacy (Stöber et al., 2022). Through experiential learning, knowledge sharing and exchange between farmers, scientists, and local community experts, the CFL approach promotes the co-creation of knowledge and co-research (Stöber et al., 2022). The concept of co-creation, by virtue of its multi-stakeholder participatory approach, makes it a key area of action research ripe for investigation especially in the context of CFS. As the multi-stakeholder exchange in CFS contributes to making rural communities resilient against the threats of climate change, it also provides an opportunity for reflexivity on climate intervention projects adopting this approach. Therefore, assessing how knowledge is co-created between researchers, local farmers (co-researchers) and different stakeholders in CFS becomes an important investigation that can reinforce strengths and reveal some weaknesses in how knowledge is produced, perceived, and shared. The aim of this study is therefore to contribute to the existing body of knowledge on co-creation by identifying which actors are involved in the CFL activities of the NUTRiGREEN project, what their roles are and how they work together to ensure effective co-creation and knowledge sharing. The CFL activities are within Work Package (WP) three (3) of the NUTRiGREEN project. By applying the co-construction prism (Bremer et al., 2019) to assess CFL activities, the study will examine how local farmer groups in two project sites in Senegal (West Africa) and other respective partners of the NUTRiGREEN project, identify, discuss, and resolve issues related to agrometeorological learning and agroecological practices in the CFS. The study will also identify and understand the structural processes involved in the collection and dissemination of climate data/information within the NUTRiGREEN project, with the aim of identifying specific practical knowledge gaps in the process. To achieve these objectives, this study begins with the questions **(Q).**

Q 1: How do CFL activities improve the adaptive capacity of local farmers in Senegal?

Q 2: How can local rural farmers be better involved and help shape the mechanisms for delivering climate services for effective adaptation?

Q 3: Can the co-creation process involving local farmers and other stakeholders be institutionalized?

The results of this study will be useful to reinforce existing partnerships of the NUTRiGREEN project, which involves local farmers in Senegal and Burkina Faso and their respective stakeholders (NGO's, Academic institutions, and Extension officers). It will provide insights into practical knowledge gaps on co-creation to guide action, share experiences of project partners that promotes co-creation, and suggest ways to avert the risk of rendering "solutions looking for problems" or academically driven projects to locally led, long-term adaptation collaborations that integrate farmers' local and experimental knowledge into decision-making.

This study consists of five (5) main chapters, namely, Introduction, Methodology, Results, Discussions, and Conclusion. The introductory chapter is divided into sub-sections that begin with a brief background, describing the current challenges facing the world, one of which is climate change and its impact on livelihoods, particularly in the West African context. This sub-section lays the groundwork for the next, which is a state of the art literature review that delves into how local farmers in West Africa are experiencing and dealing with climate change, and introduces climate governance, institutions, and some stakeholders. The following sub-section of the introduction defines some keywords used in this study, introduces aspects of the NUTRiGREEN activities and sets out an analytical framework to assess the co-creation of knowledge between stakeholders in the NUTRiGREEN project. In the next chapter, which forms the methodology of this study, the research design is outlined. In this chapter, the methods of data collection and analysis are described in detail, followed immediately by the results. The results chapter presents the findings of this study, followed by discussions and conclusions as the last two chapters.

1.2. State of the art

The local farmer and climate change

Climate conditions in the West Africa region vary from arid desert conditions in the north to wet tropical monsoon conditions along the coastal regions in the south and are influenced by a mixture of large-scale seasonal atmospheric patterns and warm winds from the Atlantic Ocean (Daron, 2014). Precipitation patterns in the subregion exhibit a considerable degree of spatial and seasonal variability due to the modulation of the seasonal cycle associated with the intensity of the Inter-Tropical Convergence Zone (ITCZ) (Rhodes et al., 2014). Temperatures are relatively high throughout the subregions, especially in the semi-arid and arid zone, with most rainfall occurring once a year during the summer months (i.e., April to September) and twice in the coastal zone of the subregion (Daron, 2014). Maximum temperatures range from an average of 30 ^{0}C to 33 ^{0}C for coastal countries and from 36 ^{0}C to 40 ^{0}C on average for countries in the Sahel region (Rhodes et al., 2014). Multi-decadal variability in rainfall, coupled with prolonged dry seasons, has had a significant impact over the past century, with the West African region experiencing severe drought in the 1980s, and is projected to worsen under future climate projections (Daron, 2014). Researchers (Roudier et al., 2014) (Sanoussi et al., 2015) (Alvar-Beltrán et al., 2020) have reported on this tragedy and its impact on the environment, the agricultural sector, and the livelihood of rural communities in the West African region. Suitable land for agriculture and the length of the growing season have been reported to have changed, as have changes in the agricultural calendar and other changes in the socio-economic structures of the region, with rural communities in the Sahelian zone being the most at risk (Alvar-Beltrán et al., 2020) (Callo-Concha, 2018) (Sanoussi et al., 2015). As indicated by Rhodes, the main causes of vulnerability in agriculture due to climate change are socially, economically, and environmentally related (Rhodes et al., 2014). Understanding the causes of the problem can be the first steps to tackling it. It is therefore imperative to examine how local farmers across the sub-region perceive climate change, its impacts on their livelihoods and their coping mechanisms to grasp the full scope of how the changing climate is impacting lives in West Africa. This chapter therefore reviews literature from multiple sources to understand the unfolding phenomenon of climate change in the agricultural sector, and to identify opportunities for strengthening the resilience of rural communities in the region.

Perception of climate change by local farmers

The studies of researchers working in the West African context show a high degree of awareness of a changing climate among smallholder farmers in their respective focus countries, with some nuances in how it is affecting livelihoods and their corresponding adaptation strategies (Alvar-Beltrán et al., 2020) (Callo-Concha, 2018) (Sanoussi et al., 2015). This sub-section discusses their approach used and main findings, juxtaposing them with other complementary articles. Alvar-Beltrán uses quantitative analysis to inquire whether local farmers had observed in the last 10 to 20 years period, temperature, precipitation, and wind patterns changes between different agro-climatic zones in Burkina Faso (Alvar-Beltrán et al., 2020). Callo-Concha and Sanoussi adopts a mixed method approach to make inter-regional comparison of countries such as Benin, Burkina Faso, Chad and Niger to understand the effects of climate change and adaptation on the livelihood of smallholder farmers (Callo-Concha, 2018) (Sanoussi et al., 2015). Alvar-Beltrán reports that Burkina Faso, over the period 1950 to 2013, has experienced a nationwide positive trend in hottest days of the year and hot day frequency (Alvar-Beltrán et al., 2020). Around the same period in Burkina Faso, mean precipitation indices were trending downwards from 1961 to 1984 and took an upward trend from 1985 to 1995 at ten (10) stations (Ibrahim et al., 2014). Farmers in the three (3) climatic zones (i.e., Soudanian, Soudano-sahelian, Sahelian) in Burkina Faso reported experiencing both historic and current dry spells during the rainy season and some extreme changes in weather patterns that have altered their planting start/end dates (Alvar-Beltrán et al., 2020). In Burkina Faso, Chad and Niger, local farmers attest that the climate has changed over the past two decades, admitting that there has been a continuous delay in the onset of the rainy season or an early cessation of rain. The greater portion of farmers surveyed in all the agro-climatic zones consider their agricultural activities to be between moderate and high vulnerability to climate change and other extreme weather events (Alvar-Beltrán et al., 2020) (Callo-Concha, 2018) (Sanoussi et al., 2015). About 92% of Sahalien farmers, for example, regard themselves as extremely vulnerable to climate change, while 73% of farmers in the Sudano-Sahelian zones and 33% in the Sudanian zone assert vulnerability to climate change (Alvar-Beltrán et al., 2020). Water scarcity is an everyday challenge for local farmers causing stress for humans, plants, and animals since the agricultural system in West Africa is mainly rain dependent, subsistence, with low/no mechanization and inputs (Callo-Concha, 2018). While pastoralists in semi-arid and arid areas such as Niger, Burkina Faso, Chad, and Senegal have known migration and conflict in search of water and seasonal grazing, fishermen in coastal areas are experiencing rapid erosion of beaches, sea level rise, saline intrusion, destruction of property etc. (Rhodes et al., 2014) (Daron, 2014) (Sanoussi et al., 2015) (Callo-Concha, 2018). Callo-Concha adds, farmers' perceptions on climate change impacts can vary due to several factors such as gender, ethnicity, beliefs etc. and some local farmers in Benin and Burkina Faso attributed climate changes to mystical and supernatural causes (Callo-Concha, 2018).

Impacts of climate change on smallholder farming

The impacts of climate change on the livelihoods of rural communities, experienced through erratic rainfall, winds and temperature events, is causing reduction in soil vegetation cover, accelerating land degradation and biodiversity loss thereby affecting agricultural production (Rhodes et al., 2014) (Sanoussi et al., 2015). The FAO reports evidence of forced migration from rural to urban areas due to increased poverty and other climate-related impacts. This rural exodus exerts pressure on urban areas to expand to accommodate the population influx, furthering the degradation of arable land (FAO, 2023). Senegal, between the year 1970 and 1990 was also impacted by the Sahel drought and the resulting water deficit and growing aridity enhanced migration of rural dwellers towards the coastline especially in the capital city Dakar (Zamudio and Terton, 2016). Below 5% of arable agricultural land in the West African region is under irrigation while farmers have reported a decline in the length of the rainy season. This decline leaves households with increased vulnerability and socio-economic impacts due to their reliance on rainfed agriculture (Sanoussi et al., 2015). The lack of irrigation systems in rural communities in an uncertain climate environment poses severe threats to food security. Food security is however not a problem exclusive to rural areas, urban and peri-urban areas are known to experience moderate to severe food insecurity across the continent but the affordability to a healthy diet is more critical to households living in peri-urban and rural areas than in urban areas (FAO, 2023). The factors associated with food insecurity are not only climate-related, albeit significant, but also embedded in the socio-economic realm and cultures of rural communities in West Africa. Unequal access to land in West Africa due to traditional land tenure systems which prioritizes male over female farmers, gender inequity in decision-making concerning land and water management, high illiteracy rates, lack of access to information and technology, low economic status of women and inadequate access to credit by smallholder farmers are the added pressures limiting climate adaptation measures (Rhodes et al., 2014). As stated by the FAO the gender gap in food insecurity narrowed between 2021 and 2022 after the covid 19 pandemic yet women and rural dwellers continue to be disproportionately affected (FAO, 2023).

Senegal for example is a decentralized state, devolving powers over land and urban planning, natural resource management, education, health, culture, and social development to local authorities (Zamudio and Terton, 2016). Each local government comprises of village clusters, which are collectively governed by locally elected rural council namely, *le conseil rural,* headed by a mayor and two deputies. After Senegal gained independence in 1960, the inherited governance structure from the previous colonial government centralized power around the executive and the ruling party (Wilfahrt, 2023). During this period, land tenure systems were based on three overlapping legal systems namely: the customary system, which originates from traditional customs; the registration system; and the French civil code system (introduced by the colonial government). The 1964 *Loi sur le domaine national* (Law 64-64) harmonized Senegal's three land tenure systems, categorizing land as state land, private land and national land, with the national land, also known as "communal land", accounting for the majority of land and are generally used for housing and most socio-economic activities in rural areas (Santpoort et al., 2021). In 1972, Senegal's administrative decentralization reform act (Acte I) gave the rural councils power over land allocation, particularly vacant land for farming or grazing, granting local authorities considerable power over agricultural activities (Wilfahrt, 2023). Rural community members do not have ownership rights to communal land, but they do have user rights, and by law communal land in Senegal is available to both men and women, provided that the applicant has the capacity to develop the area of land requested. This legal obligation to develop land is therefore an obstacle for women, who generally have much less access to the resources needed to the cultivate land (Santpoort et al., 2021), making women the most vulnerable to climate change impacts.

Farmer coping mechanisms

The most common strategies observed in the three agro-climatic zones of Burkina Faso often used by local farmers are the application of organic matter (comprising 91% of the farmers surveyed), minimum tillage (75%), crop rotation (62%), agroforestry (58%), and some furrow practices (58%) (Alvar-Beltrán et al., 2020). Soil fertilization is an important coping measure among rural farmers with about 50% of farmers surveyed in Benin and Burkina Faso rely on either the application of synthetic fertilizer or the use of organic manure or both (Callo-Concha, 2018). On-farm practices are oriented towards agroforestry, forage production and wind break to mitigate impacts from extreme temperatures (Sanoussi et al., 2015). Plant growth regulators/promoters are used differently across the country. Soudanian farmers rely heavily on synthetic fertilizers, agrochemical herbicides, pesticides, and insecticides while this practice was less prevalent among Soudano-Sahelian and Sahelian farmers (Alvar-Beltrán et al., 2020). The frequent adaptation strategies are often related to crop and soil management practices such as shifting planting dates, choosing rapidly maturing crops, and relying on heat stress tolerant crops (Sanoussi et al., 2015). Sahelian smallholder farmers generally apply traditional farming systems as an adaptation strategy as compared to Soudanian farmers (Alvar-Beltrán et al., 2020). Various rural communities reported to have adopted micro water harvesting (Zaï techniques), the use of stone lines and conservation of sorghum residues and organic matter (Sanoussi et al., 2015). Local farmers across Burkina Faso's agro-climatic zones have adopted respective traditional means to adjust their agricultural activities in a way that can withstand climate shocks to a certain degree. The use of stone ridges was widely used in Burkina Faso, while in Benin, the measures were more of spatial nature i.e., use of fallow periods, and enclosures of plots. Local farmers also used improved and resistant crop varieties and some trees and forest related practices were present (Callo-Concha, 2018). Water resource sharing from reservoirs and water wells were pointed out as a widely used approach to deal with water stress challenges (Alvar-Beltrán et al., 2020). The adaptation measures and strategies of smallholder farmers covers a large spectrum of needs (Cash in-flows, crop variety selection, preservation of soil nutrients etc.) and not only used as a measure to mitigate climate change (Callo-Concha, 2018). As Callo-

Concha argues, "*crop species selection is customary and not climatic*" (Callo-Concha, 2018). Soudanian farmers cultivate cash crops on the most arable plots and their agricultural activities are often market oriented (Alvar-Beltrán et al., 2020). Some other listed determinants include suitability to local ecology, traditions, and institutional settings. There is also the tendency of national agricultural extension services, shaping the adaptation approach of local farmers (Callo-Concha, 2018). For example, the Senegalese government after identifying coastal zones, water resources, agriculture, fisheries, and health as key vulnerable sectors in the country have adopted a national adaptation plan elaborated in their *plan Sénégal Émergent* (PSE) to cope with the threats of climate change (Zamudio and Terton, 2016) and this adaptation plan shapes the priorities of many sectors in the country including the agricultural sector.

Analyzing the results of the respective articles show that climate change is now a perpetual feature that local farmers in rural West Africa are aware of, with diverse impacts and varying adaptation measures which are place-based. Most adaptation measures, however, are oriented toward changes in agricultural practices to mitigate the impacts of climate change but fail to fully demonstrate the involvement of local farmers or the importance of their presence in decision-making regarding climate adaptation actions. In what follows, some institutions, policies and stakeholders are identified to explore how climate change adaptation strategies are addressed from a global, regional, and national perspective.

Climate change, governance & institutions

Climate governance in West Africa

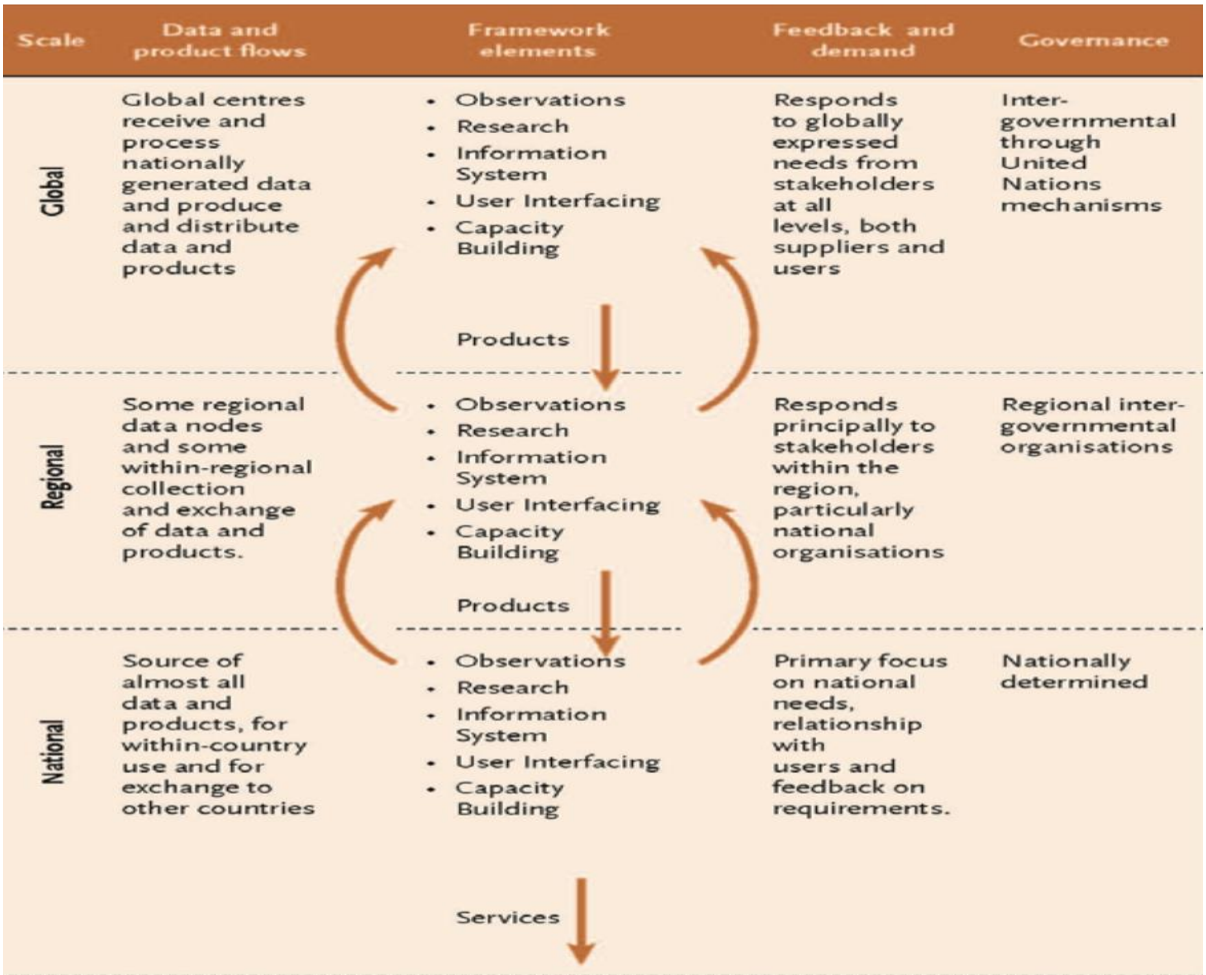
Addressing the challenges of climate adaptation in each territory requires an understanding of the policies and some partnerships between stakeholders that set out the overall vision and goals of a country's adaptation plan. Thus, this section provides a general overview of main policies and plans that shape Senegal's development and climate action. It begins with a brief look at the regional structures that govern efforts to adapt to climate change, then continues with a dive into the policies that shape national climate adaptation plans and ends with some practical examples of climate services and challenges in the Senegalese context.

To address climate change and its unfolding threats, the WMO has established a network of global and regional climate service providers to meet the needs of WMO members for climate services and to enhance their capacity to provide these services. This network is a worldwide, three-tiered structure that includes national meteorological and hydrological services operating at the national level, regional climate change centers providing regional, continent-wide climate information and services, and global production centers providing information and services on a global level (WMO, 2011). The devastating drought which occurred in the West African region in the 1980's contributed to the establishment of Regional Climate Outlook Forums (RCOFs) across the continent known in West Africa as the *Prévision Saisonnières pour l'Afrique de l'Ouest* (PRESAO) or as the West African Regional Climate Outlook Forums (WARCOF) (Blundo-Canto et al., 2021) (Campbell, 2022) (Diouf et al., 2020). Following their creation, a series of regional climate outlook forums held in the 1990's as an annual event to promote seasonal rainfall forecasts for different parts of Africa was a catalyst to the creation of the Global Framework for Climate Services (GFCS) in 2009 (Roudier et al., 2014). In West Africa, the regional climate change centers include the African Center for Meteorological Application and Development (ACMAD), the Agriculture-Hydrology-Meteorology regional center (AGRHYMET), and the Niger Basin Authority (NBA) (Blundo-Canto et al., 2021).

The regional climate change centers are mandated to provide information to the WMO Member States and to assist in the provision of appropriate climate services and products, including regional long-range climate forecasts for a wider user community (WMO, 2011). The RCOFs bring together a variety of stakeholders to form a Multidisciplinary Working Group (MWG) in providing seasonal forecasts, where they produce mutually agreed forecast products for the region (WMO, 2011). The goal is to 'strengthen the production, availability, delivery and application of science-based climate prediction and services by bridging the gap between climate information developed by scientists and service providers and the practical needs of end-users' (Tall et al., 2018) (WMO, 2011). The Senegalese National Civil Aviation and Meteorological Agency also known as *Agence Nationale de l'Aviation Civile et de la Météorologie* (ANACIM), began developing forecast for farmers after participation in seminars on seasonal agro-climatic forecasting in West African countries organized by the AGRHYMET, ACMAD and NBA (Blundo-Canto et al., 2021). As stated by Bremer climate services evolve at a *"science-society interface"* whereby climate knowledge derived from climate science is put into action at different levels through information channels to serve as a decision-base for a given society (Bremer et al., 2019). The outcomes of the various RCOFs have been supported by a number of development organizations such as the GFCS, the Climate for Development in Africa (ClimDEV-Africa) established by the African Development Bank (ADB) and its partners, the World Bank Africa Hydromet program, the Climate Change Agriculture Food Security (CCAFS) coordinated by the Consultative Group for International Agricultural Research (CGIAR) etc., in developing national policy framework and action plans for improved delivery of climate service (Chiputwa et al., 2022) (Vaughan et al., 2019). **Figure 1** shows the linkages between global, regional, and national centers for climate adaptation and how they operate. Recent achievements with national and international research partners can be found in Senegal, where ANACIM has strengthened its capacity to improve the quality of the seasonal forecasts by setting up the first decentralized local MWGs to facilitate weather and climate services, their interpretation, their dissemination, and uptake by local users (Blundo-Canto et al., 2021).

Figure 1: Operations of global, regional, and national climate change centers

Source: (WMO, 2014).



<u>Climate policy & institutions</u>

In 1999, the Government of Senegal elaborated its national strategy for implementing the United Nations Framework Convention on Climate Change (UNFCCC) and approached it through a development focus (Zamudio and Terton, 2016). The framework emphasizes the need to use climate information in the design and implementation of adaptation to climate change (Grossi and Dinku, 2022). In Senegal, the *Stratégie Nationale Initiale de Mise en œuvre de la Convention Cadre des Nations Unies sur les Changements Climatiques* (SNMO) was a pioneering policy instrument to integrate climate change, including adaptation, into its economic and social development policies and programs. The strategy emphasizes a commitment to address climate change while achieving its development goals (Zamudio and Terton, 2016). The SNMO was preceded by a series of vulnerability assessments based on participatory approaches that followed the recommendations of the UNFCCC annotated guidelines for assessing a country's climate vulnerability and effectively developed a National Adaptation Programmes of Action (NAPA) (Sultan et al., 2020). The NAPA of Senegal identifies water resources, agriculture, and coastal zones as the most vulnerable sectors and the priority measures for each of these sectors are identified in their National Adaptation Plan (NAP) launched in July 2015 (Zamudio and Terton, 2016). It is important to note that the NAP has two main objectives: 1. To facilitate the integration of climate change adaptation into relevant policies, programs, and activities and 2. To reduce vulnerability to the impacts of climate change (Sultan et al., 2020). Senegal's national development planning is currently guided by two policies: the *Plan Sénégal Émergent* (PSE) and the *Stratégie Nationale de Développement Économique et Sociale* (SNDES). The PSE defines Senegal's medium and long-term social and economic development strategy to enable the country to achieve social solidarity and the rule of law by 2035 (Zamudio and Terton, 2016) (Sultan et al., 2020). The SNDES is an updated policy document, complemented by the PSE, to increase economic and social growth to achieve its sustainable development goals (Zamudio and Terton, 2016). Another climate policy document with elaborated climate adaptation priorities and aligned with the PSE and the SNDES is *La Contribution Prévue Déterminée au niveau National,* also called the Intended Nationally Determined Contribution (INDC) (Zamudio and Terton, 2016) (Sultan et al., 2020).

The *Ministère de l'Environnement et du Développement Durable* (MEDD) and its environment directorate (*Direction de l'Environnement et des Etablissement Classés),* which are responsible for implementing environmental policies, led the development of the SNMO, NAPA and the national communications (Zamudio and Terton, 2016). The MEDD established the *Comité National sur les Changement Climatiques* (COMNACC) to serve as a central platform for inter-ministerial cooperation on climate change between global and national climate policies and to play a key role in overseeing all activities related to the UNFCCC and in disseminating climate information to support the development of national and sub-national climate projects (Zamudio and Terton, 2016) (Blundo-Canto et al., 2021). Senegal's Regional Climate Change Committees also called the *Comité Régionaux sur les Changement Climatiques* (COMRECCs), were established under the same ministerial decree that created the COMNACC and are mandated to promote synergies between the local and national levels, with the COMNACC managing and facilitating decentralized governance on climate issues (Zamudio and Terton, 2016). The decentralized government agencies use weather and climate information for operational planning and for targeting their interventions, while improving the coordination of their actions through the dynamism of the MWGs (Blundo-Canto et al., 2021).

Praxis of climate services

ANACIM fine-tunes climate information through its national MWGs and produce daily weather bulletins during the rainy season and broadcast forecasts on community and national radio stations (Blundo-Canto et al., 2021). As defined by WMO, climate services are a service that emerges from climate information to support, improve, and facilitate ex-ante decision-making of individuals and organizations in a society (WMO, 2013). In the rainy season, the local MWGs receive climate information from ANACIM and meet every 10 days to run early warning systems, review the situation concerning current crop year, pest and diseases, pastoralism, and market supplies, interpret these data in relation to climate information, and disseminate climate and agricultural advice to farmers through reports and various dissemination channels (Blundo-Canto et al., 2021). With support from USAID through the Climate Information Services for Increased Resilience and Productivity project (CINSERE), the number of MWGs active in Senegal now stands at 27, aiming to increase resilience and to scale up weather and climate services for rural users (Blundo-Canto et al., 2021). The MWGs have been operating in Senegal since 2008 and are a model for co-production of climate service at both national and local levels (Campbell, 2022). The national MWGs are made up of ANACIM, government ministries, extension agencies, research institutions, and insurance companies while the local MWGs are made up of farmer organizations, local administrative authorities, the media, and NGOs (Blundo-Canto et al., 2021). Roudier who uses a participatory approach in two agro-ecological zones in Senegal to find out how smallholder farmers in West Africa use climate forecast in making crop management decisions and whether such use leads to benefits, gives evidence that through climate forecast local farmers anticipate favorable conditions and use that to maximize benefits such as intensifying cropping systems and crop varietal choices (Roudier et al., 2014). The authors add, the farmers in Senegal postponed sowing of certain crop varieties if dry spells or heavy rains were predicted (Roudier et al., 2014).

Although the efforts made by Senegal at national and local levels are worthy of emulation, but there are still challenges to be overcome in the full implementation and integration of climate change issues to achieve development goals (Zamudio and Terton, 2016). Uncertainties remain in seasonal weather forecasting, and the way in which the uncertainties are communicated is a challenge, as most climate information providers lack the experience to explain how to make climate information more understandable. Without a close partnership with the information users, it is unlikely that the information will be of value for decision-making (WMO, 2011). As stated by Campbell, scaling up access to information does not guarantee that farmers will realize benefits at scale; it is how they are implemented that matters (Campbell, 2022). Yet, many user communities lack the capacity and skills to benefit and scale up climate information, a task that may be well beyond the mandate and capacity of National Meteorological Services (WMO, 2011). Other barriers, include a disjuncture between the high complexity of available model outputs made and users' basic information technology (IT) skills, technicalities that make interpretation and application difficult, and a lack of common understanding and vocabulary between providers and end-users (Sultan et al., 2020). In many cases, demand for climate information is often low or poorly informed due to a lack of understanding of the importance of climate information on the part of users, and a lack of understanding of the decision-making process on the part of the providers (WMO, 2011). In Senegal, evidence of public-private partnerships can be observed between ANACIM and private companies such as myAgro, Jokalante, the Senegalese Agricultural Insurance Company, MLouma, and mobile phone companies such as Tigo and Orange (Campbell, 2022) working collectively in the dissemination of climate information. Additional efforts are needed to ensure that multi-stakeholder dialogue goes beyond gathering user inputs for the design of climate service to including capacity building of both users and providers of climate services. These efforts include improving knowledge of climate impacts, understanding how to use the tools provided to access the knowledge, improving the interpretation of uncertain information for informed decision-making on the user side, improving knowledge sharing, and understanding the decision and policy making process on the provider's side (Sultan et al., 2020).

This section provides insight into global, regional, and national frameworks and policies for climate services and the respective actors involved. It highlights the need for a multi-stakeholder approach to the production and dissemination of climate information, with practical examples from the Senegalese context. Building stakeholder capacity is also evident for both the providers and the users of weather and climate information. The next section of this study looks at some development projects where capacity building and farmer inclusivity are pillars for addressing climate change and food security in rural communities.

Climate field lab approach

Learning by doing

There is a growing body of evidence that participatory communication processes empower farmers to understand and act on climate information, together with institutional set-ups that engage relevant agricultural stakeholders to co-create climate-related information and rural advisory services (Campbell, 2022). SLE, a NUTRiGREEN partner and active in rural development projects worldwide, particularly in Southeast Asia and Africa, contributed to the Climate Resilience Agriculture Investigation and Innovation Project (CRAIIP) in Indonesia, among others. The Indonesian-German CRAIIP team, which includes local farmers as co-researcher, has strengthened the resilience of smallholder farmers through co-creation of knowledge, agroecological approaches, and its success is documented in a manual that guides the use of the approach (Stöber et al., 2022). Capacity building for institutions and smallholder farmers is one of SLE's cardinal values and expertise. This section draws on the Climate Field Lab (CFL) approach used in the Indonesian context to serve as a basis for assessing the concept of co-creation in the NUTRiGREEN project in Senegal. It begins with a background on Farmer Field Schools (FFS) to pave the way for a brief description of the various elements of the CFL and ends with a contextualization of the concept of co-creation.

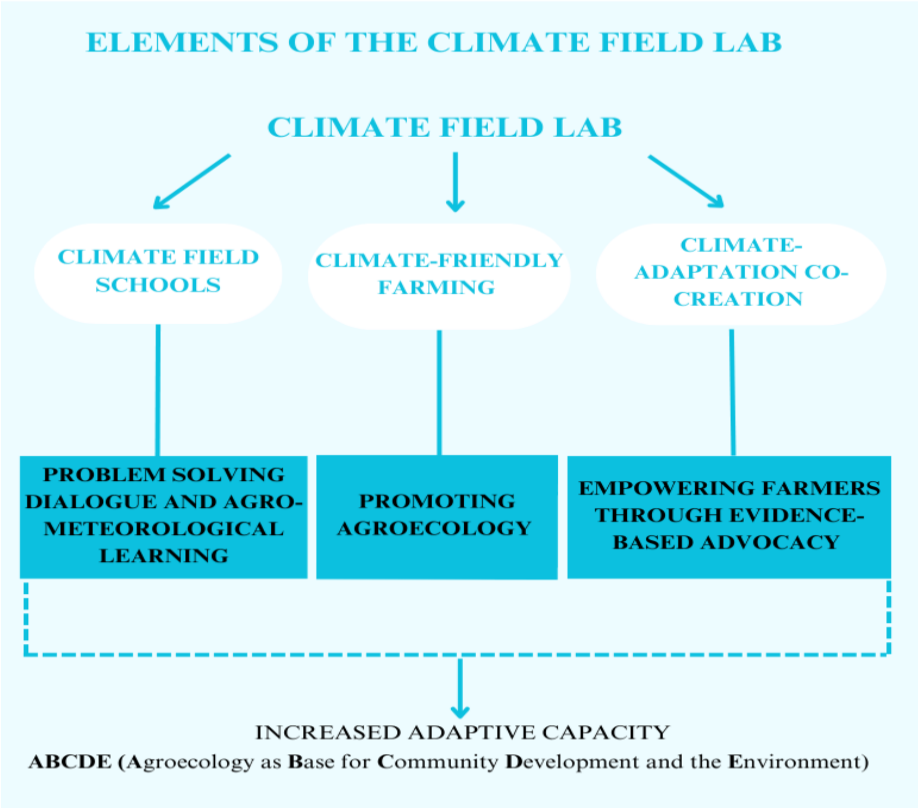
The GFCS defines capacity building in the context of climate services as an investment in people, practices, and institutions to stimulate and develop human capacities, infrastructural capacities, procedural capacities, and institutional capacity to manage and assess climate-related risk by providing decision-relevant climate information (WMO, 2011). Capacity building workshops raise local stakeholders' awareness of the importance of climate information in decision-making and acquaint participants with weather and climate forecasts and some of the terminology used in forecasting (Blundo-Canto et al., 2021). However, the efficient use of climate services is dependent on a horizontal design of climate information between providers and end-users (local farmers) coupled with a transdisciplinary approach that promotes farmer-to-farmer learning (Roudier et al., 2014).The FFS which is centered on a transdisciplinary approach was first introduced in rice fields in Indonesia in the late 1980's through an Integrated Pest Management program to tackle the excessive use of pesticides and to empower local farmers to become experts in managing the ecology of their fields (Witt et al., 2008). By the early 1990's, the program had scaled up to other parts of the world including sub-Saharan Africa in areas such as Sudan (1993), Kenya (1995), Zimbabwe (1997) and Senegal (2000) (Braun and Duveskog, 2011) to name a few. Several innovations have emerged that cover varying topics since the introduction of FFS in Asia such as the inclusion of special topics on health and nutrition due to the prevalent low level of awareness by farmers especially in the African context (Braun and Duveskog, 2011).

The FFS *"consist of groups of people with a common interest, who get together on a regular basis to study "how and why" of a particular topic"* (Braun and Duveskog, 2011). The FFS is particularly developed as participatory field studies, based on non-formal adult education principles, experiential learning "learning by doing" and requires hands-on management skills for continued innovation and local adaptation (Braun and Duveskog, 2011). Similarly, Bakker defines FFS as schools based on *"a participatory field-based approach that seek to support farmers' competences and rely on field observations, collective action and experiential learning"* (Bakker et al., 2021). The components for FFS as indicated by Braun and Duveskog include 'the group', 'the field', 'the facilitator', and 'the curriculum' (Braun and Duveskog, 2011). The group (can be a mix of men and women or separated) consists of people with common interests and they form the core of the FFS. The field plays the role of the teacher and presents the training materials and the real problems to be tackled. The facilitator is recognized by the group members as colleagues, speaks the same language and can be an extension officer or an individual technically competent to lead the group members through practical hands-on exercises with no lecture given. The curriculum springs from the natural cycle of its subjects and it is in parallel with activities taking place in group members' respective farm fields (Braun and Duveskog, 2011). Based on these characterizations of FFS, Röling acknowledges similarities in the approach to that of CFS except with the emphasis that in CFSs, farmers link their experience and understandings of their environment, climate, and weather to the components (Röling, 2011).

Considering these FFS definitions above and the topic of this study, the concept of FFS is reinstated with the notion of CFS to mean the same thing, with focus mainly on agrometeorological learning as a climate service. This study therefore attempts a definition of CFS as a participatory approach that consolidates formal and informal climate information (obtained through field experience, experiments, and studies) in a learning process that results in the co-creation of climate and weather understandings for an enhanced decision-making. The CFS is one of the key elements elaborated in the CFL approach and implemented by CRAIIP in Indonesia. The two other elements included in the CFL approach are 1. Climate-friendly farming, where the promotion of agroecological practices and principles is key and 2. Climate adaptation co-research, where the core principle is farmer empowerment through evidence-based advocacy. The CFL approach brings together several established communities of practice and broadens their scope to include a climate perspective (Stöber et al., 2022). **Figure 2** presents the elements of the Climate Field Lab as illustrated by Stöber.

Figure 2: The climate field lab approach

Source: (Stöber et al., 2022).



The climate-friendly farming is interwoven with agroecological practices, biodiversity conservation techniques and measures that facilitate ecosystem services to enhance nature-based solutions for better climate adaptation (Stöber et al., 2022). The co-research between local farmers, scientists and extension officers is undertaken through demonstration plots and on-farm field trials to find the most appropriate technologies and solutions for the most pressing problems (Stöber et al., 2022). The iterative exchange of local and scientific knowledge breaks down barriers and allows innovation to be tested on farms, providing an evidence-base for farmers to implement and an agenda for advocacy (Stöber et al., 2022). This way of empowering farmers forms the third element of the CFL approach i.e., climate adaptation co-research. Based on the CFL approach, three themes can be deduced, one from each of the elements described above. These themes are 1. Agrometeorological learning in CFS 2. Agroecological practices in CFS 3. The use of local knowledge in CFS. These themes were chosen as appropriate after extensive reading of CRAIIP's manual (Stöber et al., 2022) and the various literature reviewed in this study. The themes will serve as a basis for assessing the concept of co-creation via the CFL activities in Senegal.

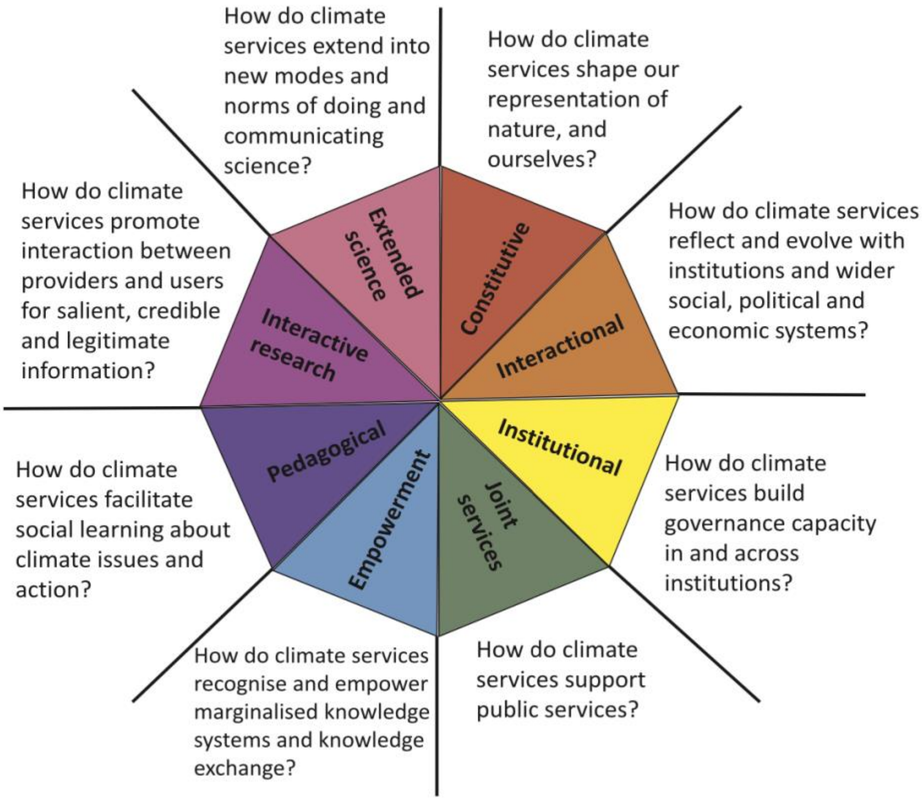
Co-creation of knowledge

Co-creating climate knowledge builds individual and institutional capacity to deliver tailored climate services to vulnerable communities and provides new opportunities for multi-stakeholder groups to re-imagine nature and society (Bremer et al., 2019). It is meant to be a deliberate action of collaboration between climate scientists or producers of climate data and end-users who require climate information for decision-making (Vincent et al., 2018). This collaboration of scientists with non-academic actors is a re-emerging approach in scientific literature stemming from participatory research methods (Mapfumo et al., 2013) (Apgar et al., 2017). The different characterizations of the forms this research approach takes in scientific literature is narrowed down into two main forms namely: 1. Crowd science or crowdsourcing, where non-academic actors are tasked with data collection and are not involved in formulating research questions. 2. Participatory research or participatory science, in which non-academic actors work with researchers to define a common problem (Coeugnet et al., 2023). The general rubric used by the authors to encompass these forms of scientist-non-scientist collaboration was citizen science (Coeugnet et al., 2023). As already indicated, recent climate service policies have been modeled on the inclusion of non-academic actors in climate science and with the ongoing technological and technical advances in weather and climate information, more targeted adaptive solutions can be generated, leading to improved decision-making. However, the major challenges in this process lie in the social intricacies of the stakeholders at play, rather than in the production of weather and climate information itself (Bremer et al., 2019).

Assessing these intricacies can add to existing knowledge of co-creation and allow the expansion of the knowledge. Researchers who have assessed the multi-stakeholder interaction, particularly in the Senegal context have addressed it from a national/regional standpoint or from an impact assessment perspective, monitoring the dissemination of forecasts and then assessing how local farmers apply the forecast information and the corresponding impacts (Blundo-Canto et al., 2021) (Sultan et al., 2020) (Vaughan et al., 2019) (Roudier et al., 2014), but rarely from a local standpoint where local farmers lead the dialogues. Furthermore, the evaluation of the concept of co-creation in climate services is either approached from a normative or a descriptive perspective but rarely done with both perspectives in consideration which can miss the wider societal impacts and qualities (Bremer et al., 2019). The purely normative approach seeks to promote, direct, iterative, interactive processes between providers and users to develop usable products, and lacks recognition of the learning spaces provided, the empowerment of the local groups, or a descriptive only perspective reveals atypical ways in which climate services are shaped, such as power relationships or institutional norms (Bremer et al., 2019). Bremer advocate the merging of both normative and descriptive perspectives and adopts a co-production prism framework originally developed by Bremer and Meisch (2017), who suggest that the co-creation prism provides an opportunity for a comprehensive view of the concept of co-creation as a multi-faceted phenomenon in an ordered way and extends the study and practice of co-creation beyond a one-dimensional process (Bremer et al., 2019). The authors state that Bremer and Meisch (2017) have refined eight different perspectives on the process of co-production, hereafter referred as co-creation, and conceptualized a 'prism' model of co-creation divided into 'eight lenses' comprising descriptive and normative criteria for evaluation (Bremer et al., 2019). **Figure 3** shows the co-creation prism that is applicable to climate service research questions. This study adapts **Figure 3** to Bremer's proposition of their co-creation prism without changing the overall meaning.

Figure 3: The eight lenses of the co-creation prism

Source: (Bremer et al., 2019).



The co-creation lenses involve constitutive, interactional, institutional, joint services, empowerment, pedagogical, interactive research, and extended science lenses. Bremer and Meisch (2017) indicates that extended science, interactive research, pedagogical, empowerment, joint services, institutional form part of the six (6) normative lenses while constitutive and interactional make up the two (2) descriptive lenses (Bremer et al., 2019). Both the descriptive and normative lenses offer eight (8) distinct but complementary insights into the production of climate science (Bremer et al., 2019). **Table 1** gives a snapshot of the co-creation of climate services, observed at different stages, through different co-creation lenses.

Table 1: Different stages of co-creating climate services through the eight lenses

Source: (Bremer et al., 2019).

Lenses	*Understanding context and co-design*	*Process of co-producing climate services*	*Co-disseminating and co-evaluating*
Constitutive	• How climate services relate to long-held ideas of weather and seasons as natural order, and how this influences their acceptability	• The role that surprises, tipping points, non-linearities and wildcards play in climate service development.	• How climate services redefine local understandings of the climate and climate action, and how communities' constitute their place in nature and broader society.
Interactional	• How institutional structures, processes, cultures, interactions, and legal frameworks currently shape the context in which climate services are produced and used.	• The social and political processes at play in dynamically renegotiating the development of climate services. • How climate change issues are (re-) considered relative to the other issues institutions face.	• The impact of climate services on institutions, including the power they exert in institutions. • The co-evolution of markets for climate services with other social, legal, political and economic systems
Institutional	• The various institutional capacities, experience, expertise and resources needed as inputs to • co-produce climate services, and how to mobilise them.	• How climate services are integrated with other information, actor networks, and on-going decision-making processes of institutions.	• How climate services contribute to a more adaptable (or fragile) body of climate knowledge for decision-making in institutions. • Impacts on expertise and capital (human, social, institutional, political) in institutions.
Joint services	• Understanding the relationship between private and public climate services, and how these competing markets provide context for developing new climate services. • The economic and institutional processes that are transforming public organisations into producing private climate services.	• Co-evolution of climate services as private and public goods and emergent tensions. • Proprietary challenges to private climate services produced for profit, using public data.	• Trustworthiness and legitimacy of public vs private climate services, or use of private climate services in public arenas. • The impact of climate services on traditional public services like weather forecasts.
Empowerment	• How stakeholders might be meaningfully engaged from the beginning in the joint design, production, evaluation and use of climate services	• How non-scientific knowledge is integrated with scientific knowledge in developing climate services. • Alternatives to science-based climate services, based on other anticipatory technologies associated with local and traditional knowledge.	• The influence of climate services on other knowledge systems in a place, like traditional or local knowledge.
Pedagogical	• Barriers to understanding and using climate services among key user groups. • Perceived knowledge gaps	• How climate service processes and products create spaces for learning and building competencies, and what collaborators learn about	• How climate services are used in educational institutions like universities or schools
Interactive research	• How collaborators negotiate across conflicting motivations, expectations, values, assumptions, vocabularies, scales of operation, and demands of climate services, and their goals of working together.	• Ways to create high quality dialogue through iterative interaction between climate service users and providers. • The role of boundary institutions in brokering knowledge partnerships	• The usefulness and usability of the final climate information product for users and their institutions, and any limits to its uptake. • Collaborators' perceived success of co-producing a high-value high-quality product
Extended science	• Reflections on an 'ethics of climate services' and what constitutes the 'responsible' production and use of climate services. • The epistemological status of climate services as a mode of practicing science, and its unique paradigm of representations, rules and methods.	• Alternative scientific practices, processes and technologies for collaboratively conducting scientific enquiries for climate services • The potential for new forms of 'citizen science' in climate services	• How scientific processes incorporate diverse criteria of knowledge quality and value, and how these criteria are layered in a final climate information product.

To access the CFL activities of the NUTRiGREEN project through the eight (8) lenses, the **Constitutive** lens seeks to diagnose the role of climate services in reconstructing representations of climate and the social order for living with this climate. The **Interactional** lens seeks to uncover and critically challenge the dominant approach that guides climate services. The iterative **Interactional** lens explores the usability of climate information products in a decision-making context. **Extended science** lens assesses the social robustness, accountability, and legitimacy of climate information in the face of uncertainty. **Joint services** lens identifies the efficient and effective delivery of public services. The **Institutional** lens assesses the building of adaptive capacity in institutions. The **Pedagogical** lens inquires the creation of a setting for social learning and the **Empowerment** lens reveals the empowerment of marginalized knowledge systems for governance (Bremer et al., 2019). Although the evaluation criteria appear to be centered on co-creating climate services, the prism has the potential to access co-creation from a systemic perspective. As stated by

Bremer, the co-creation prism allows the co-creation process to be ascertained simultaneously from several complementary theoretical perspectives through a systemic analysis of people, institutions, processes that interact and affect each other or could come into conflict in the co-creation of climate knowledge and services (Bremer et al., 2019). In this study, the co-creation prism is used to assess the themes deduced from the CFL approach i.e., agrometeorological learning in CFS, agroecological practices in CFS, and the use of local knowledge in CFS in the context of the NUTRiGREEN project in Senegal. The evaluation criteria in Error! Reference source not found. cover the co-creation processes from different perspectives to identify practical knowledge gaps that can reinforce existing partnerships of the NUTRiGREEN project in Senegal. For this reason, this study hypotheses (**H**) that:

H1: The CFL activities of the NUTRiGREEN project are designed without the involvement of local farmers in the decision-making process, and their participation is through compliance with, and feedback on, predetermined rules.

H2: The transition from ordinary local farmers to co-research farmers requires an inevitable repetitive process of familiarizing stakeholders and farmers with different knowledge systems.

These two hypotheses will be tested empirically using the co-creation prism as an analytical framework to assess the themes deduced from the CFL activities of the NUTRiGREEN project.

The introduction to this study addresses climate change and its impacts on a global scale, while highlighting the menace it poses on the African continent (specifically sub-Saharan Africa) and calls for immediate climate action by leveraging climate services to mitigate climate impacts. It also assesses the CFL activities of the NUTRiGREEN project in Senegal, involving local farmers and other stakeholders. The outcome will be to strengthen existing project partnerships and uncover new opportunities. The following chapter begins with a description of how literature was collected and analyzed, continues with a detailed description of the thought process for collecting data in the field, and ends with how data is analyzed, forming the methodology of this study.

2. METHODOLOGY

Climate change and its impacts, particularly in the context of rural development, is undoubtedly, a highly relevant issue for society and in the daily lives of people across the globe. Several researchers have explored the perceptions of climate change among rural households, its impacts, and some adaptation strategies, eminently in West Africa and the Sahel where this study predominantly focuses (Alvar-Beltrán et al., 2020) (Freduah et al., 2019) (Callo-Concha, 2018). Others, with the aim of re-orienting traditional research paradigms to engage and involve community members, especially marginalized groups, have explored Participatory Action Research (PAR) (Schindler et al., 2016) (Faure, 2010) (Chevalier and Buckles, 2013). Merging these schools of thought requires the juxtaposition of various peer-reviewed articles and "grey literature" (institutional reports, working documents, master's thesis) to construct meaning and link to the research topic and the questions. Adopting a literature review approach is therefore of high value in fine tuning an appropriate means of addressing a great deal of literature concerning the research questions to identify and compare central issues between related areas (Grant and Booth, 2009) of co-creating climate knowledge for effective climate change adaptation. This study considers literature review as an important secondary data set relevant to understand the scope and nature of the research topic. Therefore, the data collection during the fieldwork in Senegal will be the primary data for this research topic. Collecting data involved an iterative approach, requiring an interplay between data collection and analysis. In this section, the methods and tools used to collect and analyze both data sets (primary and secondary) are explained.

2.1. Collecting secondary data

The choice of conducting a 'state of the art review' for this study is based on its tendency to provide a comprehensive view of more current issues in the research topic, its potential to reveal new perspectives or to point out areas for further research (Grant and Booth, 2009). Articles or review type publications from online databases such as Google scholar, Science direct, and Cairn that are accessible and have been peer-reviewed were prioritized in this literature review. To put the research problem into context and to provide an insight into the current issues in agriculture and climate change in the focus country (Senegal), grey literature such as reports from recognized multilateral institutions such as the FAO, IFAD, WMO, etc., government reports, some working papers, and master's thesis from the NUTRiGREEN project were also consulted. Articles written in English and French were examined using series of key words. The scope of the search involved the agricultural sector, mainly smallholder farmers engaged in subsistence agriculture in rural areas, practicing crop production, dependent on the rainfed system and one way or the other relied on climate services for decision-making. Titles, abstracts, and conclusions were screened and articles that did not meet these criteria were discarded. This approach was helpful to further narrow down the vast literature on the subject especially in the sub-Saharan context. In total, thirty-one (31) articles, nine (9) books, fifteen (15) reports, two working papers, newsletters and one (1) master's thesis of the NUTRiGREEN project were reviewed for this study. Using a self-developed entry journal, each retained paper was read and analyzed in detail. The journal was created using an Excel spreadsheet, with the first column of each row in the spreadsheet representing categories that were relevant to the analysis. This step was taken to verify the authenticity of the paper, the relevance of each paper to the study, and to be able to take a critical look at each of the retained by comparing main ideas and relationships listed in the categories.

2.2. Field work preparations

The research design straddles deductive and inductive reasoning to guide the study's methodological orientation. Since the NUTRiGREEN project involves multiple actors and adopts a PAR approach, it is essential that the methodological design for data collection encourages the participation of all actors. Purposive sampling is used as a basis for setting up categories for the participants of this study. Two factors are considered in creating the categories; the relationship the participants have to the topic and the relationship the participants have with each other (Flick, 2018). The different actors are divided into the categories of experts, agrometeorological data collectors, and women farmers' groups. The experts are individuals with formal academic training in a particular discipline. The agrometeorological data collectors are groups of people trained in agrometeorological data collection by the NUTRiGREEN project. The women farmer groups are groups of individuals who are working in collaboration with the partners of the NUTRiGREEN project. These groups form a homogenous group, essential to enrich the understanding of the research questions and objectives. The participation of each category of actors is vital for this study. However, the participation of each group will be loose if the data collected from the interactions with the members of the group is the only form of data to justify a PAR approach. Therefore, an additional unique heterogenous group of selected members from each category of actors was envisaged to engage in a dialogue on the pre-selected themes. The selection process for the participants in this stakeholder dialogue involves a simple random sampling (SRS) for the agrometeorological data collectors and the women farmer groups and convenience sampling for the group of experts. For the experts, a semi-structured data collection guide designed in line with the pre-selected themes is used to collect data. Focus group discussion (FGD) was chosen as the appropriate data collection method for the agrometeorological data collectors, the women farmers' groups, and the heterogeneous group (also called the stakeholder dialogue). The FGDs however, have a peculiar twist. It is designed to serve multiple purposes in one event. First, to serve as a data collection tool for this study. Second, to serve as an opportunity for NUTRiGREEN partners to conduct the second phase of the agrometeorological training meant for agrometeorological data collectors to understand and to interpret meteorological graphs (a task that was assigned to me as part of my internship training at SLE). Third, to serve as a source agenda meant to feed the stakeholder dialogue. This approach required the use of inductive reasoning as a method for gathering data. It can be achieved by alternating data collection and analysis of the FGDs involving the agrometeorological data collectors and the group of women farmers, to provide a 'learning agenda' for the stakeholder dialogue. Further steps are taken in this aspect of field preparation to consider cross-cultural interviewing and translation (Flick, 2018), as the members of the agrometeorological data collectors and the women farmers' group who participate in the FGDs did not speak French or English. The methods described were set out in a research proposal and circulated to the project partners for review and confirmation of the planned activities. Once confirmed, the participating groups were contacted by emails for the experts group dispersed between Senegal and Germany, and through the local NGO, APAF Senegal, for the agrometeorological data collectors and the groups of women farmers (see **Annex I** for contact list). In total, thirteen (13) experts were contacted for the study, four (4) FGDs: one (1) for the agrometeorological data collectors from both villages (i.e., Nobandam and Diofior), one (1) for the women's farmer group in Nobandam, one (1) for the women's farmer group in Diofior and one (1) stakeholder dialogue were organized.

2.3. Collecting primary data

In Senegal, the CFL activities place at project sites (i.e., Nobandam and Diofior) in the Fatick region. The Fatick region shares its borders with Kaolack region to the east, Diourbel and Kaffrine regions to the north and north-east, the Atlantic Ocean to the West, the Thiès region to the north-west and the Republic of Gambia to the south (Ndiaye, 2015). The region's population was 870,361 in 2019, of which 432,257 were men (49.7%) and 438,104 women (50.3%), about 6% of the national population organized administratively into three (3) departments: Fatick, Gossas and Foundiougne, Nine (9) districts and 40 towns (ANSD, 2019). The region is characterized by ethnic diversity and varied customs and traditions. Most of the population is Sérère and speak the sérère language (55.1%), followed by Wolof (29.9%), Pular (9.2%), Soké and Bambara (5.8%). The department of Fatick covers approximately 39% of the regional surface area with four (4) districts and three (3) towns: Fatick, Diakhao and Diofior (Ndiaye, 2015). Diofior is one of the towns in the departments of Fatick with a population of about 13, 782. The town of Fatick has the highest population of 34,449 in the department, and Nobandam is one of the villages of the town (ANSD, 2019). The region's main production sectors are agriculture, livestock farming, forestry, fisheries and aquaculture, salt production, craft, and tourism, with agriculture employing over 90% of the labor force (Ndiaye, 2015). Regarding climate, the region of Fatick has a Sudano-Sahelian climate, with an alternating rainy season from June-July to October and a dry season that lasts eight (8) to nine (9) months for the rest of the year (Ndiaye, 2015). **Figure 4** shows the major climate zones in Senegal and the location of the Fatick region in respect to the zones. Average annual minimum temperatures range from 21 ^{0}C to just over 24 ^{0}C from December to the end of February, while average annual maximum temperature range from 35 ^{0}C to 42 ^{0}C, particularly from March to June (ANSD, 2019). **Figure 5** indicates the region of Fatick and the two project sites of the NUTRiGREEN project.

Figure 4: Map of agro-climatic zones in Senegal

Source: IRD retrieved from (Saunier-Zoltobroda, 2015).

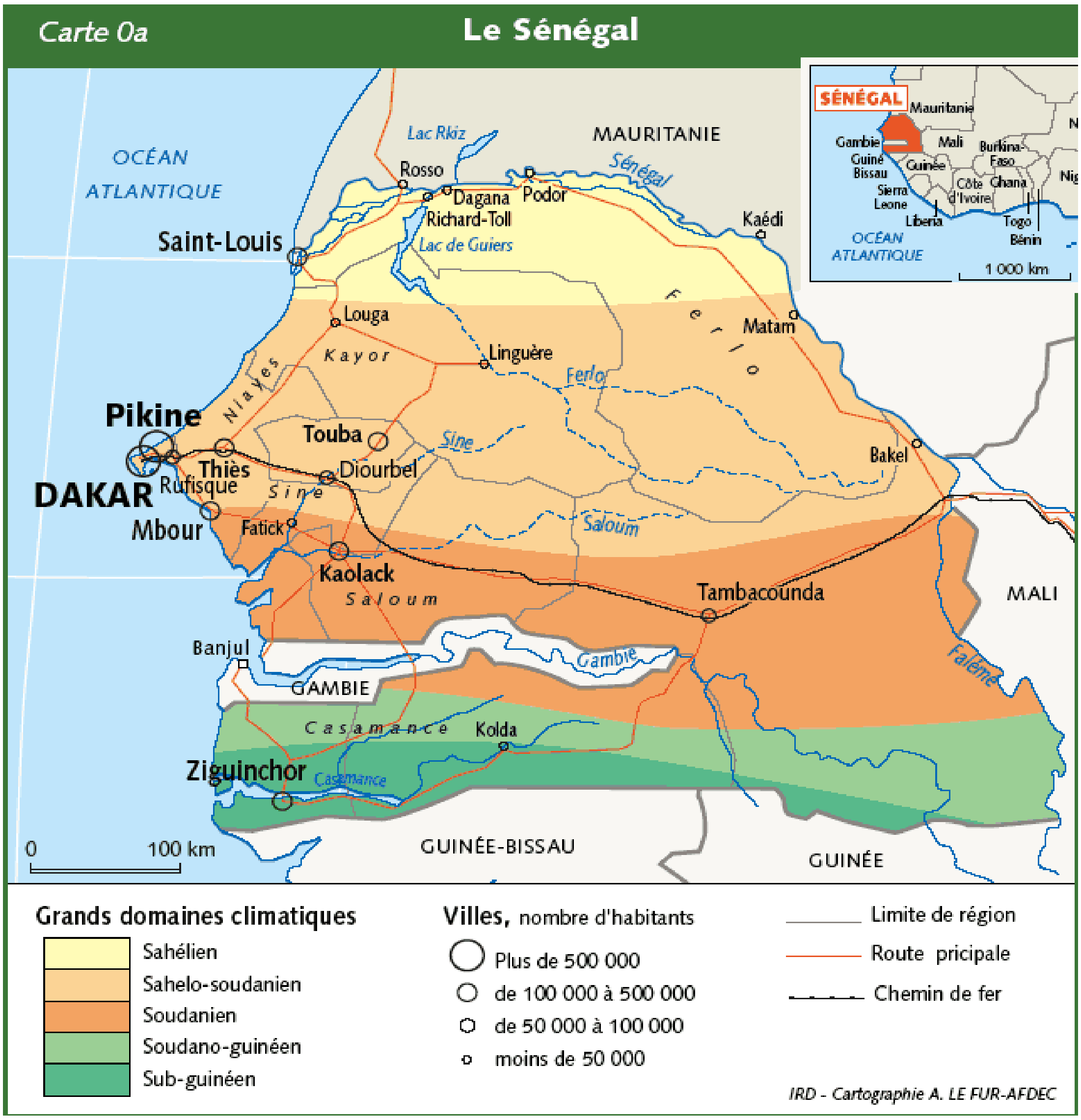
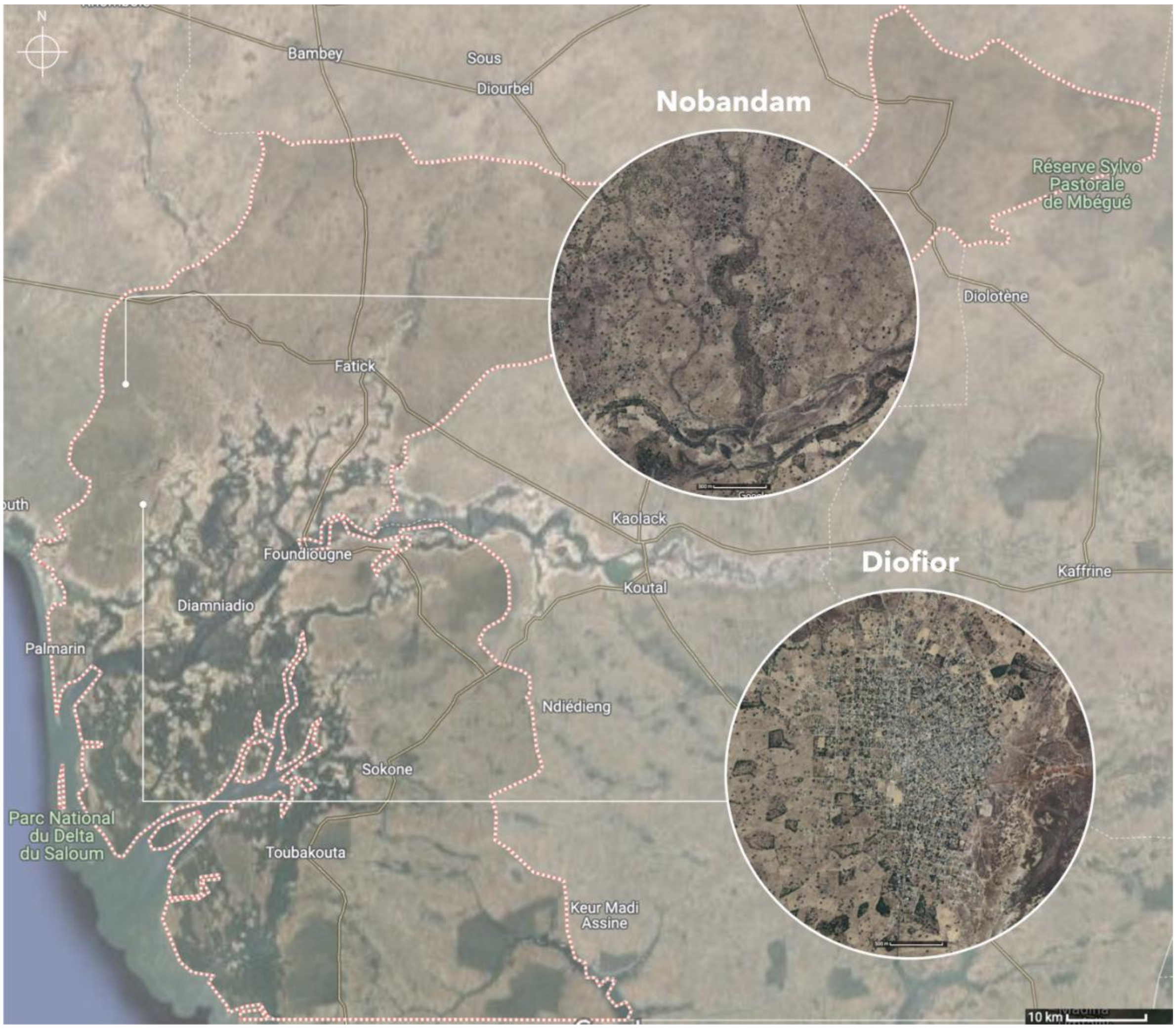


Figure 5: Map indicating the frontier of the Fatick region and the two project sites of the NUTRiGREEN project

Map illustrated by LITTLE-TETTEH, B. 2023, background generated from Google Maps satellite view, 2018 (Consulted 15/07/23).



2.4. Settings for data collection

A range of literature was consulted to design a qualitative research methodology appropriate for this study (Tracy, 2013) (Flick, 2014) (Flick, 2018) (Saldaña, 2011). Data collection began on May 25, 2023, with expert interviews for the participants in Berlin, and continued until June 24, 2023, with participants in Senegal, mainly in Dakar, M'bour, Diofior, and Nobandam. The experts were recruited based on their direct link to the CFL activities of the NUTRiGREEN project or their expertise in climate services. Emails were sent out in both the English and French language to the respective experts suggesting a meeting time and place that would be convenient for the participants, preferably in a quiet place, free of distractions that would allow for good quality audio recordings (Flick, 2018). The interviews were therefore face-to-face, taking place mainly in the participants' offices, classrooms, homes and conducted in English or French depending on the profile of each expert. Out of the thirteen (13) experts contacted via email, only one (1) participant was not interviewed. This participant did not respond to the initial contact and the reminder email sent. However, the absence did not make the data deficient, although his contribution may have added an interesting layer to the richness of the data. The tools prepared for the data collection included a smartphone audio recorder, a notebook, a pen, a printed copy of a semi-structured interview guideline and a consent form that was modeled on based on reviewing qualitative research methods (Tracy, 2013). The consent form was detailed in the research protocol, which was sent to the partners for review and approval. Before the start of each interview, participants received a brief explanation of the research topic and objectives, and then given a consent form to sign. Once signed, the audio recordings began, followed by questions from the semi-structured guideline. Though the semi-structured guideline was modeled based on the themes derived from the CFL activities, the guiding questions were adapted to each expert interviewed. The questions were organized to generate free-flowing conversations with the participants starting from broad to specific, and included follow-up questions, also known as probes (Flick, 2014) to gain deeper understanding of some of the participants' responses. Each interview lasted an average of one (1) hour. At the end of each interview, each expert was informed of the next steps. Taking advantage of the convenience of face-to-face meetings, experts were invited to participate in a stakeholder dialogue and allowed to confirm their participation on a voluntary basis. The audio-recordings of all interviews were uploaded into a google drive folder dedicated to the storing field data for this study.

2.5. FGDs planning and preparations

Preparing for the FGDs included selecting tools and assigning roles a few days before the first FGD. A facilitator and a scribe who are fluent in French and both local languages (i.e., Sérère language and Wolof) were recruited to assist with group management and the collection of data. The facilitator is an agricultural extension officer, working with the NGO APAF, trained to facilitate group discussions with local farmer groups on agroecology and agroforestry topics. The scribe is a graduate of a technical school in Senegal who was hired to act as a local guide and to take notes on the group discussions that took place during the FGDs. I played the role of the observer, watching for nonverbal expressions, and making sure every participant had the chance to be heard as the group discussed. The facilitator's role is to translate the semi-structured guidelines questions to the groups, the groups discussed and shared their responses back to the facilitator, who then translated to me (the observer). Without interfering with the discussions, the scribe takes notes in French of the exchanges in the local language during the group discussions. The scribe only intervened when a point needed to be repeated, which was rarely the case. As the FGDs were designed to serve multiple purpose in one event, it was imperative that the groups were actively involved in the discussions, effectively organized to control interactions, and the roles of the facilitators and scribe were anchored to generate a rich quality data (Tracy, 2013). Each FGD was organized to include fun activities (Colucci, 2007). A protocol for facilitating FGDs outlined for the NUTRiGREEN project (see **Annex II**) was modified and shared with the facilitator and the scribe to make sure each role was clearly understood. The semi-structured guide and the agrometeorological training guide to be used for the FGDs were tested in French with the facilitator, the scribe and myself (observer). With each member of the management team having a copy of each document, I first presented both guidelines in French to both team members, giving them the opportunity to ask questions if they did not understand. As a way of practicing and rehearsing each role, the facilitator took over after me and presented (first time in French and Second time in Sérère) to both the scribe and me, and while the scribe took notes of the presentation, I observed and made comments and suggestions. Each FGD was organized to last three (3) hours (from 9am to 12pm) and this was communicated to each participant. The tools prepared for the main FGDs included, flipchart, markers, notebooks, pens, a print-out of training guide (i.e., semi-structured guide and agrometeorological training guide), a smartphone audio-recorder, and a consent form for each participant to sign. The seating arrangements of each group discussion were also pre-planned prior to the first FGD.

2.6. Group composition and sampling for FGDs

On June 15, 2023, the first FGD hereafter referred to as FGD 1 for the agrometeorological data collectors was held in the CFS of Diofior and the two (2) subsequent FGDs' followed right after. The second FGD (FDG 2) was held on June 16, 2023, in Nobandam CFS with the group of women farmers and the third (FDG 3) held on June 20, 2023, in Diofior CFS with the group of women farmers. The FGDs ended with the stakeholder dialogue (FDG 4) on the 22nd of June 2023. Before each agreed date for the FGDs, a reminder was sent out one day in advance through field agents of APAF Senegal called *Conseiller Technique Agroforesterie* (CTA), who have the role of site managers. Regarding the FGD 1, agrometeorological data collectors from both sites i.e., Nobandam and Diofior, were combined into one (1) group. All Six (6) agrometeorological data collectors from both sites were contacted; Two (2) collectors were expected from Nobandam and four (4) from Diofior. Transport arrangements were made for those coming from Nobandam. FDG 2 aimed to sample the 58 women in Nobandam, who make up the women's group with which APAF Senegal works, and FGD 3 aimed to sample the 57 women in Diofior who make up the women's group. It was expected that the FGD 4 would consist of a mixed sample from each of the categories of groups to take part in a stakeholder dialogue. Since FGDs typically vary from five (5) to ten (10) participants, twelve (12) participants were targeted for the FDG 2, FDG 3 and FGD 4, which corresponds to the 10-20% over-recruitment requirement as suggested by Flick and Tracy to avoid the assumption that all those invited will participate in the discussion (Flick, 2018) (Tracy, 2013). All six (6) participants were maintained for FGD 1 as they met the criteria for group size. Out of all the fifty-eight (58) women farmers invited in Nobandam, only seventeen (17) showed up and a simple random sampling technique (SRS) was used to select ten (10) participants for FGD 2. Using the same SRS technique to select from the fifty-seven (57) invited women farmers, only twenty-three (23) showed up and ten (10) participants were retained for the FGD 3. The SRS technique consisted of numbering a cut-out blank sheet of paper from one (1) to ten (10) and mixing them all together in a bowl with other cut-out blank sheets without numbers, corresponding to the number of farmers present for each FGD at each site. One of the numbers mentioned above, had a special character (a smiley face) associated with it, which was randomly selected by the scribe before the meeting with each group of farmers. At the end of each FGD, the farmer who received this special mark was invited to represent their respective groups in the next steps. These randomly selected participants from FGD 1, FGD 2, FGD 3 who chose the number with the special character were to attend and participate in the stakeholder dialogue i.e., FGD 4. In total the FGD 4 consisted of nine participants (9): Two (2) agrometeorological data collectors, one (1) from each project site, one (1) woman farmer from Nobandam, one (1) woman farmer from Diofior, and the rest were expert comprising, a professor, the director of APAF, an employee of APAF, and two (2) UCAD graduate students. **Table 2** provides an overview of participants and the approach to data collection.

Table 2: Sampling stakeholders and survey approach

Table illustration by LITTLE-TETTEH, B. 2023.

	EXPERTS	FGD 1	FGD 2	FGD 3	FGD 4
Recruiting Method	Purposive Sampling	All data collectors	SRS	SRS	Convenience Sampling + SRS
No. of Participants	12	6	10	10	9
Form	Semi-structured Guidelines & Face-Face interviews	Semi-structured guidelines & Group discussions	Semi-structured guidelines & Group discussions	Semi-structured guidelines & Group discussions	Concertation, debate & Group Discussions
Duration	1 hour	3 hours	3 hours	3 hours	3 hours
Language	English and French	French and Sérère	French and Sérère	French and Sérère	French and Sérère

2.7. Action-oriented FGDs

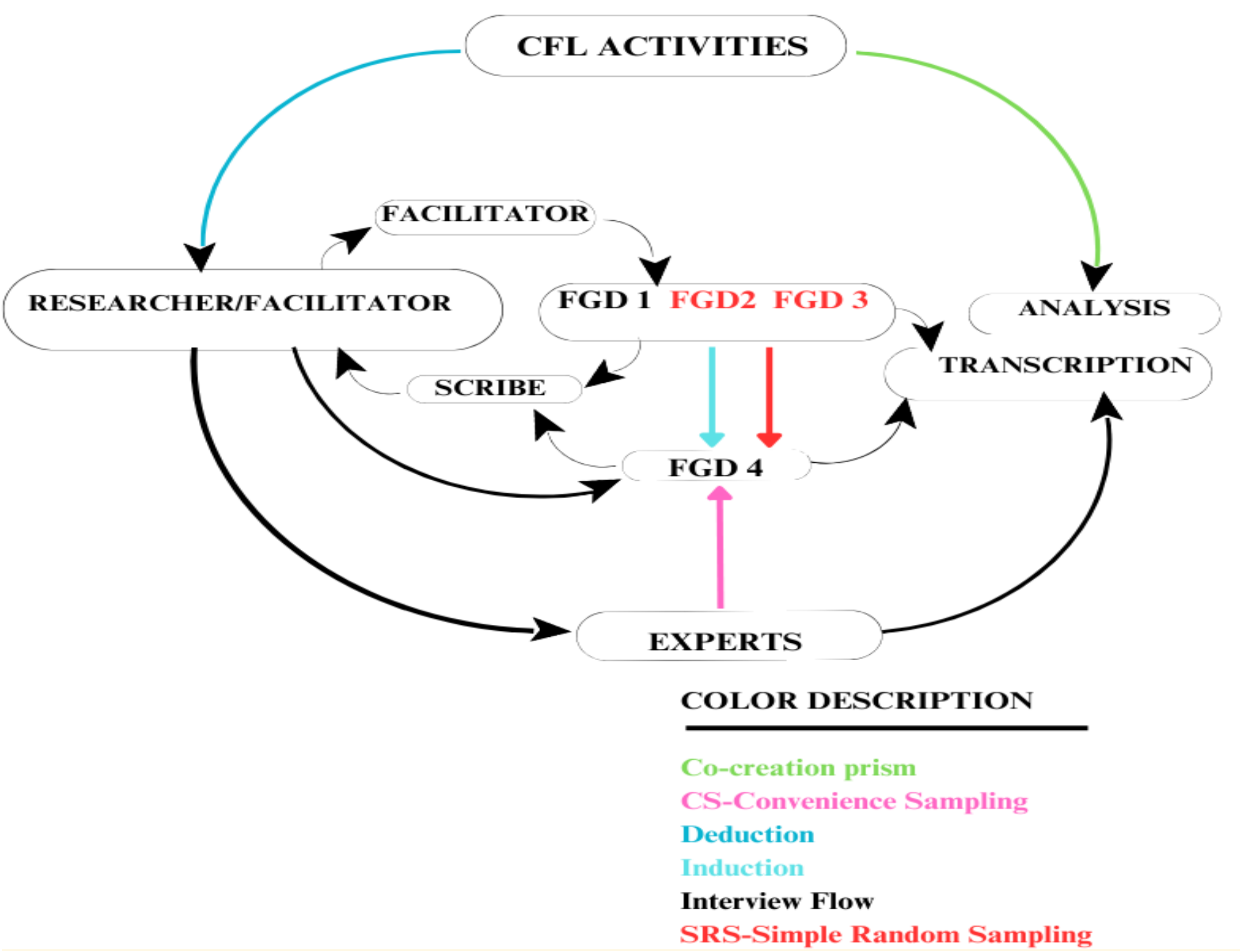
Each FGD started on time and began with the scribe registering the participants in an attendance book. While the facilitator welcomed the participants, I took charge of the set-up: organizing seating arrangements in a semi-circle to facilitate interaction between participants and positioning the flip charts so that everyone could see them. After a brief introduction of everyone present, the facilitator explained in Sérère (local language), the NUTRiGREEN project and its purpose, the current study's research themes, the purpose of the group discussions and its relevance to the farmers and the partners. The next step was for the facilitator to read the consent form in the local language to the farmers to confirm their participation and signatures, followed by discussing the agenda for the day. While the FGD 1 centered on agrometeorological learning and the use of local knowledge as the themes for the group discussions, FGD 2 and FGD 3 focused on agroecology and the use of local knowledge as themes for the group discussions. FGD 4 however, combined all three (3) themes i.e., agrometeorological learning, agroecology, and the use of local knowledge as themes for the stakeholder dialogue. FGD 1, FGD 2, and FGD 3 were each divided into two sessions. The first session was aimed at getting participants to freely list their experiences about the respective themes, which included feedback from previous training, issues that needed intervention, and solutions to each problem. Free listing is a fun-oriented activity that allows participants to share experiences and ideas while the facilitator records them on a flip chart (Colucci, 2007).The second session of the FGD, involved the second phase of agrometeorological training, which aimed to transfer knowledge to agrometeorological data collectors on how to read and interpret the graphs, so that they could disseminate the knowledge to the women's farmer groups. For FGD 1, this meant the training of all data collectors by the facilitator and myself (observer). For FGD 2 and FGD 3, this meant the training of women farmer groups by the agrometeorological data collectors. Feedback was sought after each training session and noted in the field notes. At the end of each FGD, the management team (i.e., the facilitator, the scribe and myself) met to discuss the day's activities in French about the points raised during the FGDs and these discussions were recorded on the smartphone audio-recorder. All the points listed by the facilitator during the FGDs' first session together with the audio-recordings from the management team discussions were analyzed and compiled in flip charts that served as agenda for the FGD 4 stakeholder dialogue.

2.8. Co-creating in FGD

During the FGD 4, participants were divided into three (3) subgroups of three (3) participants each. Each subgroup consisted of a mixture of experts and farmers. The aim was to create a scene for a fun debate against each subgroup who were tasked to propose their ideal and sustainable solutions to the problems raised during the previous FGDs. Each group had the chance to present their preferred solution to each problem listed on the flip chart, and after presenting, the other groups rated their solutions on a scale of one (1) to Five (5). The rating scale was presented as part of the opening introduction. One (1) being the lowest score and Five (5) being the highest score. If a group was rated with a score of three (3) as an example, the group that did that rating would justify why they rated at this score, and the group that presented had the chance to defend their stand. The scores from each group were summed up in the end and the group with the highest point won the debate. The rating scale as an approach to data collection was also inspired by Colucci who emphasizes that the rating scale is not to achieve statistical precision but to encourage discussion, get participants to think, and to identify which point needs to be discussed in more detail (Colucci, 2007). Additionally, in reporting activities that employ the rating scale approach, emphasis is placed on the resulting discussions between participants and not on the average scores (Colucci, 2007). Since most participants in the stakeholder dialogue were French speakers, the managing team's roles changed, I (researcher) facilitated the FGD 4, and the other team members managed the translation to the non-French speakers. The results of the FGD 4 were presented to the partners involved in the CFL activities as recommendations for action. Figure 6 shows a self-illustrated conceptual model for field data collection in Senegal.

Figure 6: Conceptual model for field data collection

Model created by LITTLE-TETTEH, B. 2023.



2.9. Analyzing data

Data collected from the fieldwork in Senegal were in audio formats and in field notes. For data security reasons, the audio recordings were uploaded to personalized Google Drive folders that only I could access. The archived data was transcribed using Whisper Transcription (a free transcription application available on Apple MacBook). The transcribed data was checked for possible errors by re-listening to the audio files and ensuring that the transcriptions matched the audio recordings. The qualitative analysis software MAXQDA was used for the analysis of the transcripts based on the themes derived from the CFL activities. From the eight lenses of the co-creation prism, codes and sub-codes were defined. The main codes represent each lens of the prism, and their sub-codes were defined from the different stages of the co-creation lenses (Bremer et al., 2019) that corresponds to each lens of the prism as shown in **Table 1** i.e., understanding context and co-design, process of co-creation climate services and co-disseminating and co-evaluating. Memos were defined for each code and sub-codes to indicate what each code meant to facilitate easy identification when marking the transcribed documents. The texts in the transcribed documents were analyzed manually in a systematic manner and colors corresponding to each lens were assigned to texts which formed coded segments. The codes were organized in the same way they are to be presented in the results, starting with the constitutive lens, moving clockwise through the co-creation prism, and ending with the extended science lens. Each coded segment of the transcribed document was grouped according to its corresponding themes and summaries were created using the summary grids in MAXQDA. The summaries were presented in summary tables and examined based on the themes and groups that formed the coded segments. This approach made it easy to compare the summaries from the transcribed documents. The results from the analysis are presented in the next chapter of this study.

In this chapter, the process of collecting both primary and secondary data is explained along with description of the study area, the research design, the ethical consideration in data collection and the analysis of the data. The next chapter introduces the findings of the based on the themes derived from the CFL activities of the NUTRiGREEN project using the co-creation prism.

3. RESULTS

Finding project partners with the same interests for a time-limited project cannot be left to chance. Therefore, existing networks and their links with local farmers were used to select partners for the NUTRiGREEN project. As briefly outlined in the background of this study, the WPs were designed to achieve each NUTRiGREEN project objective and milestones were set to measure success. Each WP was managed by at least one (1) European partner and one (1) African partner, and the mode of communication was mainly English and French. In total, six (6) work packages were designed and the CFL activities described falls under the WP 3. The partners managing the CFL activities in Senegal are therefore SLE, UCAD, and APAF and they all have complementary skills in agroecology, capacity building, research, and the PAR approach. With local partners at the forefront of the field activities, they work with local farmers to co-create sustainable solutions to rural agricultural challenges. This chapter presents the findings from combining all the primary data (expert interviews and FGDs) collected during the fieldwork and uses the co-creation prism to thematically analyze the elements of CFL activities.

3.1 Constitutive

Agrometeorological learning in CFS

Agrometeorological learning was introduced in Senegal as a field activity in the two project sites during the first meeting and community outreach. An APAF field officer (CTA) volunteered to supervise this activity. The CTA's role in this context is to act as an intermediary user of climate information, linking the technical producers of climate information (APAF employee and a working student from SLE) with the end-users (farmers). Having received training in French from SLE on how to read and record temperatures on a thermometer and measurements on a rain gauge, the CTA was tasked with training the farmers in the same skills. Farmers were selected on a voluntary basis to participate in data collection training, based on requirements set by SLE, such as basic literacy and a commitment to make daily records. A total of six (6) data collectors were selected, two (2) men from Nobandam and four (4) women from Diofior. Each data collector was given a booklet to record maximum and minimum temperatures, rainfall, and their respective units of measurement. As part of the normal routine, the CTA visits the two sites and photographs the data collectors' booklets. These photos are transferred to the technical team, firstly to the APAF employee for entry into a pre-structured Excel spreadsheet, and then to the student at SLE for data analysis and interpretation. However, since the start of the activity, the role for analyzing the weather data has alternated between the APAF employee and the SLE working student. The most used communication channels include phone calls, emails, WhatsApp and Zoom video calls for both document exchanges and meetings. These exchanges between the CTA and the technical team, although not regular, are often mainly to ensure the plausibility of the data, e.g., to checking for outliers and gaps in the data, challenges encountered by data collectors, and to share the possible interpretations as final products in the form of reports. The final products are graphical representations of average maximum and minimum temperature and rainfall (daily and monthly), meant to inform farmers about their seasonal activities.

Agroecological learning in CFS

Before APAF starts working with women farmers in a village, the CTA goes to the potential village to carry out prospecting exercises. Since in Senegal women have rights to access communal land, but lack the resources needed to develop it, the CTA visits the village chief or the commune on their behalf to seek communal land. Usually these are men who wish to support the women by giving them a hectare of land in the village to farm. In some cases, the women have an organized group and have negotiated land, but lack the resources, so APAF provides support in this area as well. Meetings, awareness-raising sessions, and project presentations are carried out by project partners once in the village. During this meeting, the women who wish to be beneficiaries of the project form the '*Comité Villageois d'Agroforesterie*' (CVA) and are delegated to select other interested candidates. This approach creates a strong group cohesion, as observed during my fieldwork. For a hectare of land, a maximum of 50 women farmers can work on it. The selected women farmers create the '*Groupement d'interêt Économique*' (GE) or the *Groupement de Promotion Féminine* (GPF), and APAF assists in the preparation of documents and the land negotiations through the commune. The GE or GPF must meet certain criteria for APAF to work with them and must follow a pre-defined internal regulation. The NUTRiGREEN project only works with the GPF in Nobandam and Diofior. The meeting also allows the women's group to choose which crops to grow. Crop selection was carried out through a survey study conducted by UCAD students trained in field data collection to understand the local needs of the farmers. Practical trials of the selected crops in CFS were organized in the plots or parcels by the UCAD masters students involved in these surveys and the goal was to exchange knowledge between local farmers and university students. This knowledge exchange helped the UCAD students on the one hand to conduct fieldwork for their master's thesis while gaining new knowledge, and the local farmers on the other to gain scientific knowledge to complement their local knowledge. The results of these field experiments involving the students and local farmers are shared with the project partners and the women farmer groups for integration into their farming systems.

Local knowledge in CFS

When selecting women to form GPFs, the CVAs are encouraged to select women from different village clusters and households to have a wider impact on the whole community. Before an activity is introduced to the GPF, a baseline study is conducted to understand the needs of the group and eventually an endline study to assess what the group has achieved from the project. The GPFs undergo a series of sensitization sessions at the beginning and during the project, covering topics such as desertification, deforestation, soil health, climate change etc. The awareness-raising sessions also introduce agroecological practices and agroforestry and its benefits to the community. These sessions emphasize the value of local knowledge and the aim to promote not only traditional crops but also those that have a nutritional and commercial value for farmers. The GPF from each project site makes a list of crops they wish to focus on, and with scientific experts, the crops are narrowed down and validated based on their adaptive capacity to the environment and the season. The GPFs also decide on their working methods e.g., whether to work the plots collectively or to divide the one (1) hectare into sub-plots managed by sub-groups. The two project sites of the NUTRiGREEN project use different working methods i.e., in Diofior the GPF work collectively and in Nobandam the GPF work in sub-groups. Whatever the working method, the UCAD students are urged to follow the organizational setup of the GPF and are allocated an experimental plot for field research. Parcels are normally planned and designed by the CTA in collaboration with the members of the GPF. Agroecological practices are not a new approach to farming for the women, but the conventional farming system is still the dominant trend in the two communities. The NUTRiGREEN partners therefore support the agroecological transition by integrating of beneficial tree species into the farming systems of the rural communities.

3.2. Interactional

Agrometeorological learning in CFS

Out of all the partners in the project, APAF's CTAs have the closest relationship with the GPFs. They facilitate meetings, organize training sessions and relay relevant information in both direction to the management team and to the GPFs. Weather data has been structured so that it is collected daily by the data collectors and transmitted monthly by the CTA during routine visits if everything goes as planned. Otherwise, it could happen that the data transfer is delayed for two (2) or three months (3). The exchanges between the CTA and the agrometeorological data analysts are aimed to address some of these challenges. In Senegal, the initial training for the agrometeorological data collectors focused only on the collection of weather data, which was to be followed by another session on the visualization and interpretation of weather graphs for decision-making. Thus, communication regarding agrometeorological activities is centered on data collection and ensuring that it is being done correctly. In an instance where the maximum temperature is lower than the minimum temperature or there are some gaps in the transferred data. The SLE analyst communicates with the APAF employee who feeds the data in the Excel spreadsheet, who then communicates with the CTA to understand and, if possible, correct the problem. Rarely has the SLE analyst had contact with or been introduced to the CTA, and very occasionally the

APAF data entry officer has contacted the farmer data collectors directly. There have been some exchanges between UCAD and SLE regarding agrometeorological activities, the most recent being on scale calibrations which was meant to provide more information on weather data analysis that could be relevant to the farmers' decision-making.

Agroecological learning in CFS

In addition to the support GPFs receive from APAF and its partners on agroecological and agroforestry practices, they also foster the organizational dynamics of women in their fieldwork. For this reason, APAF has established four criteria and internal rules for the selection of potential villages and for the GPFs to follow. These four criteria are 1. The farmers must own the piece of land. 2. The parcels must be enclosed to keep animals out and to protect the trees that will be planted. 3. The parcels should be close to a water source to ensure irrigation and planting during the dry season. 4. The farmers must accept the technical advice given by the CTAs. These requirements are mandatory if farmers wish to receive APAF's support. However, as indicated above, APAF can only assist motivated groups of women to secure land and documentation if the other conditions are met. The internal rules, which consist of five (5) main points are meant for field operations to ensure farmers' commitment. These points are 1. Adherence to work schedules and time limits. 2. The prohibitions of the use of agrochemicals 3. The obligation to be present during farming activities and meetings 4. The organizations of the perimeter 5. Water management on parcels. The UCAD students working with the GPFs are not obliged to follow the internal rules, but they are encouraged to do so, and they must follow and plan around the various divisions of the parcels and organizations of the GPFs. Their respective research topics are conducted on the crops selected by the GPFs and are supervised by researchers of UCAD. The partners design the training curriculum and content for the young academics and the co-research farmers to measure vegetative and generative growth parameters of plants and identify plant needs related to the agroecological system. Various field experiments are carried out on the use of organic fertilizers and materials that are accessible and easy to prepare by the GPFs and measured against the growth parameters. Young academics will learn from the GPFs and their field, and the GPFs will learn basic scientific skills from the students.

Local knowledge in CFS

The GPFs have the autonomy to self-organize. Each GPF is led by a group executive committee made up of women who are part of the group. There is a president and a vice-president, a secretary, a treasurer/accountant, and an auditor, and these positions are often nominated by other members of the group or elected if there's more than one candidate interested in a position. The president and the vice-president are responsible for the internal structure of the group and its welfare e.g., they organize watering schedules for the women, managing conflicts, they pre-set sowing and harvest dates etc. The secretary is responsible for keeping track of women attendance and stocking of materials and inputs. She's the one who keeps the production sheet and translates it for the others. The treasurer and the auditor work together. The treasurer manages the cash inflow and outflow and keeps the cash register, while the auditor gives approvals e.g., women who are fined for non-complicate of the internal rules pay to the treasurer which is kept in the cash register. These accumulated funds are used to purchase necessities such as materials or seeds when they are in short supply. Anyone in the group can hold any of these positions, except for the secretary and treasurer positions, which require some basic literacy skills. The group's executive committee works very closely with the CTA, who ensure that this governance system is maintained. In terms of the field experiments, the daily activities for the women are organized by the UCAD students and the group's executive committee.

3.3. Institutional

Agrometeorological learning in CFS

SLE has four main areas of activity: studies, training, research, and advisory services and has worked for many years in many Asian, African, and Latin American countries on a wide range of topics related to sustainable food systems, healthy nutrition, and climate change adaptation. They see climate change as an additional challenge to local agricultural systems and integrate this into their strategy, along with the promotion of agroecological practices to ensure resilience in rural areas. The setup for agrometeorological learning is therefore meant to encourage dialogue and problem solving on issues that local farmers have, such as when does the rainy season starts, when to start planting after the first rain, how to identify heavy rainfall and dry spells etc., to complement the local knowledge that farmers have. Through CFS, local farmers can exchange knowledge and learn new methods of adaptation. The weather data collected by the farmers themselves and the conclusions that can be drawn from the weather graphs answer these questions, and through interaction with the farmers and stakeholders involved, further questions and answers can be derived that can be essential to the farmers' decision-making. The role of the CTA is to facilitate these dialogues and report back as already mentioned above. However, the UCAD students are not directly involved in this learning approach, nor are they involved in any of the data collection and interpretation processes, although their tutors are involved to some extent.

Agroecological learning in CFS

UCAD has three main areas of activity: training, research, and community service. They have a moral obligation to be involved in projects or programs that support local development, and this is done through researchers and students working on projects such as the NUTRiGREEN project or the Great Green Wall project, which aims to combat land degradation and deforestation in the Sahel region. They produce a workforce that is qualified to take on these pressing challenges and engage in local and international partnerships with stakeholders such as SLE and NGO's such as APAF. In practice, they carry out surveys to identify the needs of the local population and design an approach to meet them. In the two project sites of the NUTRiGREEN project preliminary studies have been carried through household surveys and the evaluation of farmers' perception and knowledge on agroecology and climate change. In Nobandam for example, through the survey, several traditional crop species were identified that had high nutritional qualities and were adaptable to the local climate. Upon careful consultation with the GPFs, the partners discovered that the farmers were more interested in these four (4) crops for their market garden: Okra (*Abelmoschus esculentus*), Baobab (*Adansonia digitata*), Moringa (*Moringa oleifera*) and Hibiscus (*Hibiscus sabdariffa)* because the crops had commercial value and their leaves were frequently consumed by households as an accompaniment to couscous. Diofior settled with a different and a wider range of traditional crop species but followed the same process. It was also discovered that the GPF in Nobandam were more interested in the use of horse manure as compared to cow manure because these were animals that were common in the village. These propositions were integrated in the design of the field experiment carried out by the UCAD students and the co-research farmers.

Local knowledge in CFS

APAF's main activities are the conception and design of parcels to accommodate trees with fertilizing properties, and the provision of technical advisory services on the management of these trees in market gardens. They have several years of experience working with farmers in Senegal to establish community gardens (GE) and women-only market gardens (GPF). They make use of several tree species such as *Senegalia mellifera* as hedgerow for protecting parcels, *Senna siamea* as a windbreaker to reduce wind and soil erosion, *Albiza lebbeck* for fodder, wood and for fixing soil nutrients etc. The NGO relies on research to make tree selection adaptable to the local context and use field experiments to demonstrate and confirm the effectiveness of one method or another. If the CTA discovers a practice that is common in a particular village while prospecting potential villages, the information is passed on to the technical management team and, after careful consideration, the practice is incorporated into their intervention. Local farmers have years of experience observing natural phenomena in their community, such as watching the baobab tree blossom as a sign of the start of the rainy season, and several other techniques in managing pest and diseases in their farming systems even though they might not have scientific arguments to back them. This form of knowledge system is encouraged by the NUTRiGREEN partners and complemented with scientific knowledge through field trials and experiments.

3.4. Joint services

Agrometeorological learning in CFS

Farmer data collectors were trained to record the measurements from the weather instruments given to them. There have been cases where data were incomplete for a particular period or where errors have been identified. These errors are often spotted when data is being analyzed by the technical team, especially when the maximum temperature of the day is lower than the minimum temperature, or if there are any outliers. When the data collectors are asked about these issues, their responses often are “I wrote down what I saw”. The data collectors are advised to call the CTA to report instrument malfunctions or any doubts they may have in carrying out their duties, which should then be passed on to the management team, yet the challenge persists. To address some of these challenges, APAF has established a relationship with ANACIM who have already provided the NGO with some additional rain gauges and promised follow-up training for local farmers. ANACIM highlighted some of the challenges they have in disseminating climate information, such as upscaling, providing a more precise weather forecast to a wider population in remote villages, and getting the local communities to trust the weather forecast and its relevance in decision-making. However, local farmers using sophisticated weather instruments to collect data was not an appropriate approach for ANACIM, although they confirm the relevance of the rain gauges given to farmers to inform them when to start planting after receiving about 15 mm of rain. According to ANACIM, it is the end products of the weather that are useful to the local farmers for decision-making, rather than understanding the processes and technicalities of generating climate information.

Agroecological learning in CFS

Agroecological learning activities carried out in the CFS are usually discussed between the partners who agree on how and when they will be implemented. The local partners, who are closer to the GPFs, are expected to take the lead in organizing of these activities, while the project manager from SLE carries out regular follow-up to ensure the timeline and project objectives are being met. Whiles some milestones in agroecological learning have been reached, others have been delayed. The local partners associated these challenges with the difficulties of working in the terrain, which brings farming activities to a halt. While efforts are being made to resolve these challenges on the ground, communication between local and international partners about them remains scant resulting in uncertainties in the achievement of certain objectives. The NUTRiGREEN project runs simultaneously in Burkina Faso but the cross-collaboration of partners within the project was not explored further.

3.5. Empowerment

Agrometeorological learning in CFS

Training on agrometeorological data collection and analysis is provided not only to the CTA and the data collectors, but also to the analyst. Data analysis and interpretation training is provided to the data analysis technical team. The partners also share opportunities with each other, such as international conferences and calls for proposals, to improve their capacity to support more farmers in rural areas. Some milestones on agrometeorology learning were highlighted, e.g., farmer data collectors are now familiar with the weather instruments and have a sense of what the numbers mean and the respective units of measurement, but as the interpretation and use of the end products of weather information is what is needed for decision-making, this leaves the accomplishment incomplete. In Senegal, there had been no discussion or training on how to interpret or use of climate and weather information until I arrived at the two project sites, and that's when the discussions were held. In addition to the milestones, a new relationship has been forged between APAF and ANACIM because of the introduction of agrometeorological learning in CFS. APAF found the training enriching for their employees and acknowledged that the credibility of their organization has been enhanced by the introduction of this form of learning for farmers. Training the data collectors in this new form of knowledge, in addition to what they already knew, was also seen as an added benefit not only for the women's groups, but also for other household members and the community. The data collectors expressed that being involved in the learning activity meant that they would be able to make their own decision regarding their farming activities.

Agroecological learning in CFS

The NUTRiGREEN project partners are determined to work with farmers on an egalitarian basis, where farmers can express their needs and collectively find sustainable solutions adapted to their local context. All training is coupled with practice. The dialogue between the holders of the two knowledge systems was described as unproblematic since most of the women already have some notion about certain agroecological practices. Some milestones highlighted were that through the NUTRiGREEN project, more than one hundred (100) women who make up the GPFs in the two project sites are being supported. The GPFs can now try to produce crops all year round. They have secured access to land and received material to assist them in their operations. They are being trained by APAF in group organization and farm management and have been able to grow crops to sell in the market. The sale of the farm produce supports each other and increases household income, so that the women are not entirely dependent on the men for their livelihood. The GPFs are the first to have access to the fresh vegetables of very good quality because they are organically produced which helps to improve their diet and nutritional needs. APAF employees also purchase produce from the GPFs for their own consumption. The partners' capacities are being strengthened and the UCAD students have gained new knowledge and exposure.

Local knowledge in CFS

At the end of each season, the GPF executive committee, together with the CTA, organize a meeting to plan the harvesting roles. The women are organized into those who harvest and those who take the produce to weekly markets in neighboring villages. Various reconciliations of cash inflows and outflows are made with the CTA, who also cross-checks with their accounting ledger. The GPFs divide the income equally among the members of the group, and a small percentage of the income goes into a fund to maintain the farm e.g., if there's no more money in the budget for the season, or if there's a shortage of materials such as seeds for planting, or for personal emergencies. Any member of the group can borrow from this fund in the event of an emergency and must repay the loan in due time. The CTA has also taken the lead in organizing farmer-to-farmer field visits. Newly formed GPFs are given the opportunity to visit older, active GPFs in their fields to engage in dialogue. The older group explain their practices, how their parcels used to be and how they have evolved over time.

3.6. Pedagogical

Agrometeorological learning in CFS

Agrometeorological learning was designed to take place in CFS, where groups of farmers, facilitators and scientists can discuss and find practical ways to integrate climate and weather knowledge into farm decision-making. Not all the farmer data collectors who attended the training were familiar with the use of weather instruments, particularly the thermometer, although some had already some notion on how to use rain gauges. During FGD 1, the farmer data collectors were asked for feedback on the first training they had received, and they mentioned that the training had enabled them to know the amount of rain per day, when it rains and how hot it is during the day. Others expressed satisfaction that they have acquired new knowledge and skills that other farmers do not have and are willing to share this knowledge with them. Some collectors reported difficulties in using the weather instruments particularly the thermometer, but said if there was a malfunction, they call the CTA to rectify it. When data analysts were asked about their perception of possible gaps in agrometeorological learning, they identified a lack of frequent communication and a lack of farmer inputs needed to enrich the interpretation of weather graphs. What was partially working was the unidirectional flow of information from data collection to analysis and interpretation, but the reverse flow was lacking. The farmer data collectors also identified a lack of top-down feedback on whether their efforts were good enough, which they considered was an important factor in their motivation.

Agroecological learning in CFS

Learning about agroecology and agroforestry takes place in the fields of the GPFs. The training starts with theoretical elements to introduce the topics and ends with practical work in the field. For instance, the CTA presents the steps involved in setting up a tree nursery, starting with preparing the soil, cleaning the plots, demarcating the plots etc., to give the farmers an idea of what to expect in practice. Several topics have been covered using this approach such as tree nursery management, soil and water management, market gardening nurseries, training on biopesticides etc. The GPFs were also introduced to new measurement tools while conducting field trials with the UCAD students. The GPFs also share their knowledge with the UCAD students on how to prepare horse manure, how many days it takes to decompose, and the students test different doses of the organic manure and measure different plant growth parameters. The students showed the women group what a tape measure looked like and how to use it to measure the height of the plants as it geminated, calipers to measure the plant diameters and counted the leaves when different doses of organic manure were applied. When the students planned an activity, they did it with the GPFs, they informed the president of the GPFs and the CTA who then organized the women. They worked together in this fashion from land preparation to harvesting.

Local knowledge in CFS

The UCAD students share their experience of what they learned from the women group during their fieldwork. The students discovered some of the traditional techniques used by the GPFs such as mixing potions of Neem (*Azadirachta indica)* leaves with ash and spreading it on their parcels to control pests. Another practice that the GPFs commonly used in managing nematode invasion in soil was the rotation of crops and the planting of leguminous plants and this knowledge was shared with the students. The students were delighted with the welcome they received from the GPFs and the enthusiasm with which they learned and shared their parcels and stories about their village and way of life. The GPFs commented on the patience with which the students responded when they asked a question during their encounter with them. The GPFs highlighted that they learned how to keep an organized field notebook after working with the students. They developed new skills on how to use the tool they were introduced to measure the height of the plants as they germinate, calipers to measure the diameter of the plants, and how to count the leaves when different doses of organic manure were applied.

3.7. Interactive research

Agrometeorological learning in CFS

The research consortium of the NUTRiGREEN project was formed through a complex co-funding system. Various institutions from different countries were to forge alliances and respond to the FOSC-Eranet project call which aims to promote transnational collaboration that drives sustainable and climate-resilient food systems. Each member country then commits a certain amount of funds through its funding agency towards the implementation of the project, with European countries having slightly larger budgets than African countries. During the proposal phase of the project to obtain funding, not all the NUTRiGREEN partners were involved in the writing of the proposal. The bulk of the proposal writing was left in the hands of the European partners, and the African partners agreed to everything that was proposed. Whether the reason for non-participation is related to the differences in budget size or in the uncertainties of winning project calls is unknown, but what is known is the internal challenges this has created. Some local and international partners have requested for a re-plan of certain activities or have delayed certain activities and the local partners are uncertain about the end game of certain activities, particularly agrometeorological learning. There is a general lack of ownership of agrometeorological data collection and analysis by local partners, and a general difficulty for international partners to manage or supervise activities carried out with data collectors and farmer groups. For instance, it is not clear which of the local partners will take the lead in organizing meetings with the farmer groups to transfer and disseminate interpreted weather graphs. These challenges have delayed the training and the use of climate and weather information in decision-making.

Agroecological learning in CFS

The agroecological activities are somewhat different in terms of organization and involve different partner interactions in the management of the activities. However, there have been many delays in the implementation of certain field activities planned, such as training in composting, some of which have been related to difficulties in working in the terrain due to water shortages in the project sites caused by the pilferage of the solar panel water pump or the salinization of drilled water wells. Another challenge, perhaps the most significant, which has caused delays in the realization of some of these activities to fruition, has been the absence of the general project coordinator (European partner) since the beginning of the project and the lack of proactivity on the part of local partner institutions. One of the important objectives of the project was to study the value chain of the local food system, in particular the marketing of traditional crops and the strengthening of the producer-consumer link (part of the WP4) has not been carried out since it was introduced due to this absence. Consequently, the PhD students who were originally supposed to carry out these studies on the production of the GPFs have not had the opportunity to do so. Most of the participants interviewed for this study confirmed that the challenges in terms of group organization were at the managerial level and not at the farmer level, while at the farmer level the challenges were more economical, technical, and environmental.

Local knowledge in CFS

The challenges on the farmer level were environmental, technical, and financial, but primarily environmental and technical because the GPFs are transitioning from the dominant conventional farming system in their community to adopting agroecological and agroforestry practices. These socio-ecological changes required lots of capacity building and training on how farmers can sustainably manage a complex farming system. It is equally imperative that the transition is economically viable to sustain the GPFs field activities and generate income for their household. As already indicated above, efforts for capacity building and training are being organized in the two project sites, but in the absence of studies on the different outlets for marketing agricultural products, it is becoming challenging to convince the local farmers on the durability of an agroecological system. The parcels on which the GPFs in Nobandam carry out their farming activities were given to them by men who subdivided part of their land for farming. This group of men share land boundaries with the GPFs and continue to use the conventional system of farming i.e., the use of agrochemicals for plant treatment and the application of synthetic fertilizers. Although the women, understand the need to develop an agroecological system of farming and are committed to achieving their goals, there have been instances where they have been tempted to use the conventional farming methods on their fields, especially when they are being attacked by pest and insects fleeing from their neighbors' plots to their own. Water is very scarce in the two project sites, finding quality reproductive seeds for production, soil, pest, and disease infestations are together all the challenges that the GPFs face in their activities.

3.8. Extended science

Agrometeorological learning in CFS

The initial quality control of the weather data collected by the farmers is carried out by the CTA during the monthly visits. The CTA simply checks the values recorded in the farmer's notebook and makes sure that the numbers make sense. Further checks are made by the data entry officer and the analyst, and any outliers are discussed and reconciled. During the FGDs with the farmer data collectors, the participants identified some challenges in carrying out their duties, such as the malfunctioning of the thermometer caused by the mercury getting stuck in the tube, the absence of someone to cover for them when they must travel, or the breakage of the weather instruments. The farmer data collectors also expressed the need to have supplementary training on better practices in handling weather data. It remains unclear how the quality of the data generated during the project will be monitored and what measure will be taken to ensure efficient storage of the data after the project ends. The weather data are currently stored in a shared Google Drive, to which all the partners have access. This cloud storage also contains weather graphs derived from the data collection and reports from their interpretation.

Agroecological learning in CFS

The NUTRiGREEN project places great value on local traditions and knowledge. As one of the participants stated in their interview “the training and the approach we use is meant to pay tribute to the local knowledge”, which indicates the care and attention given to safeguarding the social dynamics of the communities. The partners are interested in the local practices, knowledge, and networks, and strive to preserve them. For example, the UCAD students who worked with the GPFs on field experiments are trained before going into the field on how to present themselves to the women’s groups and how to behave in the event of a stressful situation during the fieldwork. The GPFs are encouraged to ask multiple questions if they have difficulty understanding a technique or using a tool. The partners therefore agree that all the efforts made by each participating member are intended to enrich both knowledge systems (scientific and local) and to enable farmers to try out new agroecological practices and experiments based on their own research questions. The project partners are discussing the extension of research to explore additional alternative local seeds that are adapted to the local climate and the other challenges raised by the GPFs.

4. DISCUSSIONS

In this chapter, the discussion begins by restating the main findings from the analysis of the data collected during the fieldwork in Senegal. The results are then compared with the state of the art literature review for this study to show similarities and differences and how the results fit into the PAR approach. Differences between the literature and the results obtained are explained with reasons why they may have occurred. The results are then interpreted to answer the research questions, confirming, or refuting the hypothesis, and finally the limitations of this study are addressed.

4.1. Agrometeorological learning in CFS

Six (6) farmers were selected on a voluntary basis and given weather instruments to assist with data collection, with the CTA visiting monthly to take photographs of data and forwarding them to the technical team for analysis. The data collection process thus starts from the data collectors to the CTA to the data entry officer to the data analyst. The technical team communicates identified errors, discusses farmer input or final reports back to the CTA. In Senegal, however, the data collectors only received initial training on weather data collection, so most of the communication was about challenges. Communication was not cross-cutting, it was mainly from the data analyst to the data entry officer to the CTA, with rare cross-interactions. Agrometeorological learning was set up by the project partners to raise farmers' awareness on climate related issues and to deliver tailor-made weather information to complement their local knowledge. Challenges have been known to persist in data collection and in efforts to resolve them, has led APAF to establish a relationship with ANACIM. ANACIM forms part of a wide network of actors who operate on international, national, and local level to deliver climate services to various sectors and agencies in Senegal. They identified upscaling of climate information and gaining farmers' trust on weather forecasts as some of their major challenges in rural areas. Local farmers in Senegal are now familiar with weather instruments and their units of measurements but lacked knowledge of how to use the information for decision-making. Data collectors gained new knowledge and skills about the weather through their involvement in agrometeorological learning. Although data was being collected and transferred through structured channels, the flow of information was one-sided and some of the gaps identified were linked to lack of frequent communication and the lack of feedback loops to incite farmers' input. The partners' commitment to agrometeorological learning was uneven and this has had impact on certain aspects of the learning activities. This partial commitment of local partners was traced back to the very inception of the project and the disengagement of the project lead. Agrometeorological learning is considered a separate activity from agroecological learning in CFS even though the partners involved in both activities are the same. The quality of the data collected by farmers goes through checks and verifications on different levels, but the challenges associated with the data collection raises questions on the legitimacy of the data for decision-making.

4.2. Agroecological learning in CFS

Although women in Senegal have the right to use communal land, they have lacked the necessary resources to develop it, but paradigms are shifting. Women interested in agroecological farming form groups and receive support from international and local partners through APAF. The women are given one hectare of land to start their activities and are given pre-defined rules to follow. Farmers are given the liberty to choose which crops to grow and which experiments to carry out through preliminary surveys. The farmers are introduced to new tools and work together with young scientists in field trials. The rules are meant for land preservation and to help the farmers in their group organizations. The students working with the farmers are not obligated to follow the rules but follow the structural organizations of the women group. Together, the farmers and the students carry out field trails and exchange knowledge. Farmers are encouraged in many ways to express their needs and no challenges were identified in the dialogue between farmers and students. Through the NUTRiGREEN project, several women have gained access to land, have a source of income, and eat healthy foods. Agroecological learning takes place on the farmer’s field and starts with theories, continues with practice, and covers a range of topics. Several challenges were identified and can also be associated with the engagement of some partners to follow through with some activities. The partners value the knowledge and traditions of the communities they operate in. They safeguard social norms and networks and aim to enrich them with scientific knowledge and skills.

4.3. Local knowledge in CFS

The creation of the women groups is done by the women themselves and are autonomous in group organization and choosing methods for working. The women group is run by an executive committee, all of whom have different roles and functions. They coordinate field activities and work closely with the CTA. The local knowledge of the farmers is mostly gained through years of experience and this knowledge system is considered in partners’ intervention strategies. Income generated from harvest is distributed equally among the women and a small fraction of it goes into the common fund to maintain farming activities. Farmers also visit each other's farms and share knowledge amongst themselves. University students carrying out field trials with farmers also share knowledge with and learn from farmers. The challenges affecting the farming operations are mainly water scarcity, pest and disease management, difficulties in selling farm produce and even though the women group recognized the benefits of agroecology, if these challenges persist, there is the tendency of women falling back to the conventional system of farming.

4.4. Comparing results with state of the art

The outcomes of this study show that for women to be able to access land to farm, there need to be men who agree to provide that land. The finding is in line with previous studies that describes this customary system whereby land in Senegal's rural communities is collectively owned by the family or village and managed by the head of the unit (village chief), basically a man, in consultation with an all-male assembly (Santpoort et al., 2021). In practice, village chiefs have right to participate in land deliberations organized by the local government but have no official role in these deliberations, yet the village chief continue to informally distribute parcels of land within villages (Wilfahrt, 2023). The women are silenced when land issues are discussed and only have access to land through a father, husband or son and lose this access if single, divorced, or widowed (Santpoort et al., 2021). This finding supports argument that traditional land tenure systems in West Africa favor male over female farmers, thus limiting women's decision-making power (Rhodes et al., 2014). The NUTRiGREEN project is therefore challenging these narratives by helping women secure land for farming and giving them a seat at the decision-making table. Researchers described water scarcity as a daily reality for local farmers in rural West Africa (Sanoussi et al., 2015) (Callo-Concha, 2018) (Alvar-Beltrán et al., 2020), a similarity observed in the two project sites of the NUTRiGREEN project. The intervention strategies of the NUTRiGREEN project partners to tackle climate change, food insecurity and healthy nutrition are to build resilience in farming systems through agrometeorological and agroecological principles and evidence-based practices. The survey for understanding farmers' needs and crop choices is the first step to merging scientific and local knowledge. These strategies, with the added element of involving local farmers in decision-making, are consistent with the coping mechanism of farmers in West Africa (Sanoussi et al., 2015) (Callo-Concha, 2018) (Alvar-Beltrán et al., 2020).

The uncertainties of weather information and the way it is communicated by providers were highlighted (WMO, 2011), and this challenge is evident in the agrometeorological learning process in CFS. In the agrometeorological learning activities of the NUTRiGREEN project, the uncertainties in reliable data and the checks associated with data collection, processing, dissemination and storage reveals the importance of extending ethics to climate services, for promoting responsible production and use (Bremer et al., 2019). Enhancing capacity building and close partnerships in the development of climate information can be useful for decision-making (WMO, 2011), and these are in line with the principles of the NUTRiGREEN project, however additional efforts are needed in procedural capacities, strengthening partner engagement, and nurturing new relationships. In the CFS of the NUTRiGREEN project, evidence of interaction between the group, the facilitator, the field, and the curriculum can be observed in a participatory learning and exchange approach (Braun and Duveskog, 2011). These exchanges and learning are more present in agroecological learning in CFS than in agrometeorological learning in CFS. In practice, the two CFL activities in Senegal do not overlap, although the partners and the actors involved in the activities are the same. There was a lack of knowledge sharing and feedback for agrometeorological learning in CFS, and there was no sharing or exchange between the CTA or data collectors with the GPFs. Farmers participation in agrometeorological learning in CFS was therefore in line with crowdsourcing or crowd science (Coeugnet et al., 2023) where farmers are tasked with weather data collection but not yet involved in the formulating of their research questions. However, in the agroecological learning in CFS, the groups of women work with academic actors and a field agent in defining common research questions, which makes it adopt the form of participatory research or participatory science (Coeugnet et al., 2023). This first part of the discussion therefore shows how CFL activities are improving the adaptive capacity of local farmers in Senegal and goes to answer the research question one (1) **Q 1**. The implementation of CFL activities in CFS therefore adds to the existing knowledge of the PAR approach which seeks to integrate views of non-academic actors into research design and lead to action.

4.5. Discussing the implication of the findings

During the interview with one of the ANACIM experts, this question was asked **Q:** What role do you think citizen science can play in agrometeorological data collection and analysis? Should local farmers be involved in the data collection and interpretation process? **R:** "You must separate the data from the products. The farmers can collect data, but it's not going to be a great service to them if they cannot use that information. They can collect data to get an idea of rainfall. But us we can use the data to produce useful information. The local farmer may not have the science tools to collect data, analyze and have many end products. Maybe if it rains in his locality, it's good. In the past, we've had to do capacity-building science to enable farmers to use rainfall. Because it allows them, in relation to local science, for example, local knowledge, when there is useful rain. In other words, the most useful amount of the rain that can make the groundnuts germinate. Now, we're at the beginning of the season, you need a certain amount of rain to go and do the sowing. So, it's beneficial to give them rain gauges for measuring rainfall. Because when they have 15 mm, we say when you have 15 mm of rain you can go to plant, and we do a lot of these capacity building during the raining season in rural communities. Only in this case is it useful for farmers". These sentiments were expressed differently by the farmer data collectors during in FGD 1, when they described the relevance of the training they had received for weather data collection.

During FGD 1, the data collectors were asked about their motivations for continuing to collect weather data, and the participating farmers gave their responses. One farmer data collector confessed that after the first rain he dug a hole in the ground the length of his fingertip to his wrist to check if the soil was wet enough before planting. This practice was sometimes misleading, but now with the weather instruments he can easily tell how many millimeters of rainfall he needs before planting and having this knowledge about the weather is what keeps him interested in collecting the weather data. Another collector shared with the group that she realized the benefits of acquiring this knowledge about the weather when it was introduced to her in the training and made a commitment to collect the weather data. She emphasized that due to this commitment, she has more understanding of what is being said about the weather when she listens to the radio and that even without the NUTRiGREEN project, she will continue with the activity because she knows how this information can serve her to make decisions about her farming activities. Nobandam's data collectors expressed that renumeration was an important source of motivation, whereas Diofior's data collectors expressed the opposite. For the collectors in Diofior their motivation was the knowledge gained from the agrometeorological learning, rather than any financial benefit. The group collectively emphasized that the weather graph generated through their activities should be transferred back quarterly for them to discuss how it can be applied in their farming activities.

The responses of the meteorological agent at ANACIM and that of the farmer data collectors reveal insights about the role citizen science plays in bridging technicalities gaps about climate and weather information. While the end products of weather and climate information products are indeed useful for farmers decision-making as expressed by the meteorological agent at ANACIM, the agrometeorological learning of the NUTRiGREEN project allows the farmers to understand what the numbers and units of measurement mean and how they can generate their own questions and solutions in relation to their farming activities. The farmer data collectors can now relate the knowledge they have acquired through agrometeorological learning to the weather and climate information produced by ANACIM, and to what is being said on the radio and other information channels. The responses of the data collectors also suggest a willingness to continue the activity if the support is available and an openness to receive and scale up further training. Therefore, the errors and gaps identified in the weather data could be rectified with a reconfiguration of the process flows and an update training.

The weather data analyst was asked **Q:** What do you think is working well in the agrometeorological learning activities and what do you think could be improved? The response was **R:** "I think what works is this, the fact that this involves different stakeholders, what works is getting the data and what works is the farmers experimenting with the thermometer and the rain gauges, what works is this one way until the analysis and interpretation. What is more needed is the transfer back. Definitely! So even though this doesn't mean that there aren't challenges in collecting the data, we have missing data, we have challenges in that, but I think those can only be addressed if there is this communication back." Building on already existing communication channels with the aim of close dialogue with the GPFs seem appropriate to ensure that the weather information is used effectively.

Agrometeorological learning in CFS turned out to be a separate activity from agroecological learning in CFS mainly because of the lack of ownership of partners at the local level. However, another reason proves this point. The weather data collectors are not all members of the GPFs. In Diofior, agrometeorological data collectors are all women who are member of the GPF, but in Nobandam the collectors are men and therefore not members of the GPF. As the agrometeorological learning was designed to inform GPFs on how to gain new knowledge about the weather and how to link it to their farming system, the mixed gender arrangements could create constraints in the dissemination of climate information and disrupt the feedback flow from the women group. The fact that the men are not part of the GPFs means that they may not be aware of the pressing questions that the GPFs have that need to be answered, which is information also needed to enrich the interpretation of the data collected. The GPFs do not fully benefit from the knowledge acquired by the male data collectors unless deliberate attempts are made to organize the upscaling of information. Additionally, the findings of Schwartz 2022's master's thesis are relevant in explaining the economic mindset of the male agrometeorological data collectors. Schwartz states that while male farmers in the Fatick region favor incremental adaptation (maintaining the essence and integrity of a system at a given scale), the women farmers prefer transformative adaptation (systemic changes in anticipation of climate change by enforcing social inclusion in a social-ecological system) (Schwartz, 2022). These reasons may explain why male data collectors desire renumerations as compared to their female counterparts or why there has been no exchange of agrometeorological learning between farmer data collectors and the GPFs.

The findings from this study goes to disprove **H 1,** which states that the CFL activities of the NUTRiGREEN project are designed without the involvement of local farmers in the decision-making process, and their participation is through compliance with, and feedback on, predetermined rules. Although there are some predefined rules for farmers to follow in the NUTRiGREEN project, various evidence has been given through the results of this study which indicates farmers involvement in the decision-making process of the CFL activities. From the selection of the GPFs by the CVAs, the surveys and training, to the selection of crops and the field trials with university students, right down to the creation of the women's executive committee and the autonomy to self-organize are all proofs of their involvements. Even with the agrometeorological learning which is considered a separate activity in the CFL approach, still shows a blueprint of farmers involvement in the decision-making process and with little adjustments in the process flow and a rekindling partner engagement, full farmer involvement will be evident. The feedback sessions can be regular, and the initiative locally drawn to bridge the obvious gap in the lack of communication. Research question three (3) **Q 3:** Can the co-creation process involving local farmers and other stakeholders be institutionalized is answered through refuting **H 1**, due to all the evidence pointing to the existence of co-creation between farmers, scientist, and field officers. These interactions confirm that the process of non-academic actors and scientists' co-creation solutions to existing problems affecting farmers in rural areas has been institutionalized in the NUTRiGREEN project and the partners are aware of the benefits. Additionally, evidence of local farmers and multiple stakeholders working together to find adaptive solutions to climate change can be observed on the national level in Senegal through the MWGs approach by ANACIM confirming the institutionalization of the co-creation process.

The **H2,** which states that the transition from ordinary local farmers to co-research farmers requires an inevitable repetitive process of familiarizing stakeholders and farmers with different knowledge systems, remains true due to the lack of cross-cutting communication and feedback loops in the agrometeorological learning process. The agroecological learning in CFS presents a different picture as several interactions between different partners and the GPFs can be observed, however these interactions between scientist-non-scientist should be frequently organized and can be enhanced by the proactiveness of partners. Research question two (2) Q **2:** How can local rural farmers be better involved and help shape the mechanism for delivering climate services for effective adaptation is answered through the confirmation of **H 2**. Through iterative interactive dialogue between project partners and the GPFs, the challenges and milestones arising from the agrometeorological and agroecological learning could be revealed through feedback sessions. These dialogues should be initiated at first by project partners and could be restructured to encourage farmers to initiate them as non-academic actors and scientists familiarize themselves with the process and farmers gain deeper understanding of the purpose of the dialogue.

4.6. Lessons learned from using the co-creation prism

The co-creation prism used to assess the themes of the CFL activities provides an opportunity to suggest new stakeholders for the NUTRiGREEN project partners that would not have been apparent otherwise, as the focus for assessment was mainly on the NUTRiGREEN project partners. Since the prism is mainly for the evaluation of co-creation of climate services, it required a broader look at how climate services are governed, how they are being produced, the stakeholders involved and how they interact within a country. Through the literature review and the interview with the expert at ANACIM, public-private partnerships between stakeholders such as ANACIM, MyAgro, Jokalante, some insurance and communication companies in

Senegal who are involved in the production and dissemination of climate services were revealed. The joint services section of the prism was therefore an opportunity to assess whether these public-private partnerships were present in the assessment of the CFL activities especially in the production of climate information. The results show no evidence of such partnerships on climate services, apart from the initial step taken by APAF to engage ANACIM's services. However, some joint partnerships were briefly highlighted in the agroecological learning process, but the question was not explored further during the interview. The co-creation prism posed no huge challenges in its usage except in its application on the theme "local knowledge in CFS" where certain defined codes for analysis did not fit. There were also some overlapping contents in the use of the prism, but Bremer points out that these overlaps are to be expected and originate from the way Bremer and Meisch (2017) developed the eight lenses (Bremer et al., 2019).

4.7. Limitations of the study

The main limitation of this study lies in the research design. This study did not involve the participation of the stakeholders of the NUTRiGREEN project in the formulation of the research questions. The questions were neither that of the farmers nor were they collective questions of the partners involved. The lack of involvement of the stakeholders in the formulation of the research questions also meant that I took on the role of an "outsider researcher" who was investigating how co-creation and interaction between partners and local farmers took place in CFS without being directly involved in these activities. This outsider role may have influenced the participants' responses during the field data collection and thus the results. Therefore, the PAR approach is limited in this study especially in the literature review section. However, efforts were made to ensure that the methodological design was sufficiently participative and involved dialogue with all the stakeholders involved in the CFL activities in the Senegalese context (FGD 4). Additionally, the use of CS to recruit experts for FGD 4 may have introduced a degree of bias into the field data collection. Attempts to reduce this bias were made by sending emails with similar wording and structure to all partners involved in the CFL activities including local experts in Senegal, who took part in the interviews, inviting everyone to the attend the meeting and thus giving participants the choice of accepting or declining the invitation. These voluntary responses from participants introduced a degree of randomness in the selection of experts to participate in the FGD 4. The page limit of this master's thesis and the objectives of this study made it challenging to present the experiences of the second phase of the agrometeorological learning that took place in CFS with the FGD 1, FGD 2 and FGD 3. Nor is it possible to fully present the outcome of the FGD 4 and how it led to practical actions in this study. However, the solutions that emerged from the stakeholder dialogue were presented to the partners after the end of the FGD 4 and each partner were assigned a task that was meant to be implemented.

Several key issues can be identified in this chapter. These are highlighted in the final chapter and suggestions on how to address them are presented as conclusions and recommendations and outlook.

5. CONCLUSION

5.1. Concluding remarks

The purpose of this research study was to understand how multi-stakeholders' engagement and collaborations with local rural farmers in Senegal are contributing to making rural communities resilient against the threats of climate change and to reveal practical knowledge gaps in the CFL activities of the NUTRiGREEN project. The focus was on co-creation which is an approach adopted by the project to involve non-academic actors and scientists in a mutually beneficial sharing of knowledge. Qualitative research methods involving semi-structured interviews and FGDs are used to generate primary data and the co-creation prism is used to assess the CFL activities of the NUTRiGREEN project in two project sites in Senegal (West Africa). Based on this methodological design, it can be concluded firstly that the CFL activities of the NUTRiGREEN project improves the adaptive capacity of local farmers in Senegal through women empowerment, the processes of concertation, and evidence-based practices that encourage farmers to lead dialogues. Secondly, there is sparse evidence of farmer involvement in the design of climate services delivery mechanisms within the project. While structures are in place to incite farmers participation, tailoring procedural capacities in the agroecological learning process flow by making dialogue between local farmers and partners iterative can enhance their involvement in decision-making. Lastly, the interactions in the CFL activities, especially with the agroecological learning in CFS, confirm that process of non-academic actors and scientists co-creating solutions to existing problems affecting rural farmers have been institutionalized in the NUTRiGREEN project and that the partners are aware of the benefits. In addition, evidence of local farmers and multiple stakeholders working together to find adaptive solutions to climate change can be observed at local and national levels in Senegal through ANACIM's MWGs approach. This approach confirms the institutionalization of the co-creation process in climate services and can be coupled with citizen science practices. Citizen science therefore not only involves farmers in research, but also prepares them to make the connection between the end products of science and what they observe, learn, and try out in their fields. The results of this study indicate that the agrometeorological and agroecological learning in CFS are activities that do not overlap which creates gaps in the way in which knowledge is generated, shared, transferred, and stored. Communication in agrometeorological learning was rarely transversal and the flow was one-way. Partners' commitment to agrometeorological learning was imbalanced, affecting certain aspects of learning activities. Since the aim of this study was to understand how co-creation of knowledge took place in the CFL activities of the NUTRiGREEN project, it was imperative that the methodological design encouraged the participation of all actors involved in the CFL. This approach was effective in reinforcing the process of co-creation within the NUTRiGREEN and an avenue to demonstrate how the discussions can be organized in a fun way. Some new questions and unexpected insights arose from this research design particularly in relation to agrometeorological learning such as the legitimacy and ethics of the data collected by farmers, and some new relationships that could be nurtured.

5.2. Recommendations

Based on these conclusions, the partners of the NUTRiGREEN project should consider merging the agrometeorological learning with the agroecological learning activities in such a way that they are a continuum rather than separate. Regarding the agroecological learning in CFS, the scientific tools introduced to the farmers during field trials with university students could be made available to the farmers so that they can apply what they have learnt and be in the position to develop new challenging questions. The farmer data collectors involved in the agrometeorological learning could all be members of the GPFs to ensure the free flow of information to other members and feedback. If the mixed group for weather data collection is maintained, a conscious effort could be made to organize frequent meetings between data analysts and data collectors. The organization of these meetings will require the proactivity of all partners involved in the CFL activities. To better resolve the data gaps, errors and to improve how uncertainties in weather information can be well communicated for effective use, new modes of communications and feedback routes could be experimented, and new relationships could be nurtured. The feedback sessions could be prioritized as the farmers' input is key to interpretating and the using of the information. The CTA is therefore in the best position to point out difficulties with agrometeorological data collection and provide inputs and feedback on how the information could serve the needs of the farmers. Additionally, the relationship between APAF and ANACIM could be further explored to the mutual benefit of both institutions. The capacity of the CTA to communicate weather and climate information will be enhanced through training and familiarization with the bulletins produced by the MWGs, which will expand the network base of APAF and the other NUTRiGREEN partners. ANACIM could also overcome its challenges of reaching more users in remote areas and gaining farmers' trust in weather forecasting, because the CTA can be exposed to all the services that they offer and see how that can be integrated with agrometeorological learning in CFS and benefit the local farmers. Further studies could explore how non-academic actors can generate quality data and store the data effectively to ensure the durability of the weather and climate information. The work of the MWGs could be explored at the local level in Senegal to see how farmer groups and projects could participate in and benefit from the results and exchanges of the MWGs to translate climate science into climate services.

5.3. Outlook

Finally, this study also raises questions about the way calls for projects are designed, particularly when co-financing projects involving international and national partners. Donors seeking to promote bottom-up approaches should consider creating flexible working arrangements in line with co-creation principles to avoid constraints on participating partners and project implementation.

REFERENCES

Alvar-Beltrán J, Dao A, Dalla Marta A, Heureux A, Sanou J, Orlandini S (2020) Farmers' Perceptions of Climate Change and Agricultural Adaptation in Burkina Faso. Atmosphere, vol. **11**: 827p DOI: 10.3390/atmos/11080827

Amegnaglo CJ, Anaman KA, Mensah-Bonsu A, Onumah EE, Amoussouga Gero F (2017) Contingent valuation study of the benefits of seasonal climate forecasts for maize farmers in the Republic of Benin, West Africa. Climate Services, 2017, vol. **6**: p. 1–11 DOI: 10.1016/j.cliser.2017.06.07

ANSD (2019) Ministère de l'Éconimie, des Finances et du Plan: Situation Economique et Sociale Regionale. Service de la Statistique et de la Démographie de Fatick. 20–28 URL: https://www.ansd.sn (Consulted: 21.07.23)

Apgar JM, Allen W, Albert J, Douthwaite B, Paz Ybarnegaray R, Lunda J (2017) Getting beneath the surface in program planning, monitoring and evaluation: Learning from use of participatory action research and theory of change in the CGIAR Research Program on Aquatic Agricultural Systems. Action Research, 2017, vol. **15**: p.15–34 DOI: 10.1177/1476750316673879

Bakker T, Dugué P, de Tourdonnet S (2021) Assessing the effects of Farmer Field Schools on farmers' trajectories of change in practices. Agronomy for Sustainable Development, vol. **41**: p.18 DOI: 10.1007/s13593-021-00667-2

Blundo-Canto G, Andrieu N, Soule Adam N, Ndiaye O, Chiputwa B (2021) Scaling weather and climate services for agriculture in Senegal: Evaluating systemic but overlooked effects. Climate Services, 2021 vol. **22**: 216p DOI 10.1016/j.cliser.2021.100216

Braun A, Duveskog D (2011) The Farmer Field School Approach - History, Global Assessment and Success Stories. Background paper for the IFAD poverty report 2010, 2011. p. 7-25 URL: https://citeseerx.ist.psu.edu (consulted: 26.03.2023)

Braun J von, Afsana K, Fresco L, Hassan M, Torero M (2021) Food Systems-Definition, Concept and Application for the UN Food systems Summit. Sci. Innov. 2021: p 27

Bremer S, Wardekker A, Dessai S, Sobolowski S, Slaattelid R, van der Sluijs J (2019) Toward a multi-faceted conception of co-production of climate services. Climate Services, 2019, vo. **13**: p. 42–50 DOI: 10.1016/j.cliser.2019.01.003

Callo-Concha D (2018) Farmer Perceptions and Climate Change Adaptation in the West Africa Sudan Savannah: Reality Check in Dassari, Benin, and Dano, Burkina Faso. Climate, 2018, vol. **6**: 44p DOI: 10.3390/cli6020044

Campbell BM, ed (2022) Transforming food systems under climate change through innovation. Cambridge University Press, Cambridge, United Kingdom; New York, NY ISBN: 978-1-00-922721-6

Chevalier JM, Buckles D (2013) Participatory action research: theory and methods for engaged inquiry. Routledge, Abingdon, Oxon; New York, NY ISBN: 978-0-203-10738-6

Chiputwa B, Blundo-Canto G, Steward P, Andrieu N, Ndiaye O (2022) Co-production, uptake of weather and climate services, and welfare impacts on farmers in Senegal: A panel data approach. Agricultural Systems, 2022, vol. **195**: DOI: 10.1016/j.agsy.2021.103309

Clement V, Kanta Kumari R, Alex de Sherbinin, Bryan J, Adamo S, Schewe J, Sadiq N, Shabahat E (2021) Groundswell: Acting on internal Climate Migration, The World Bank 2021, part II: 326 p URL: https://www.worldbank.org (Consulted: 28.01.2023)

Coeugnet P, Labatut J, Duval J, Vourc'h G (2023) Including citizens through co-design in a participatory research project to explore innovative agro-food systems: the case of future dairy livestock systems. Frontiers in Sustainable Food Systems, 2023, vol. **7**: DOI: 10.3389/fsufs.2023.1098295

Colucci E (2007) "Focus Groups Can Be Fun": The Use of Activity-Oriented Questions in Focus Group Discussions. Qualitative Health Research, 2007, vol. **17**: 1433 p DOI: 10.1177/1049732307308129

Daron JD (2014) Regional Climate Message: West Africa. Scientific report from the CARIAA Adaptation at Scale in Semi-Arid Regions (ASSAR) project. International Development Research Centre, Ottawa, ON, 2014: 29 p. URL: https://www.assar.uct.ac.za (Consulted: 23.03.2023)

Diouf NS, Ouedraogo M, Ouedraogo I, Ablouka G, Zougmoré R (2020) Using Seasonal Forecast as an Adaptation Strategy: Gender Differential Impact on Yield and Income in Senegal. Atmosphere, 2020, vol. **11**: 1127p DOI: 103390/atmos11101127

FAO (2022) State of food security & nutrition in the world 2022: Repurposing food and agricultural policies to make healthy diets more affordable. Food & Agricultural organization, 2022: 209 p. URL: https://www.fao.org (Consulted: 02.02.2023)

FAO (2023) State of food security & nutrition in the world 2023: urbanization, agri-food system transformation. Food & Agriculture organization, S.l., 2023: 236 p. URL: https://www.fao.org (Consulted 17.07.2023)

Faure GG Pierre; Triomphe, Bernard (2010) Agricultures tropicales en poche: innover avec les acteurs du monde rural. Editions Quae, Place of publication not identified ISBN: 978-2-7592-0608-7

Flick U, ed (2018) The Sage handbook of qualitative data collection. Sage Reference, Los Angeles. 708 p. ISBN: 978-1-4739-5213-3

Flick U, ed (2014) The SAGE handbook of qualitative data analysis. SAGE, Los Angeles. 634 p. ISBN: 978-1-4462-0898-4

Freduah B, MacCarthy D, Adam M, Ly M, Ruane A, Timpong-Jones E, Traore P, Boote K, Porter C, Adiku S (2019) Sensitivity of Maize Yield in Smallholder Systems to Climate Scenarios in Semi-Arid Regions of West Africa: Accounting for Variability in Farm Management Practices. Agronomy, 2019, vol. **9**: 639 p. DOI: 10.3390/agronomy9100639

Grant MJ, Booth A (2009) A typology of reviews: an analysis of 14 review types and associated methodologies: A typology of reviews, Maria J. Grant & Andrew Booth. Health Information & Libraries Journal, 2009. vol. **26**: p. 91–108 DOI: 10.111/j.1471-1842.2009.00848.x

Grossi A, Dinku T (2022) Enhancing national climate services: How systems thinking can accelerate locally led adaptation. One Earth, 2022, vol. **5**: p. 74–83 DOI: 10.1016/j.oneear.2021.12.007

Ibrahim B, Karambiri H, Polcher J, Yacouba H, Ribstein P (2014) Changes in rainfall regime over Burkina Faso under the climate change conditions simulated by 5 regional climate models. Climate Dynamics, 2014, vol. **42**: p. 1363–1381 DOI: 10.1007/s00382-013-1837-2

IFAD (2020) International Fund for Agricultural Development. Annual Report 2020. URL: https: www.ifad.org (Consulted: 18.02.203)

Leal Filho W, Barbir J, Gwenzi J, Ayal D, Simpson NP, Adeleke L, Tilahun B, Chirisa I, Gbedemah SF, Nzengya DM, et al (2022) The role of indigenous knowledge in climate change adaptation in Africa. Environmental Science Policy, 2022, vol. **136**: p. 250–260 DOI: 10.1016/j.envsci.2022.004

Mapfumo P, Adjei-Nsiah S, Mtambanengwe F, Chikowo R, Giller KE (2013) Participatory action research (PAR) as an entry point for supporting climate change adaptation by smallholder farmers in Africa. Environmetal Development, 2013, vol. **5**: p. 6–22 DOI: 10.1016/j.envdev.2012.11.001

Mfitumukiza D, Sinha Roy A, Simane B, Hammill A, Feisal Rahman M, Huq S (2020) Scaling local and community-based adaptation. 27

Ndiaye DS (2015) Conseil Interministériel: Contribution du Centre de Suivi Ecologique (CSE). MINITÈRE DE L'ENVIRONNEMENT ET DU DÉVELOPPEMENT DURABLE, Senegal: URL: https//www.cse.sn (Consulted: 23.06.2023)

Peng W, Berry EM (2019) The Concept of Food Security. Encyclopedia of Food Security and Sustainability. Elsevier, p 1–7 ISBN: 978-0-12-812688-2

Rhodes ER, Jalloh A, Diouf A (2014) AfricaInteract: Enabling research-to-policy dialogue for adaptation to climate change in Africa: review of research and policies for climate change adaptation in the agriculture sector in West Africa. Future Agric Consort **Working paper 090**: 18–26

Röling NG (2011) Agrometeorological learning: coping better with climate change. LAP Lambert Academic Publishing, Saarbrücken, Germany. ISBN: 978-3-8465-0821-3

Roudier P, Muller B, d'Aquino P, Roncoli C, Soumaré MA, Batté L, Sultan B (2014) The role of climate forecasts in smallholder agriculture: Lessons from participatory research in two communities in Senegal. Climate Risk Management, vol. **2**: p. 42–55 DOI: 10.1016/h.crm.2014.02.001

Saldaña J (2011) Fundamentals of qualitative research. Oxford University Press, New York. 191p ISBN: 978-0-19-973795-6

Sanoussi A, Mohamed L, Seyni S, David AG (2015) Adapting to climate variability and change in smallholder farming communities: A case study from Burkina Faso, Chad, and Niger. Journal of Agricultural Extension and Rural Development, 2015, vol. **7**: p. 16–27 DOI: 10.5897/JAERD14.0595

Santpoort R, Steel G, Mkandawire A, Ntauazi C, Faye EH, Githuku F (2021) The Land Is Ours: Bottom-Up Strategies to Secure Rural Women's Access, Control and Rights to Land in Kenya, Mozambique, Senegal, and Malawi. Frontiers in Sustainable Food Systems, 2021 vol. **5**: 697314 p DOI: 10.3389/fsufs.2021.697314

Saunier-Zoltobroda T (2015) Flux de biomasse à l'échelle du paysage et hétérogénéité spatiale des bilans d'azote Cas de trois terroirs du bassin Arachidier au Sénégal. DOI: 10.13140/RG.2.1.3395.9927

Schindler J, Graef F, König HJ (2016) Participatory impact assessment: Bridging the gap between scientists' theory and farmers' practice. Agricultural Systems, 2016, vol. **148**: 38–43 p. DOI: 1016/j.agsy.2016.07.002

Schwartz K, (2022) Everyday pathfinders: A gender-sensitive analysis of climate impacts and adaptation of smallholder farmers in Fatick, Senegal. Department of Earth sciences, Freie Universität, Berlin, MASTERS THESIS 2022: p 35-42

Stöber S, Adinata K, Ramba T (2022) Between heavy rain and sea level rise. Co-research with smallholder farmers in Indonesia. A manual for the Climate Field Lab approach. Center for Rural Development (SLE) ISBN: 978-3-947621-35-4

Sultan B, Lejeune Q, Menke I, Maskell G, Lee K, Noblet M, Sy I, Roudier P (2020) Current needs for climate services in West Africa: Results from two stakeholder surveys. Climate Service, 2020, vol. **18**: p. 15-22 DOI: 10.1016/j.cliser.2020.100166

Tall A, Coulibaly JY, Diop M (2018) Do climate services make a difference? A review of evaluation methodologies and practices to assess the value of climate information services for farmers: Implications for Africa. Climate Services, 2018, vol. **11**: p. 1–12 DOI: 10.1016/j.cliser.2018.06.001

Tarchiani V, Camacho J, Coulibaly H, Rossi F, Stefanski R (2018) Agrometeorological services for smallholder farmers in West Africa. Advances in Science Research, 2018, vol. **15**: p.15–20 DOI: 10.5194/asr-15-15-2018

Torquebiau E (2015) Changement climatique et agriculture du monde. Éditions Quae, France 327 p. ISBN: 978-2-7592-2299-5

Tracy SJ (2013) Qualitative Research Methods: collecting evidence, crafting analysis, communicating impact, Wiley-Blackwell, Chichester, West Sussex, UK. p. 94–100 ISBN: 978-1-4051-9202-6

UN DESA (2022) United nation department of economic and social affairs population division: World Population Prospects 2022: Summary of Results. New York UN DESA/POP/2022/TR/NO.3: 40 p. URL: https://population.un.org/wpp/ (Consulted: 15.01.2023)

Vaughan C, Hansen J, Roudier P, Watkiss P, Carr E (2019) Evaluating agricultural weather and climate services in Africa: Evidence, methods, and a learning agenda. WIREs Climate Change, 2019, vol. **10:** p. 1-20 DOI: 10.1002/wcc.586

Vincent K, Daly M, Scannell C, Leathes B (2018) What can climate services learn from theory and practice of co-production? Climate Services, 2018, vol. **12**: p. 48–58 DOI: 10.1016/j.cliser.2018.11.001

WEF (2023) WORLD ECONOMIC FORUM: The Global Risks Report. Ed. 18 Insight report: p.13–26 URL: https://www.weforum.org (Consulted 19.01.2023)

Wilfahrt M (2023) Precolonial Legacies in Postcolonial Politics: Representation and Redistribution in Decentralized West Africa, 1st ed. DOI: 10.1017/9781009286176

Witt R, Pemsl D, Waibel H (2008) The Farmer Field School in Senegal: Does Training Intensity Affect Diffusion of Information? Journal of International Agricultural Extension Education, 2008, vol. **15** DOI: 10.5191/jiaee.2008.15204

WMO (2013) World Meteorological Organization: What Do We Mean by Climate Service? URL: https//www.public.wmo.int (Consulted: 27.02.23)

WMO (2011) Climate knowledge for action: a global framework for climate services: empowering the most vulnerable: the report of the high-level taskforce for the global framework for climate services. World Meteorological Organization, Geneva, 2011: 10 p. URL: https//www.wmo.int (Consulted: 03.03.2023)

WMO (2014) Global Framework for Climate services: Implementation of the Global Framework for Climate Services. World Meteorological Organization, Geneva, 2014: 81 p URL: https//gfcs.wmo.int (Consulted: 04.03.2023)

Zamudio AN, Terton A (2016) Review of current and planned adaptation action in Senegal. CARIAA Working Paper no. 18 International Development Research centre, Ottawa Canada and UK Aid, London, United Kingdom. 16–22 URL: https://www.iisd.org (Consulted: 05.07.2023)

ANNEX

Table in annex

Annex I : List of contacted participants during field studies

Date contacted	Participants	Meeting confirmed	Location	Reminder sent	Interview Time
10.05.23	APAF-Director	06.06.23	M'Bour, Senegal	05.06.23	13:00
17.05.23	UCAD professor 1	N/A	Dakar, Senegal	06.06.23	N/A
17.05.23	UCAD professor 2	07.06.23	Dakar, Senegal	06.06.23	12:00
17.05.23	APAF data entry officer	06.06.23	M'bour, Senegal	05.06.23	11:00
17.05.23	UCAD master student 1	12.06.23	Dakar, Senegal	09.06.23	10:00
17.05.23	UCAD master student 2	12.06.23	Dakar, Senegal	09.06.23	11:00
17.05.23	UCAD PhD student 1	12.06.23	Dakar, Senegal	09.06.23	14:00
17.05.23	UCAD PhD students 2	12.06.23	Dakar, Senegal	09.06.23	15:00
27.04.23	SLE-Data Analyst	04.05.23	Berlin, Germany	03.05.23	14:00
09.05.23	SLE-project manager	25.05.23	Berlin, Germany	24.06.23	14:00
09.06.23	ANACIM-meteorological expert	13.06.23	Dakar, Senegal	12.06.23	09:00
03.05.23	Stakeholder dialogue (FGD 4)-APAF meeting room	22.06.23	M'Bour, Senegal	21.06.23	09:00
Contacted via APAF					
12.05.23	CTA 1	12.06.23	Ngéyene, Senegal	11.06.23	10:00
12.05.23	CTA 2	22.06.23	Ngéyene, Senegal	21.06.23	14:00
12.05.23	Farmer data collecors-FGD 1 (Nobandam + Diofior)	15.06.23	Diofior, Senegal	14.06.23	09:00
12.05.23	Women famer group-FGD 2	16.06.23	Nobandam, Senegal	15.06.23	09:00
12.05.23	Women famer group-FGD 3	20.06.23	Diofior, Senegal	19.06.23	09:00
					N/A: Not Available

Annex II : Copy of protocol for organizing FGD used in field data collection in Senegal. (Derived from NUTRiGREEN project archives with modifications based on consultations (Stöber et al., 2022) to fit the local context)

LIGNE DIRECTRICE POUR LES DISCUSSIONS DE GROUPE
Étapes importantes pour planifier, mener et documenter une discussion de groupe.

Qu'est-ce qu'une discussion de groupe (DG) ?

Une DG est une technique de recherche qualitative consistant en une discussion structurée et utilisée pour obtenir des **informations approfondies** (données qualitatives) d'un groupe de personnes sur un sujet particulier. Le but de la discussion est d'utiliser la **dynamique sociale du groupe**, avec l'aide d'un modérateur/facilitateur, pour encourager les participant.es à partager des informations essentielles sur leurs **opinions, croyances, perceptions et attitudes**. La recherche par groupe de discussion est également utilisée pour développer ou améliorer des produits ou des services.

Les discussions de groupes sont souvent organisées parmi des populations cibles uniformes, qui partagent généralement une caractéristique commune telle que l'âge, le sexe ou le statut socio-économique, ce qui encourage le groupe à parler plus librement du sujet sans craindre d'être jugé par les autres.

Dans notre cas, le groupe uniforme sont :
- Collecteurs de données agrométéorologiques.
- Groupement de femmes agricultrices à Nobandam.
- Groupement de femmes agricultrices à Diofior.

Par conséquent, si vous planifiez une DG, soyez clair sur le but et les objectifs de votre DG !

1) PLANIFIER une discussion de groupe

- **Date et heure du DG** : veillez à informer les participant.e.s ciblés avant la réunion, dans la mesure du possible, et prévenez le chef du village avant la discussion pour qu'ils soient au courant.
    a. Confirmer à nouveau que le DG aura lieu peu avant l'événement.

- **Lieu de la réunion** : organiser la réunion dans un environnement privé, sûr et confortable (par exemple, pas directement sous le soleil) et accessible (en particulier aux personnes handicapées, aux personnes âgées et aux femmes enceintes).

- **Taille du groupe** : la taille idéale est de 8 à 12 personnes, mais des groupes plus petits ou plus grands peuvent très bien fonctionner.

- **Comprendre votre (vos) rôle(s)** : Le rôle de l'animateur est d'aider tous les membres à s'exprimer à un moment donné, de gérer les membres dominants du groupe et d'être capable de poser des questions ouvertes et de les faire suivre de questions supplémentaires pertinentes afin de stimuler la conversation et la réflexion. Je (chercheur) assisterai l'animateur dans son rôle, car je serai principalement observateur. Le scripteur prendra **UNIQUEMENT** des notes (**en français**) sur le dialogue.

- **Animateur/chercheur/scripteur** : Il peut être efficace que plusieurs personnes dirigent le groupe de discussion - l'une posant les questions (l'animateur) et l'autre écrivant. J'observerai les expressions, le langage corporel, etc., qui peuvent donner des indices sur les sensibilités, etc. et je poserai des questions à l'animateur pendant qu'il traduit. Vous (le scripteur) ne ferez qu'écouter et écrire et ne pourrez intervenir que si vous avez besoin qu'un point soit répété par le groupe.

- Planifier vos questions/sujets de discussion en fonction du **but et des objectifs** spécifiques de votre DG. (Vous aurez tous deux des copies des questions préparées)
    - Les questions doivent être:
      - Courtes et précises
      - Clairement formulées
      - Ouvertes - ce qui signifie que les questions sont formulées de manière à ce qu'on ne puisse pas y répondre par un simple "oui" ou "non" (**utilisez plutôt "pourquoi" et "comment"**).
      - Non menaçantes ou embarrassantes

2) FACILITER une discussion de groupe

Partie a) Arrivée des participant.es

- Accueillir tout le monde à l'arrivée
- Pour des raisons de documentation, il est important de faire signer à chacun une **feuille de présence.**

Partie b) Introduction

- **Animateur : Présenter nous** et laisser les participant.es se présenter.

- **Animateur : Introduire le projet** et le thème général de la recherche et sa pertinence pour les agriculteur.rices.

- **Animateur** : Expliquer l'objectif de la discussion de groupe et le rôle des animateurs.

- **Animateur :** Confirmer aux participant.es que leurs réponses ne seront utilisées qu'à des fins de recherche et d'analyse et que les informations resteront **confidentielles/anonymes** et ne seront partagées avec personne d'autre que les chercheurs de l'étude.

- **Animateur** : Prendre quelques minutes pour traduire le **formulaire de consentement** pour eux et demander aux participant.e.s de le signer.

- **Animateur : Éviter de susciter des attentes**. Expliquer ce que nous ferons de l'information, en étant très clair sur le fait que lorsqu'on pose des questions sur les besoins, il n'y a aucune garantie que les choses changent.

- **Animateur :** Expliquer que **le scripteur** prendra des notes pendant la DG pour m'aider (**chercheur)** à me souvenir de ce qui a été dit, mais que ces notes sont destinées à notre usage de recherche et ne seront pas partagées avec d'autres.

- **Animateur** : Veiller à ce qu'une seule personne parle à la fois.
- **Animateur** : S'assurer que des personnes extérieures (ne participant pas à la discussion de groupe) ne soient pas présentes ou à portée de voix, car ceci pourrait empêcher les participant.es de s'exprimer librement.
- **Scripteur :** Veiller à ce que les notes reflètent le plus fidèlement possible ce qui a été dit. Ce travail est très important pour l'analyse des résultats, plus il y aura de détails dans les réponses, mieux c'est, et plus j'aurai de chances d'avoir des passages citables qui peuvent être très puissants. **NB** : Les notes mal prises rend l'exercice inutile, il faut donc essayer de les organiser et de les numéroter.

Partie c) Questions et discussion

- **Scripteur :** Demander s'il y a des questions avant de commencer la discussion et s'assurer de prendre des notes sur les données démographiques du groupe (âge, sexe, ...).
- **Scripteur :** Il est important de noter au plus près ce que disent les participant.e.s.
- **Animateur** : Poser une question à la fois - et donner du temps et de l'espace pour une discussion animée.
    - Pour les collecteurs de données agrométéorologique : Commencer par obtenir un retour sur la première formation agrométéorologique qu'ils ont reçu
- **Animateur** : Essayer d'impliquer tout le monde dans la discussion et noter clairement les points d'accord et de désaccord.

  Exemples : "Qui est d'accord avec ça ?"
  "Est-ce que quelqu'un a une opinion différente ?"

- **Animateur** : Utiliser des commentaires neutres et **encourager les** personnes les plus silencieuses à contribuer - "Autre chose ?", "Quelqu'un d'autre a quelque chose à ajouter ?", "Et de ce côté du groupe ?".
- **Animateur** : Veiller à **écouter** les participant.es sans les juger et à intervenir si d'autres les jugent, en leur rappelant le respect des autres opinions.
- **Animateur** : Sans être trop personnel, rester ouvert pour en savoir un peu plus sur eux et les mettre à l'aise.

Partie d) Récapitulation

- **Animateur** : Obtenir une déclaration finale de chaque agriculteur.rice pour conclure la DG :

  Exemple :
    - Imaginez que vous êtes le ministre de l'Agriculture du Sénégal : que voudriez-vous voir se produire pour vous aider à améliorer votre production ou *apprentissage sur l'agrométéorologique ?
    - Chacun d'entre vous a un souhait libre : que souhaiteriez-vous qu'il se passe pour améliorer les processus de production et de l'agrométéorologique* comme moyen de subsistance dans votre exploitation ?

- **Scripteur :** Noter tous les aspects
- **Animateur** : Demander aux participant.e.s de donner leur avis sur la discussion de groupe qu'ils viennent d'avoir et sur l'impression qu'ils ont eue de la formation qu'ils viennent de recevoir.
- **Animateur** : Remercier toutes les personnes impliquées pour leur contribution. Je (chercheur) vous aiderai.
- **Animateur** : Dire que nous fournirons une copie écrite de la discussion à celles et ceux qui sont intéressé.es.
- **Animateur** : Partager des rafraîchissements (par exemple, des boissons) pour la fin de la DG afin de motiver les participant.es et de les remercier pour leur temps.

*Réservé aux collecteurs de données.

DOCUMENTER et ENREGISTRER une Discussion de Groupe > **Animateur, scribe et chercheur.**

Après la réunion avec chacun des groupes, nous aurons une brève réunion entre nous pour discuter des informations recueillies.

Je vous invite à vous engager pleinement dans ce dialogue et à ne pas hésiter à nous faire part de vos commentaires en cas de contradictions.

Fiche résumé

L'INSTITUT agro Rennes Angers	**Diplôme** : Master **Spécialité** : Génie de l'environnement (GE) **Spécialisation / option** : TEAM-actors /ADT **Enseignant référent** : Phillipe Boudes

Auteur(s) : Bright LITTLE-TETTEH Date de naissance* : 30/06/1991	**Organisme d'accueil** : Center for Rural Development (SLE), Humboldt-Universität zu Berlin. **Adresse** : SLE, Humboldt-Universtität zu Berlin Hessische Str. 1-2, Berlin 10115, DE Maître de stage : Dr. Silke Stöber
Nb pages : 60 Annexe(s) : 5	
Année de soutenance : 2023	

Titre français : Démocratisation des connaissances sur le climat : Evaluation de la co-création de connaissances via les activités du Climate Field Lab au Sénégal

Titre anglais : Democratization of climate knowledge : Assessing co-creation of knowledge via Climate Field Lab activities in Senegal

Résumé (1600 caractères maximum) :

Le climat change rapidement, affectant les moyens de subsistance en particulier dans les pays du Sud. En Afrique, des efforts pour lutter contre cet enjeu sont déployés aux échelles mondiale, régionale, nationale, et locale, principalement par le biais du développement de services climatiques. Cependant, l'implication des agriculteurs locaux dans la conception des services climatiques reste faible, bien que des mécanismes soient en place. L'un de ces mécanismes est porté par le projet NUTRiGREEN qui vise à améliorer la nutrition et renforcer les capacités des agricultrices face au changement climatique, via notamment des écoles de terrain sur le climat combinant apprentissage agrométéorologique et apprentissage agroécologique. L'étude adopte une approche de recherche qualitative pour montrer comment la co-création de connaissances se déroule dans les écoles de terrain sur le climat du projet NUTRiGREEN au Sénégal, et les efforts déployés pour impliquer les agricultrices dans la prise de décision. Les résultats de l'étude montrent que les deux activités ne sont pas mises en lien, bien que les acteurs soient les mêmes. Ils révèlent une insuffisance de communication entre les scientifiques et les acteurs non académiques dans l'apprentissage agrométéorologique, mais à l'inverse des interactions fréquentes dans l'apprentissage agroécologique. Cette étude sert de point de départ pour combler les lacunes dans le processus de co-création, encourager de nouveaux partenariats et renforcer ceux qui existent déjà dans le projet NUTRiGREEN.

Abstract (1600 caractères maximum) :

The climate is changing rapidly, affecting livelihoods particularly countries in the Global south. In Africa, efforts are being made at global, regional, national, and local levels to address this issue, mainly through the development of climate services. However, the involvement of local farmers in the design of climate services remains weak, although mechanisms are in place. One such mechanism is the NUTRiGREEN project, which aims to improve nutrition and build capacity of women farmers in response to climate change, particularly through climate field schools that incorporate agrometeorological and agroecological learning as activities. The study adopts a qualitative research approach to show how knowledge co-creation takes place in climate field schools of the NUTRiGREEN project in Senegal, and the efforts made to involve women farmers in decision-making. The results of the study show that the two activities of the climate field schools are not linked, even though the actors involved are the same. They reveal a lack of communication between scientist and non-academic actors in agrometeorological learning but in contrast there is frequent interactions in agroecological learning. This study serves as a starting point for bridging gaps in the co-creation process, encourage new partnerships and strengthening existing ones in the NUTRiGREEN project.

Mots-clés : Services climatiques, écoles de terrain sur le climat, Afrique sub-saharienne, adapatation, co-création/construction, connaissances autochtones/locales.

Key Words : Climate services, Farmer and/or climate field schools, sub-Saharan Africa, adaptation, co-creation/construction, Indigenous/ local knowledge.

Acknowledgement to Research Grant: The NUTRiGREEN project and research results is financially supported by the German Federal Ministry of Food and Agriculture (BMEL) through the Federal Office for Agriculture and Food (BLE), grant 2821ERA14C. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862555.

Remerciements pour la subvention de recherche: Le projet NUTRiGREEN et les résultats de la recherche sont soutenus financièrement par le ministère fédéral allemand de l'alimentation et de l'agriculture (BMEL) par l'intermédiaire de l'Office fédéral de l'agriculture et de l'alimentation (BLE), subvention 2821ERA14C. Ce projet a reçu un financement du programme de recherche et d'innovation Horizon 2020 de l'Union européenne dans le cadre de l'accord de subvention n° 862555.

With support from

Federal Ministry of Food and Agriculture

by decision of the German Bundestag

FOSC

ERA-NET Cofund on Food Systems and Climate