Weathering Climate Uncertainty

A case study on factors influencing the use of Weather and Climate Information Services (WCIS) by smallholder farmers in Tattaguine District, Senegal

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Abstract

This research investigates how Weather and Climate Information Services (WCIS) have been used by farmers in the Tattaguine district of Senegal, where rainfed agriculture faces challenges due to increasing climate variability. The study employed qualitative methods, including structured interviews, key informant interviews, and a focus group discussion. The findings reveal high WCIS use rates but less than 50% of farmers use them systematically, and significant gender differences exist. This research argues that the differences can be explained by a lower asset composition of female-headed households, in turn restraining direct access to an accessible format and, thereby, increasing perceived complexity and contributing to less systematic use. The study highlights that household assets are the result of a complex interaction between vulnerability, institutional, political, and sociocultural context and that tradition and gender norms disadvantage women in accessing and deciding over their use. The research also identified three different groups of traditional beliefs and forecasting systems to understand their role in WCIS adoption. While natural indicators are highly compatible and Saltigué highly incompatible with WCIS use, leading to a decline in belief in them, the compatibility of WCIS with traditions in agricultural practice depends on the individual farmer.

Keywords: Tattaguine, WCIS use, Livelihood assets, Innovation adoption, Traditional forecasting systems, Gender, Gender norms.

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List of abbreviations

ANACIM *Agence Nationale de l'Aviation Civile et de la Météorologie*
National Agency for Civil Aviation and Meteorology

ANCAR *Agence Nationale de Conseil Agricole et Rural*
National Agency for Agricultural Extension

DoI Diffusion of Innovation

NGO Non-governmental organization

PISC Policy, institutional and sociocultural context

SDG Sustainable Development Goal

SLF Sustainable Livelihoods Framework

TAM Technology Acceptance Model

WCIS Weather and Climate Information Services

WCI Weather and Climate Information

WFP World Food Programme

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1. Introduction

1.1 Background

Agriculture has often been coined one of the most weather-depending human activities (Hansen, 2002). The weather's variability on an intra-annual scale and long-term climate trends influence the planning of agricultural activities, production output, and thereby prices and food security worldwide. The West African region has been identified as '*particularly vulnerable to climate change*' (Sultan and Gaetani, 2016, p. 1) and robust evidence for yield loss exists, likely to be more pronounced in areas with decreasing rainfall such as the Western part of the Sahel (Sultan and Gaetani, 2016).

This is equally true for Senegal whose agricultural sector has been characterized as underdeveloped and having low productivity due to '*a combination of poor soil and weather conditions, a lack of infrastructure and access to quality seeds and fertilizer*' (Ouedraogo et al., 2018, pp. 2–3). Deryng (2015) predicts[1] decreases in the country's average yields in 2030 by 7,5% to 16,7% compared with 2000, with yield decreases between 5,4% and 12,3% in the country's main crops groundnut, millet, sorghum, and maize driving the trend. These climate change-related effects add to and reinforce the already existing high inter- and intra-annual rainfall variability, with recent increases in rainfall intensity and the frequency of heavy rainfall events (Sultan and Gaetani, 2016), which poses particular difficulties for Senegal as 93% of the smallholder farmers rely on rain-fed agriculture (DAPSA, 2022).

Supporting farmers to adapt to climate change is therefore intrinsically linked to several Sustainable Development Goals (SDG) such as SDG 1 'No Poverty', SDG 2 'Zero Hunger' (Khanal et al., 2021)**,** and SDG 13 'Climate Action' (Campbell et al., 2018).

Weather and Climate Information Services (WCIS) have been identified as a key instrument to help farmers to make decisions that reduce their vulnerability to the climate and increase their productivity (Tall et al., 2018). Weather information such as daily information up to a 10-day forecast, describing the *'state of the atmosphere at a particular time'* (Hansen and Whitbread, 2022, p. 3) enables farmers to plan sowing, fertilizer use, harvest, and other agricultural activities (Ouedraogo et al., 2021). Climate information describes weather over longer time intervals such as an agricultural season or even several decades (Hansen and Whitbread, 2022) and allows farmers to plan their labor and capital use as well as to select crops and their varieties adapted to the length and the expected amount of rainfall during the

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[1] The predictions are based on a model accounting for the fertilizing effect of an increased CO2 concentration in the atmosphere and assuming a business-as-usual greenhouse gases emission scenario.

rainy season (Ouedraogo et al., 2021). Despite the differences between the two, in the following the expression Weather and Climate Information (WCI) is used.

The global promotion of the WCIS gained momentum after the third World Climate Conference with the launch of the Global Framework for Climate Services in 2009 (Larosa and Mysiak, 2019). In the same year, the Senegalese National Agency for Civil Aviation and Meteorology (ANACIM) started producing and disseminating WCI. In the following years, a research partnership between ANACIM and national[2] as well as international research partners[3] was formed and created in several pilot projects evidence for a national scale-up of the services. (Blundo-Canto et al., 2021).

Today, a multidisciplinary working group[4] (MWG) has been established nationally, and localized MWGs have been created in sub-regions[5] nationwide. They bring together representatives of relevant state and civil society actors and meet regularly to discuss the implications of the forecast for the different action weather-affected sectors (Chiputwa et al., 2020). A performance evaluation of the MWGs in 2017 highlighted that there are big differences between regions in the number of MWGs present, their novelty, and the frequency of meetings held by them (Ouedraogo et al., 2018). According to estimates, in 2015 between 3,9 million (Lo and Dieng, 2015) and 7 million people living in rural areas (Diouf et al., 2019) had access to WCIS combining all diffusion channels including word-of-mouth distribution. Hence, a great majority of Senegal's rural population of about 9 million (ANSD, 2022) is considered to have at least indirect access to WCIS, and the country's institutional setup, as well as its information products, are now considered *'among the strongest in West Africa'* (Hansen and Whitbread, 2022, p. 1).

1.2   Problem statement and research questions

The potential of WCIS and its contribution to the livelihoods of farmers are not fully exploited nor equally distributed (Hansen and Whitbread, 2022). Several quantitative studies have outlined differences in access to, and the comprehension, use, and impact of WCIS based among others on the region, socio-economic background, age, ethnic group, and gender of the potential recipient (Diouf et al., 2019, 2020b; Ouedraogo et al., 2021). Moreover, depending on the local context, '*endogenous beliefs'* (Diouf et al., 2019, p. 106) and traditional forecasting systems might influence confidence in WCIS.

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[2] Institut Sénégalais de Recherches Agricoles (ISRA)
[3] the Consultative Group on International Agricultural Research (CGIAR),
the Research Program on Climate Change, Agriculture and Food Security (CCAFS),
and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
[4] Original designation : *groupe de travail pluridisciplinaire* fr.
[5] Original designation : *département* fr.

A qualitative approach is needed to untangle the broader social aspects (Carr et al., 2020) and conditions on the farmer level influencing WCIS use by smallholder farmers. One case study (Carr et al., 2016) already exemplified the utility of such a qualitative approach highlighting the interplay of the Wolof ethnicity and gender aspects that form information needs and mediate access to WCIS in the Kaffrine region. Furthermore, a qualitative approach relying on participatory simulations was used to understand how farmers would potentially adapt their strategies based on given WCI (Roudier et al., 2014).

Besides those examples, qualitative inquiries remain scarce, and I want to contribute to a better understanding of WCIS use by focusing on a different regional context, the Tattaguine district[6], with a different ethnic majority, the Serer. This research aims to investigate if farmers with access to WCIS can make use of it and which factors influence this. Moreover, I want to shed light on the role of traditional beliefs and forecasting methods in the uptake of WCIS.

My research questions, therefore, are the following:

RQ 1: To what extent and under what conditions can smallholder farmers in the Tattaguine district make use of WCIS?

RQ 2: To what extent and in what way do traditional beliefs and forecasting methods influence perceptions of WCIS in the Tattaguine district?

1.3   Structure of the thesis

The thesis is structured in six chapters. The first one provides an overview of the background of the research, the research problem, and the research questions. The second chapter comprises a comprehensive literature review and introduces relevant evidence to WCIS in Senegal. This is followed by a presentation of the theoretical framework underpinning the research and guiding the interpretation of the research results. Chapter four outlines the methodological aspects of the study including the approach and methods used, sampling strategy, data analysis, a reflection of the author's positionality and limitations of the research, and a presentation of the study site. The fifth chapter delves into the research findings structured by the theoretical framework and the research questions. Lastly, chapter 6 summarizes the main conclusions of the study and provides recommendations to improve the use of WCIS by farmers in the Tattaguine district as well as for future research.

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[6] Original signification: *l'arrondissement de Tattaguine* fr

2. Literature review

This chapter introduces studies related to WCIS in Senegal to situate this thesis within the existing research landscape and contextualize my findings. Literature on WCIS has its origins in the fields of climatology and meteorology but has seen a shift to social science authors taking the users of WCIS, their needs, and the impact realized into account (Larosa and Mysiak, 2019).

The first section covers existing evidence of conditions and factors influencing the use of WCIS in line with RQ1. This is followed by a presentation of literature on traditional beliefs and forecasting and their role in WCIS uptake (RQ2).

2.1　Conditions and factors influencing productive use of WCIS

Research on WCIS in Senegal has covered among others the preferred access channels, and factors influencing access to WCIS, the use of WCIS, the impact of WCIS use, as well as differences in WCIS use impact.

Concerning preferred access channels, research is not conclusive with some authors arguing that community radios are the best reception channel due to information diffusion in local languages (Diouf et al., 2019; Nantongo et al., 2021), while others argue that voice messages and SMS are the predominant channel now (Ouedraogo et al., 2021). Moreover, social networks should not be neglected in the diffusion of WCIS and might be of particular importance for women (Diouf et al., 2019; McOmber et al., 2013).

Access to those channels is highly gendered with men having more access to almost all channels of WCIS than women (Diouf et al., 2019). This has been explained by the relatively low control of women over household income and therefore, their lowered probability to invest in communication technologies (McOmber et al., 2013). Moreover, women might be also less likely to be reached by extension agents and information distributed at the household level might not reach them due to gender norms. Lastly, women often bear a double burden of engaging in agricultural as well as domestic tasks and therefore, might have less time to engage in information-seeking behavior (McOmber et al., 2013).

Gender-independent factors influencing access to WCIS are ethnicity, area of residence, and perceptions of the usefulness of WCIS since farmers that see the usefulness of WCIS for their production are more likely to seek the information (Diouf et al., 2019).

With regards to the use of WCIS, research based on representative surveys indicates that the older a farmer the less likely he is to incorporate WCIS in his decisions. Two other important socio-economic variables are the area of residence and level of education, with

Koranic education being detrimental and average school education increasing the probability of WCIS (Ouedraogo et al., 2021). This is in line with McOmber et al. (2013), additionally pointing out that women tend to have lower literacy and educational levels than men. Other factors boosting the uptake of WCIS are membership in a farmer organization (Diouf et al., 2019; Ouedraogo et al., 2021) and having received training on WCIS (Ouedraogo et al., 2021). One impediment to WCIS use might be unmet user needs. Depending on the interplay of cultural norms, social status, and their intersection with age, marital status, and gender, household members hold very different access to resources, agricultural equipment, decision-making power, and time to cultivate their plot creating different information needs (Carr et al., 2016). Different information needs based on gender are confirmed by Diouf et al. (2019) with a greater percentage of women seeking information on rainfall pauses. Furthermore, Carr et al. (2016) illustrate that the capacity of exploiting WCIS has been highly determined by access to plows and other agricultural equipment.

Lastly, studies have investigated the impact of WCIS use and found high satisfaction rates among producers and 75% reporting increased harvest (Ouedraogo et al., 2021, 2018). Yield improvements are confirmed by Lo and Dieng (2015), tend to be further amplified by the presence of an MWG (Chiputwa et al., 2020), and are in line with earlier estimates on the economic value of seasonal forecasts in Senegal (Roudier et al., 2014; Sultan et al., 2010). However, studies have equally revealed great economic and gender disparities in the impact of WCIS use (Hansen and Whitbread, 2022) with men experiencing higher income increases per hectare in comparison to women and yield increases for a higher number of crops (Diouf et al., 2020b). The authors explain those differences by cultural and gender-specific roles in agricultural production as well as different socio-economic positions. They state that gender-based crop specialization leads to restricted adaption choices to react on WCIS (Diouf et al., 2020b) because women have to focus their productions on certain crops (Carr et al., 2016). Moreover, restricted access to land, labor, and financial resources equally impedes women to realize the full potential of WCIS (Diouf et al., 2020b). The relevance of sociocultural norms in agriculture and land governance among members of the predominant ethnic group in my study area, the Serer, has been confirmed (Evans, 2016). The author argues that Islam's influence changed originally matrilinear heritage structures and that now women can access land only through their husbands or brothers, with rice paddies being the only exception due to the predominant role of women in cultivating this crop.

To summarize, existing studies show evidence that gender and sociocultural roles as well as different forms of household capital such as human capital in the form of labor or educational level, equipment, land, or financial resources but also location, age, and membership in organizations influence or are positively related with access to, use of and impact of WCIS.

However, the way all those factors interact has not been entangled and systemized yet, and responding to RQ1 would both address this gap and help to identify recommendations for improvement.

2.2   The role of traditional beliefs, and forecasting systems

The role of traditional beliefs and trust in the uptake of WCIS has been the subject of several studies. The attempt of Ziervogel et al. (2005) of modeling the role of trust in the uptake of seasonal forecasts in Lesotho can be considered as one of the early examples. Her work outlined how trust is directly linked with forecast accuracy but also already accounts for locally specific traditional or cultural beliefs that might conflict with the forecast and lead to its rejection (Ziervogel et al., 2005).

In the Senegalese context, only a few peer-reviewed papers touch on the interrelation of WCIS and traditional beliefs. One paper mentioned how indigenous climate knowledge was incorporated in training sessions with farmers to increase the acceptance of WCIS (Ouedraogo et al., 2018), further detailed in the grey literature evaluation report of the director of the meteorological department of ANACIM (Ndiaye, 2011). Another paper draws on participatory research with smallholder farmers exploring the role of climate forecasts. Traditional knowledge is classified as either being based on natural indicators or spiritual beliefs and is predominantly used to predict the onset of the rainy season (Roudier et al., 2014). Moreover, it has been linked to reduced confidence in WCI (Diouf et al., 2019) as well as to lower adoption of the use of life jackets among Senegalese fishermen (Diouf et al., 2020a) and characterized as of higher relevance to local decision-making (Ouedraogo et al., 2021). However, these papers do not explore in what way traditional beliefs and existing forecasting systems influence the adoption of WCIS, they are simply used as an explanation for lower rates. Other scholars have already identified a gap to understand how users of WCIS weigh up natural indicators, spiritual beliefs, and scientific information against each other (Blundo-Canto et al., 2021).

Although not peer-reviewed, an important addition to this literature review is a participatory climate information systems mapping performed by Catholic Relief Services (CRS, 2018). The authors introduce the Saltigué as a central actor in the diffusion of WCI named by several discussion groups in their mapping. They are considered *'advisors of kings and guardians of indigenous knowledge'* (2018, p. 15) of the Serer. Every year before the onset of the rain season, the Saltigué announce their predictions called 'Xooy' which include among others a qualitative description of the rain season and advice on which crops to use. The authors characterize the xooy as a widely followed event even outside the Serer ethnic group but underline that participants of the actors mapping did not bring up contradictions

between their predictions and WCIS due to their different nature and that generally, participants would show higher confidence in scientific forecasts. However, they hypothesize that this might be different in the Fatick region since the belief in the Saltigué tradition is the strongest there.

The importance of the predictions of the Saltigué in the agricultural decision-making of the Serer is confirmed by Manga et al. (2009)[7]. According to their analysis, the predictions of the Saltigué are often confirmed by meteorological data, notably in the years 1999, 2001, 2002, 2005, and 2008. However, they outline in other cases that the actual rainfall was contrary to the predictions of the Saltigué. They describe how positive predictions encourage farmers to increase the size of their cultivated land and give them the courage to cultivate despite adverse conditions while negative predictions might lead to a concentration of means on the most fertile parts of the land (Manga et al., 2009).

To summarize, existing literature differentiates between traditional forecasting methods based on spiritual beliefs and empirical observation of natural indicators. While their concrete influence in the individual decision-making process has not been researched yet, they have been linked to lower uptake of WCIS and related practices while their integration in training on WCIS use has been described as beneficial to build trust. Among spiritual beliefs, the predictions of the Saltigués seem to be key to understanding the uptake of WCIS in the Fatick region. Consequently, answering my RQ2 will contribute to an existing research gap on the role of traditional forecasting methods in the decision-making process on the uptake of WCIS.

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[7] Despite the plethora of studies on WCIS use in Senegal, the Saltigué as a Weather and climate information source have not been mentioned in English academia. The paper of Manga et al. (2009) is the only publication on this matter but unfortunately not widely quoted – most likely to English research bias in research.

3. Theoretical framework

This chapter presents the theoretical framework that guides the analysis of the collected data. To answer my first research question and gain a comprehensive understanding of factors influencing the smallholder's capacity to make productive use of WCIS, a consideration of the livelihoods of the research participants embedded in broader structures is necessary (Tall et al., 2018). Therefore, I will briefly present the Sustainable Livelihoods Framework (SLF) as well as an adaptation of it – the rural livelihoods framework by Ellis (2000). In the second section, I will introduce the Diffusion of Innovation theory by Rogers (2003) and justify its selection for this research. Lastly, I will present an integrated framework of the two theories inspired by Dinh et al. (2015) and adapted to my research purpose.

3.1   Livelihood Frameworks

Livelihood frameworks aim to understand the multidimensionality, and social differentiation, as well as spatial and temporal variability that render livelihoods complex by providing a hypothesis on the relation of different components (Scoones, 2015).

The arguably most widespread livelihoods framework is the DFID Sustainable Livelihoods Framework (SLF) based on an initial framework developed by Scoones and his research team in 1998. This framework (presented below) is composed of 5 distinct elements: 1) Contexts, Conditions, and Trends – encompassing contextual factors ranging from policy to agro-ecological features as well as dynamics of social differentiation; 2) Livelihood resources – distinguishing between at least 4 different forms of capital (natural, economic, human and social); 3) Institutional processes and organizational structures; 4) Livelihood strategies and lastly 5) Sustainable Livelihood Outcomes. It establishes a linkage between the micro and macro level to explain why certain compositions of factors lead to their respective outcomes and to demonstrate that the two levels cannot be separated (Scoones, 2015, pp. 34–36).
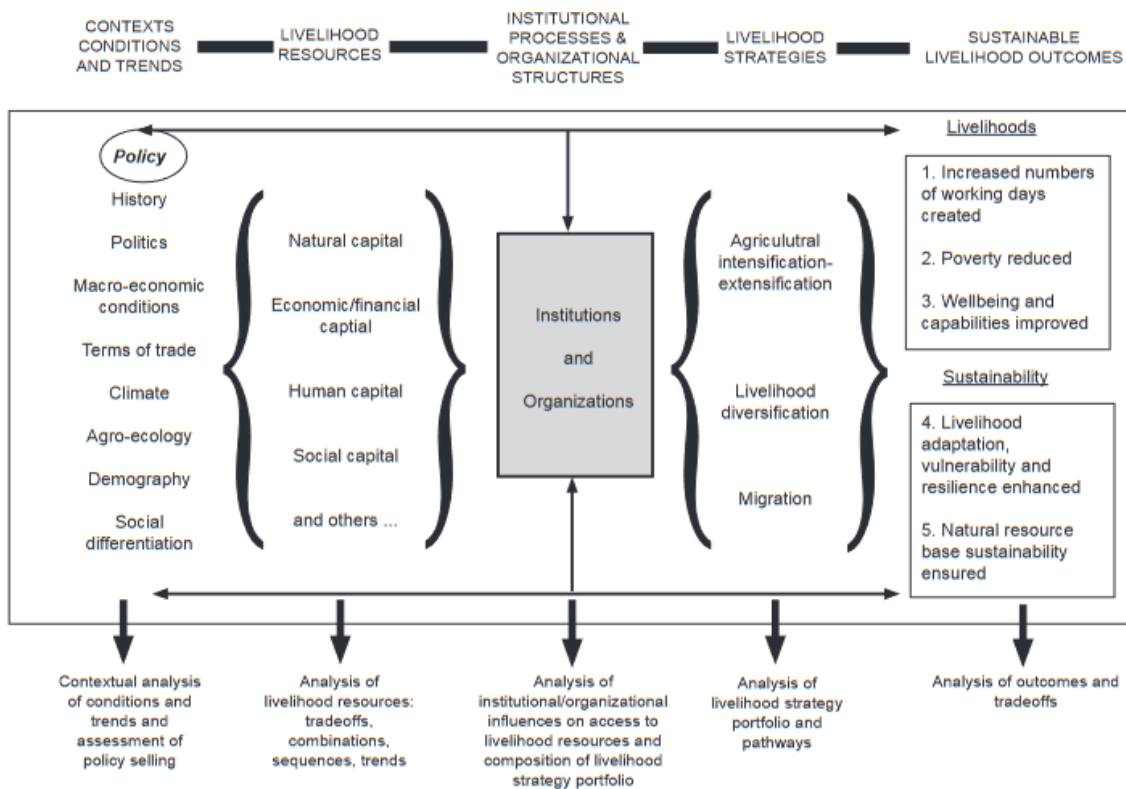
Illustration 1: The Sustainable Livelihoods Framework (Scoones, 2015: 36)

One of Ellis's main contributions to the livelihoods literature was his emphasis on a diversity of different livelihood strategies (Scoones, 2015) and developing an adaptation of the SLF that outlines the conditions and the context in which new livelihood strategies are elaborated.
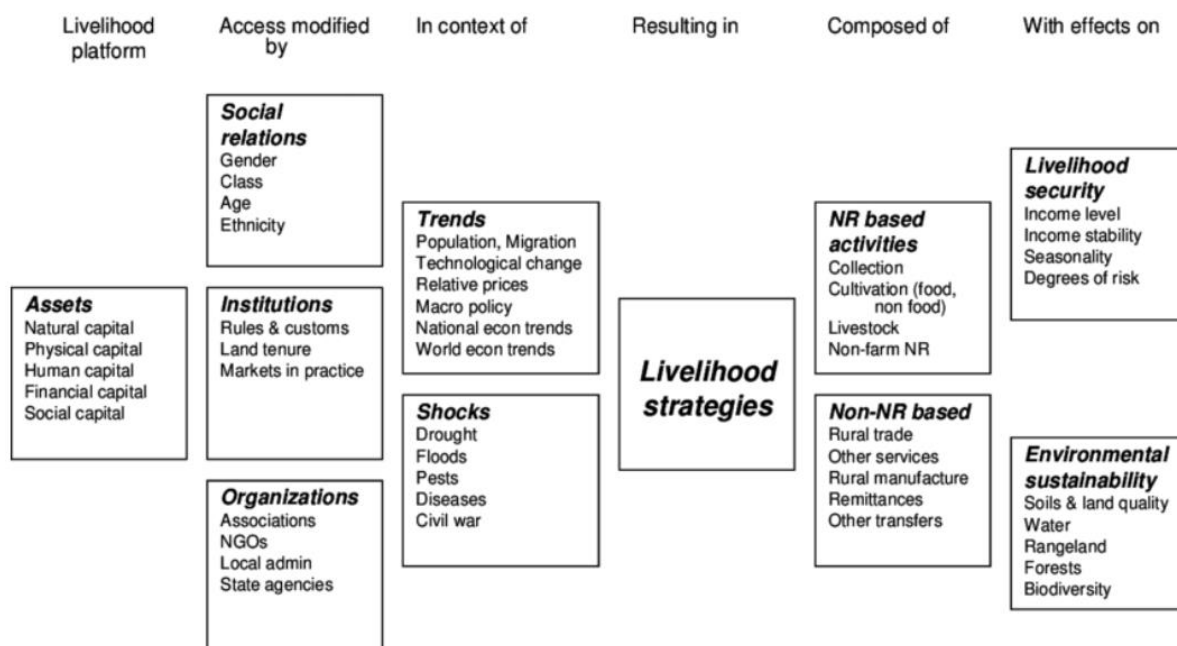
Illustration 2: A framework for the analysis of rural livelihoods (Ellis, 2000)

Ellis' framework for the analysis of rural livelihoods (presented above) demonstrates that assets – while central to analyzing an individual's capacity to pursue a certain livelihood strategy – must always be thought of in terms of how social relations, institutions, and organizations mediate access to them. Moreover, it outlines that these three just as assets and livelihood strategies must be seen in the context of ongoing trends and shocks (Ellis, 2000). His way of thinking about the viability of a livelihood strategy for an individual and influencing factors is a useful way to focus on the micro level without *'relegating'* broader factors to the *'context'* section (Scoones, 2015, p. 39). I argue that the use of WCIS in agricultural decision-making can be considered as an adaptation of an existing livelihoods strategy, which is why Ellis' SLF adaptation is used as a departure point for the theoretical framework of this research.

3.2   Theories on the uptake of innovation

While livelihood frameworks are helpful to understand contextual factors influencing the uptake of an innovation, a dedicated theory is required to learn more about how communication channels and innovation characteristics steer the decision-making process on the adoption of an innovation. Innovation can be defined as *'an idea, practice, or object that is perceived as new by an individual or other unit of adoption'* (Rogers, 2003, p. 24). This research considers WCIS as an innovation that must be evaluated and adopted by an individual. Hence, a theory modeling this process is required.

3.2.1   The Diffusion of Innovation theory

The Diffusion of Innovation (DoI) theory was originally developed by Rogers in 1962 and influenced by research undertaken on the diffusion of agricultural innovations in Iowa. He understands diffusion *'as the process by which (1) an innovation (2) is communicated through certain channels (3) over time (4) among the members of a social system'* (Rogers, 2003, p. 24). Especially his reflections on the advantages of different communication channels as well as the different features of social systems are helpful for the analysis of the WCIS in this research. He argues that mass-media channels are very effective in spreading information and increasing awareness about innovation, while personal information channels are deemed more effective in forming and changing attitudes toward an innovation (Rogers, 2003, p. 36). The DoI equally includes reflections on the structural characteristics of systems such as hierarchies or norms that can facilitate or impede the diffusion of an innovation.

The two most relevant aspects of the DoI theory for this research are the outline of the innovation-decision process as well as the identification of characteristics of innovations influencing their successful diffusion. Rogers argues that the innovation-decision process is comprised of 5 stages – 1) knowledge, when the individual learns about the innovation; 2)

persuasion, when the individual is in the process of forming an opinion on the innovation; 3) decision, when the individual arrives at a conclusion; 4) implementation, when the individual puts the innovation to use; and 5) confirmation, when the individual decides to either accept or reject the innovation (Rogers, 2003, p. 126).
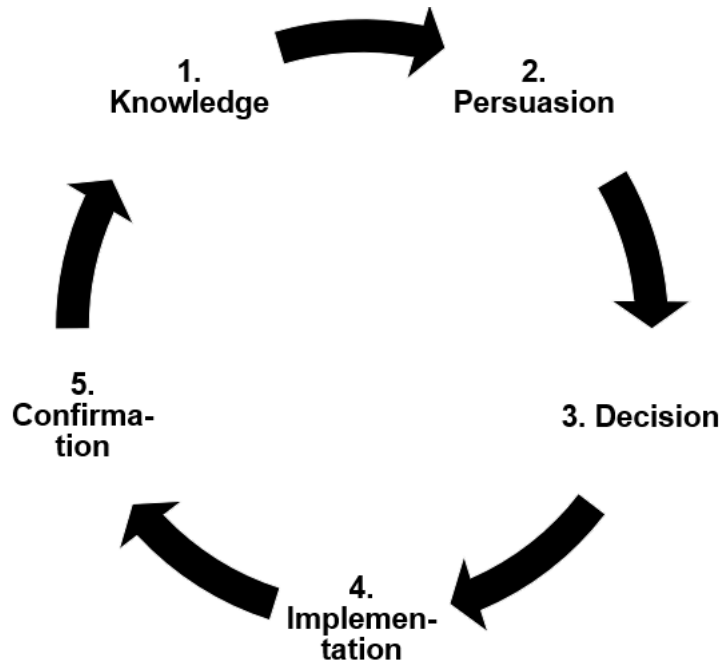
Illustration 3: Illustration based on Rogers (2003: 126)

He presents five characteristics of innovations that play a key role in the persuasion stage of the innovation-decision process. 1) Relative Advantage: Is the innovation perceived as having a relative advantage to the practices in use? 2) Compatibility: Is the innovation perceived as being compatible with the experience, values, and needs of the potential adopter? 3) Complexity: Is the innovation perceived as difficult to understand and use? 4) Trialability: Can the innovation be tested on a limited basis? 5) Observability: Are the results of the innovation use visible to others? Rogers argues that the higher the perceived relative advantage, compatibility, trialability, and observability, and the lower the perceived complexity, the higher the chances for adoption (Rogers, 2003, p. 26).

… increases the chances for adoption.	… decreases the chances for adoption.
• High relative advantage • High compatibility • High trialability • High Observability	• High Complexity

Table 1: Tabular overview of innovation characteristics and their influence on adoption based on Rogers (2003:26)

3.2.2 Why the diffusion of innovation theory?

Besides the DoI theory, other theories model the adoption of an innovation similarly well with the technology acceptance model (TAM) by Davis (1985) and Bandura's theory on Social Learning (Bandura, 1971) as prominent examples. While the Social Learning theory would be a very suitable model if the focus of the research would be on the role of social capital in accessing information, the TAM and the DoI theory are more fitting for the general adoption of an innovation. The TAM was developed to predict the step from motivation to actual use of any technology and its strength lies in the subdivision of motivation into subcomponents that are well suited for analysis (Marangunić and Granić, 2015).

Both, TAM and DoI, have their merits and have been employed by scholars to analyze the adoption of an innovation in a rural setting as illustrated by a selection of studies in the table below.

Use cases of the TAM by Davis (1985)	Use cases of the DoI by Rogers (2003)
• Analysis of the uptake of an integrated production system of beans (Silva et al., 2018) • Research on the acceptance of agricultural market information systems (Singh and Gurung, 2022) • Evaluation of agricultural decision support systems (Mir and Padma, 2020)	• Analysis of the adoption of integrated pest management practices (Peshin et al., 2009) • Analysis of WCIS uptake (Freeman and Mubichi, 2017; McOmber et al., 2013)

Table 2: Tabular presentation of a selection of studies on innovation adoption in agriculture

The main reason to select the DoI theory over the TAM is that the DoI encompasses more aspects of interest to diffusion processes itself and is not limited to the innovation-decision process, equally well modeled by the TAM. Rogers' (2003) insights on different information channels and the effects of social structure on access to WCIS link well with aspects of the livelihood framework. Moreover, the two innovation characteristics perceived relative advantage as well as perceived compatibility allow for meaningful integration of the interaction of WCIS with traditional knowledge in the decision-making process in line with the second research question.

Nevertheless, I want to acknowledge that the DoI theory has been developed to understand agricultural extension in the Global North and has been criticized for being applied to settings in the Global South with the perspective of a rural population in need of externally devised innovation neglecting existing indigenous innovation processes (Matthews, 2017). Rogers acknowledged that DoI research often came hand in hand with a pro-innovation bias – the implication that *'an innovation should be diffused to and adopted by all members of a*

social system' (Rogers, 2003: 84). Matthews (2017) proposes to engage meaningfully with and try to understand existing systems of knowledge. Rogers (2003) underlines, that acknowledging the existence of the pro-innovation bias is already the first step in counter-acting it. Hence, I plan to use the relative advantage and compatibility component of Roger's DoI theory to explore traditional forecasting systems as such and their interrelation with WCIS while being open-minded for the agency of the farmers to evaluate what works best for them.

3.3 Presentation of an integrated framework

After presenting the individual building blocks, this section proposes an integrated framework. Dinh et al. (2015) have already combined the SLF and the DoI theory to develop their Rural Livelihood Adoption Framework (RALF) to explain under what conditions individuals decide to adopt a new livelihood strategy. They argue that a livelihood framework alone does not represent the dynamism of changing livelihood strategies and lacks the conceptual framework to account for the decision-making process behind the selection, evaluation, and adoption of a new livelihood strategy.

The framework (presented below in illustration 4) encompasses 7 elements.
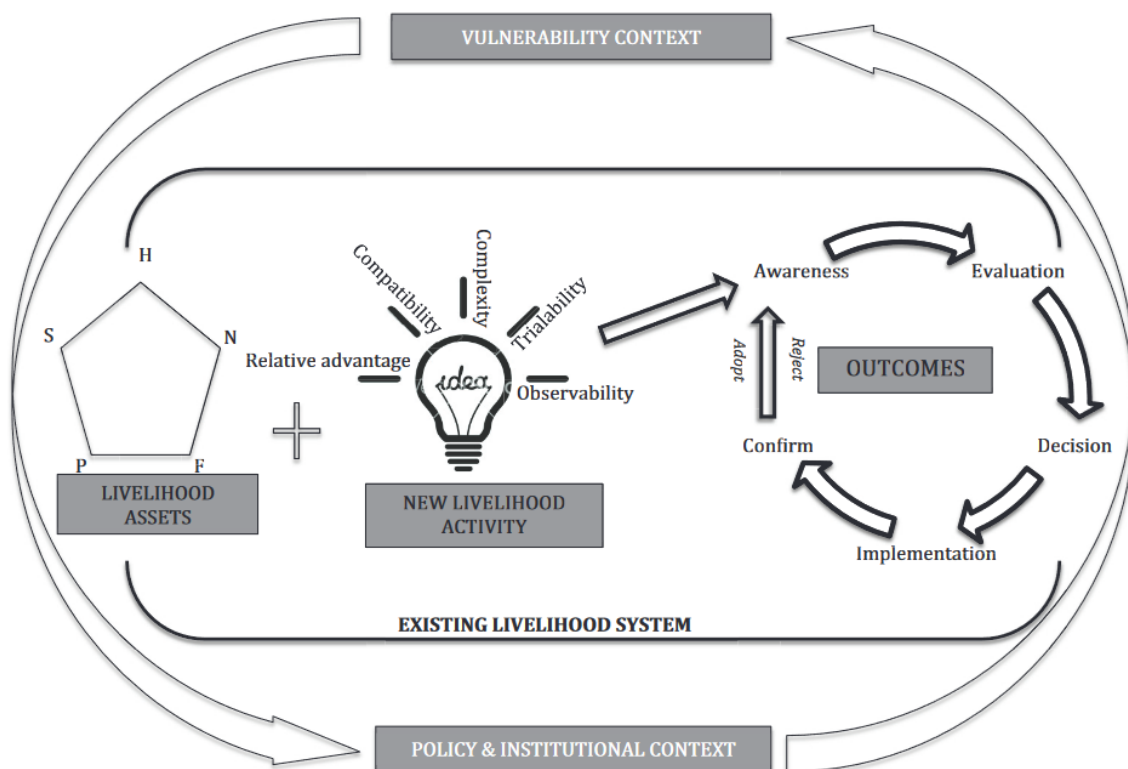
Illustration 4: The Rural Livelihood Adoption Framework (Dinh et al., 2015: 165)

It includes an existing livelihood system - representing activities and experiences; outcomes – which are the ends of each livelihood activity; a set of livelihood assets (physical, natural, financial, human, and social); a new livelihood activity which is considered for adoption in the innovation-decision process based on available assets and the characteristics of the innovation; and lastly an outer layer of vulnerability as well as policy and institutional context as external factors of the model influencing all the other components.

In my adaptation of the RALF by Dinh et al., I reuse 5 elements, the **existing livelihood system**, the **vulnerability context**, **outcomes**, **livelihood assets**, and the **innovation-decision process** including the characteristics used to evaluate an innovation.

My understanding of **human capital** comprises the labor available on a household level as well as the educational level and literacy of household members implicated in decision-making. I argue that it influences whether the WCIS is perceived as complex. **Social capital** is understood as the relative positionality of the household and its decision-makers in their community. Hence, it can enable a household to compensate for weaker assets by accessing the support of friends, family, and other community members. I hypothesize that it can improve a household's access to WCIS. **Physical capital** comprises among others agricultural equipment such as plows or sowing machines and radios or other devices used to access WCIS. A high physical capital can therefore enhance a household's capacity to access and exploit the potential of WCIS. **Natural capital** refers to a household's land and its ecological features such as soil composition and fertility as well as to livestock possession. Weak natural capital due to infertile land or no access to land at all can consequently limit the potential of WCIS use. **Financial capital** represents the household's access to financial resources that can be used to procure other forms of capital.

Moreover, I modified two elements, the 'policy and institutional context' as well as the 'new livelihood activity', to better reflect the research context. Because the literature review already indicated that gender norms, ethnicity, and other sociocultural aspects should be considered when analyzing WCIS uptake and use, I included them in the now-renamed **Policy, institutional and sociocultural context (PISC)**.

The second change concerns the new livelihood activity. The use of WCIS does not equal a new livelihood activity per se since it rather concerns a strategic approach to already existing activities. Nevertheless, it concerns the adoption of an innovation in Rogers' sense. Consequently, **WCIS use** replaces the new livelihood activity. Besides those 2 modifications of existing elements, I decided to include the element **support mechanism** at the border of the existing livelihood system. I argue that organizations such as NGOs, rural extension services, local information channels such as community radios, and local authorities are

already part of an individual's existing livelihood system. They have a direct influence on it and should be separated from the macro influences of the PISC.

An illustration of my Rural Innovation Adoption Framework based on the RALF by Dinh et al. (2015, p. 165) and applied to WCIS use is presented below.
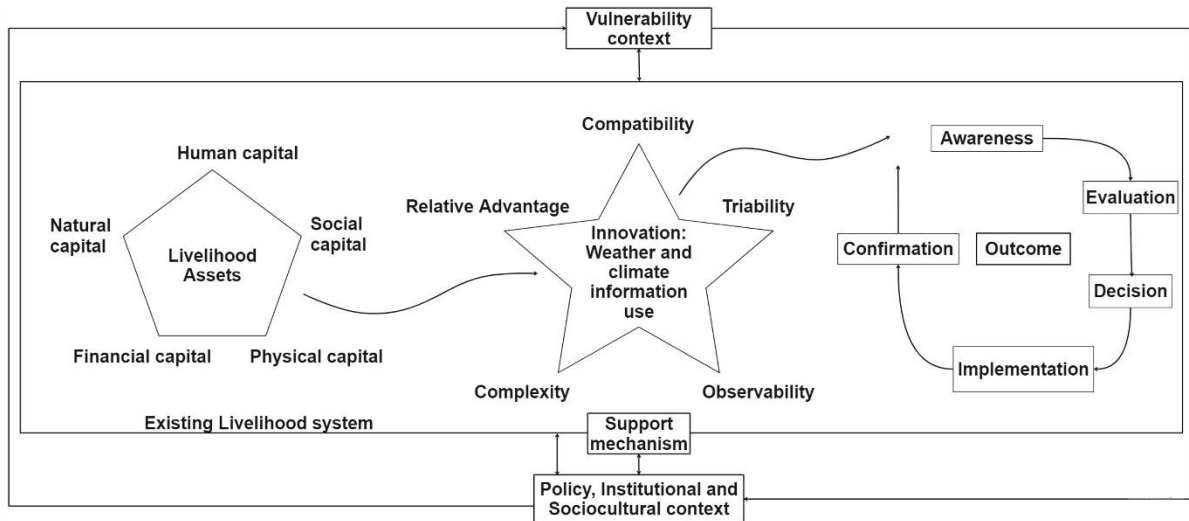
Illustration 5: Rural Innovation Adoption Framework based on the RALF by Dinh et al. (2015, 165)

4. Methodology

This chapter presents the methodological aspects of this research starting with the research design, followed by a description of the research site and sampling approach, a presentation of the data collection methods, and as well as the processes underpinning data analysis and presentation. The chapter is concluded with a reflection on ethical considerations and positionality as well as the limitations of this research.

4.1   Research design

In line with the research questions, this research adopts a qualitative approach. A case study research design is selected because the livelihood aspects of the participants are included as contextual variables due to their importance to explain conditions of use of WCIS and the role of traditional beliefs and forecasting systems in its uptake (Creswell and Creswell, 2007, p. 76).

4.2   Site description and sampling approach

4.2.1 Research context

My research site is the Tattaguine district, situated in the Fatick region in the West of the country and sharing a frontier with the Gambia.
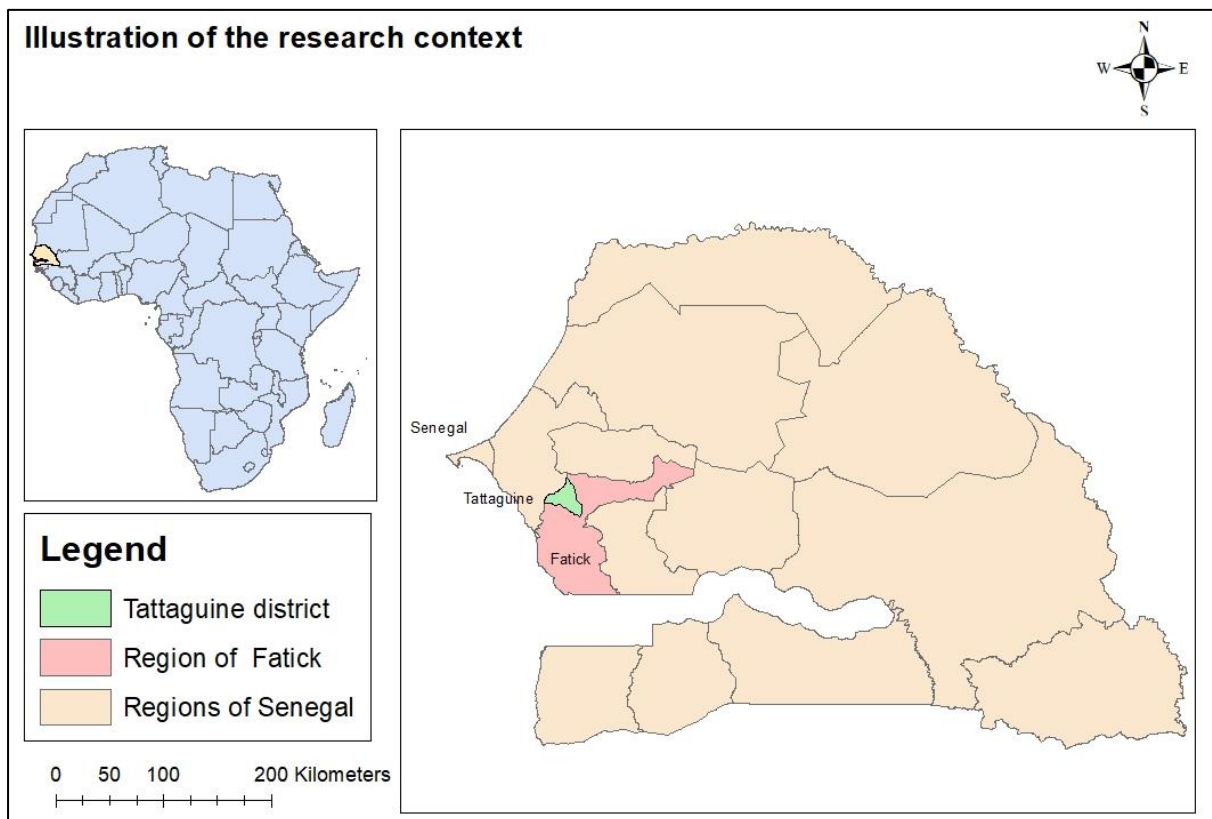
Illustration 6: ArcGIS visualization of the location of the research area within the country

The region will reach 1 million inhabitants in 2023 with approximately 117 thousand of them living in the Tattaguine district (ANSD, 2013). They are distributed over 3 communes[8] – Tattaguine, Diouroup, and Diarrère – and several small villages. Agriculture is the main economic activity of the region with 50% of the regional surface cultivated and almost 90% of the active population engaged in agriculture (ANSD, 2021). The education level of household heads in Senegal is overall very low – 67% of the men and 77% of women have not finished education of any level. This is also reflected in the literacy rate with only 40% of the male and 26% of the female household heads being able to read. The average size of cultivated land per household is 2,7 hectares (DAPSA, 2022).

4.2.2 Sampling approach to site selection

The selection of the region was purposive (Creswell and Creswell, 2007) due to its great Serer majority to understand WCIS use in a different ethnic contest as already covered by Carr et al. (2016). Within the region, the decision for the Tattaguine district was convenient because my host organization Enda Pronat has already established structures there, facilitating my access to research participants and enhancing my understanding of the research context.

For the sampling of villages, on the one hand, I wanted to strike a balance between having varying location characteristics to illustrate the diversity of settings in the Tattaguine district and the respective communes. On the other hand, I wanted to be able to compare individuals with very similar livelihood contexts to increase the comparability between cases. Lastly, I also wanted to investigate differences between villages currently accompanied and not accompanied by my host organization. This led to the decision of sampling three villages per commune, in each commune two villages were accompanied by my host organization, and one was currently not accompanied.

The decision on the study sites was convenient because I had to rely on interpreters employed as relays by the NGO[9] due to language barriers. The selection of interpreters with the best French-speaking skills to ensure high data quality led to the selection of the following villages (see table and illustration below).

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[8] Original designation: communauté rurale fr.
[9] The relays are farmers in target communities of Enda Pronat and were selected due to their capacity to transfer information and to support the facilitation of activities. Hence, by selection a relay I selected the village they were living in/or close by as a study site.

Commune	Village	
	Accompanied by my host organization	Currently not accompanied by my host organization
Tattaguine	Bacobof, Tattaguine Sérère	Ngohé Mbadatte
Diouroup	Njongolor, Ndoundour	Senghor
Ndiarrère	Mbassis, Wandiana	Mbetit Guye

Table 3: Tabular overview of the selected research sites

Senghor was purposively included despite having profited from interventions of my host organization a few years ago, because I had heard of Saltigué ceremonies taking place in this village, making it a particularly relevant research site for RQ2.
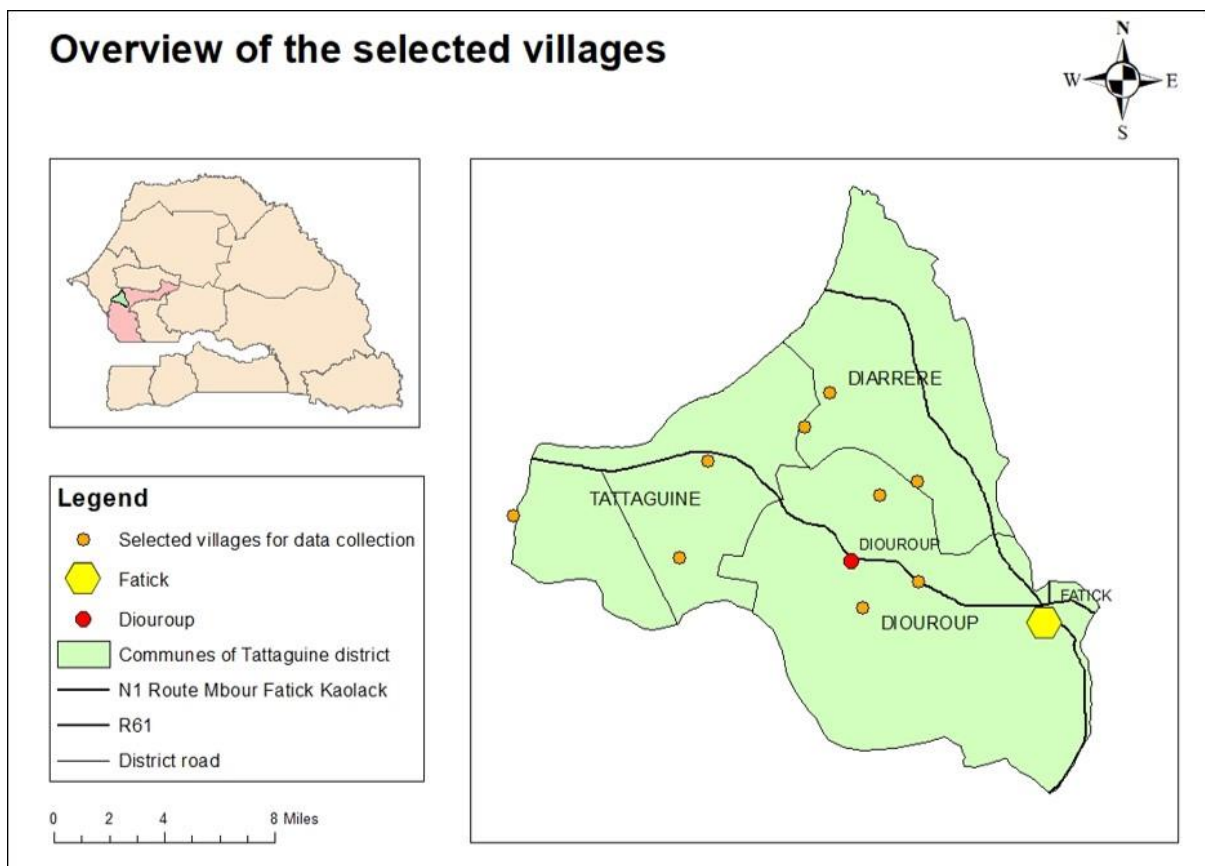
Illustration 7: ArcGIS visualization of the selected villages

4.3 Data collection methods

This research uses both primary and secondary data to gain a complete understanding of the complex conditions underpinning the decision-making process on WCIS use and its outcomes. Primary data was gained using a mixed-method qualitative approach based on structured interviews with smallholder farmers, key informant interviews with representatives of support mechanisms, and a focus group discussion with relays of my host organization. A

mix of qualitative methods was selected to contextualize the insights on individual decision-making processes gained from the individual interviews by approaching the same subject from different perspectives and to further corroborate my findings using method triangulation (Hammett et al., 2015). The insights were complemented by secondary data.

The main data collection took place between January 25th and February 17th, 2023, with some additional key informant interviews and the focus group discussion taking place in March and April 2023. The interview guides used for the structured interviews, key informant interviews, and focus group discussions can be found in Annex 1, 2, and 4.

4.3.1 Structured interviews

The structured interviews form the core of my research by investigating the livelihood conditions of the research participants as well as shedding light on their innovation-decision process of WCIS use (RQ1) and the role of traditional beliefs and forecasting systems mediating the process (RQ2). Because subsistence agriculture is undertaken as a family but usually controlled by a household head, unlike Carr et al. (2016) who focus on individuals within households, my unit of analysis is household heads and their livelihood asset composition. To increase the number of female participants, I decided to also interview female smallholder farmers that were not heading their households under the condition that they were engaged in agriculture and in the position to decide on WCIS use.

Originally, I wanted to conduct semi-structured interviews since they strike a balance of interview comparability and openness to allow the participant to share his perceptions (Hammett et al., 2015). However, this would have required a well-trained research assistant fluent in both French and Sérère to handle the openness and interactivity of this interview setting. Since budget constraints did not allow me to hire a research assistant, my host organization proposed that its relays could do the translation. While this meant a cost-effective approach to translation and greatly facilitated the sampling of the respondents, it equally meant relying on changing interpreters each of them based in their respective village. Hence, I decided to opt for a more structured interview guide to counteract the loss in comparability.

A total of 36 smallholder farmers were sampled for the individual structured interviews. The sampling strategy was a combination of purposeful sampling and a snowball technique relying on the relays of the organization to identify research participants for their village based on a defined profile – whenever possible an even number of male and female household heads representing the diversity of socio-economic situations of the village.

The composition of the respondent sample is presented in the table below:

Research participants	Male	Female	Total
Accompanied by my host organization	15	11	**26 / 72,2%**
Not accompanied by my host organization	5	5	**10 / 27,8%**
Total (absolute / %)	**20 / 55,6%**	**16 / 44,4%**	**36 / 100%**

Table 4: Tabular overview of the composition of research participants of the individual interviews

4.3.2 Key informant Interviews

Key informant interviews were used to better understand the production and diffusion of WCI in the Fatick region and the Tattaguine district by talking to different members of the local MWG. Moreover, they served to provide contextual information on support mechanisms, vulnerability context, and the PISC of the theoretical framework.

In total, 9 key informant interviews were conducted with representatives of state agencies on the national, regional, and local levels, the director of a community radio involved in the diffusion of WCIS and an employee of the World Food Programme (WFP), implicated in the promotion of the uptake of WCIS. An overview of the key informants, their responsibilities, and their contribution to the research will be provided in Annex 3.

4.3.3 Focus group discussion

The Focus group discussion (FGD) was conducted to gain group-level insights on the role of the relays of my host organization as one of the channels in the diffusion process of WCIS (Hammett et al., 2015) as well as to gain further contextual insights on the use of smallholder farmers and its potential difficulties in their respective villages. It took place on March 20th, approximately one month after the core data collection, to allow the design of the interview guide of the FGD to be informed by a review of the transcripts of the individual interviews.

Following the group size recommendation of Hammett et al. (2015), I selected 5 relays for participation resulting in an almost equal gender representation (3 men, 2 women). Loosely following a set of themes and questions, I have let the conversation flow and allowed the relays to react to each other's statements and challenge opinions (Bryman, 2012).

4.3.4 Analysis of secondary data sources

Secondary data sources were consulted to validate collected data on the livelihood system and complement the theoretical framework sections vulnerability context and PISC. Examples of secondary data include meteorological data on the vulnerability context, national statistics, policy documents, and reports. In the analysis of the secondary data

sources, their advantages such as their unobtrusiveness as well as potential pitfalls considering interest conflicts of authors were considered (Bryman, 2012).

4.4 Data transcription

Most interviews were conducted in both Sérère and French. However, I was only able to transcribe the French sections[10] of these interviews. To highlight this in the data, I encouraged the interpreters to replicate what the research participants shared in the third person as discussed by Temple and Young (2004). The transcription process was started directly after the first interview to identify potential problems with the recording and to reduce the amount of transcription work piling up after the data collection stage (Bryman, 2012).

4.5 Data analysis and presentation

For the analysis of the primary data collected, a thematic analysis following Braun and Clarke (2006) was employed due to its flexibility to be used with different theories. For the data analysis, the qualitative data analysis software NVIVO was used to organize and reorganize previously coded sections (Bryman, 2012). In line with Braun and Clarke (2006, pp. 86–87), I started the analysis process by familiarizing myself with the data during transcription but also through detailed re-reading and writing short descriptive memos for every transcript. A flexible deductive approach to coding driven by theory (2006), was used while maintaining an inductive stance, being open to themes emerging from the data that are not reflected by the theoretical framework (Bryman, 2012, p. 27). The codes used as well as insights into the analysis are included in Annex 6.

4.6 Ethical considerations and positionality

Using the ethical review self-evaluation provided by the LUMID program, I critically questioned the planned research procedures to identify potential problems and deemed that my research project entails minimal risk.

All research participants were informed in detail about the research, anonymity, the use of the data, and the voluntariness of their participation. They were then asked for their consent regarding participation and recording of the interview. In consideration of the high illiteracy rate among the research participants, I decided to abandon the use of a consent form and the consent was obtained orally (Bryman, 2012; Hammett et al., 2015).

Another important aspect of the research process is to practice self-reflectivity concerning my positionality as a researcher and potential personal biases (Bryman, 2012). My socio-

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[10] I asked the questions in french, the translator translated them to the research participant, listen to his response and translated it back to me in French as close to the original as possible.

economic background, being born and raised in a rich European country, and being academically and epistemologically trained in European academic institutions might for instance reinforce the pro-innovation bias of WCIS use and reduce the belief in the utility of traditional methods. These aspects in combination with my gender might have equally influenced the behavior of research participants as well as impeded my understanding of certain aspects of the study. I tried to counteract this by immersing myself in the local context and spending more than 1,5 weeks there before starting the data collection, by practicing continuous reflexivity, and by conducting the interviews always accompanied by a relay of my host organization well familiar with the local context.

While on the one hand, I profited from their familiarity with the context and their creation of a comforting interview atmosphere, their potential adverse influences on the interview situation as well as on data quality as '*gatekeepers*' and '*active producers*' of information have to be acknowledged (Williamson et al., 2011, pp. 383–384).

4.7   Research validity and limitations

Method triangulation and an extended stay in the study area were used to increase internal validity. With regards to external validity and the possibility of further generalizing the results, the case study approach of this research imposes its limitations (Bryman, 2012) since its aim was specifically to shed light on contextual factors as well as the role of traditional beliefs and forecasting methods of the research participants in WCIS use. Consequently, the applicability of the findings presented in the following sections is limited to the researched context, while the methodological and analytical approach could be reproduced elsewhere.

The central limitations of this research are methodological and were already indicated in the presentation of the followed procedures above. The reliance on interpreter-facilitated interviews can potentially introduce new biases to the data such as loss or modification of meaning due to the value-laden nature of words, concepts, and language as such (Temple and Young, 2004). It also introduces an additional actor to the interview situation with possibly positive and adverse implications (Williamson et al., 2011). My setup was further complicated by changing interpreters. I tried to circumvent negative implications for my research by briefing the interpreters on the research, the importance of '*conceptual equivalence*' of the translation, by standardizing the questionnaire, and by not relying on the individual interviews as a single data source (Williamson et al., 2011, pp. 383–384, 391).

5. Results

This chapter presents the research findings and is composed of 3 major sections. The first one situates the findings in the overarching context and explains the regional WCIS production and diffusion system. The second section explores the findings related to RQ1 with particular consideration of gender differences. Lastly, a detailed presentation of the existing traditional beliefs and forecasting systems and their interaction with the adoption of WCIS is given (RQ2).

5.1   Situating the analysis

Decisions of smallholder farmers do not happen in a vacuum. Their livelihood system is influenced by the vulnerability context, the PISC, and support mechanisms active in the region which are presented in the following sub-sections.
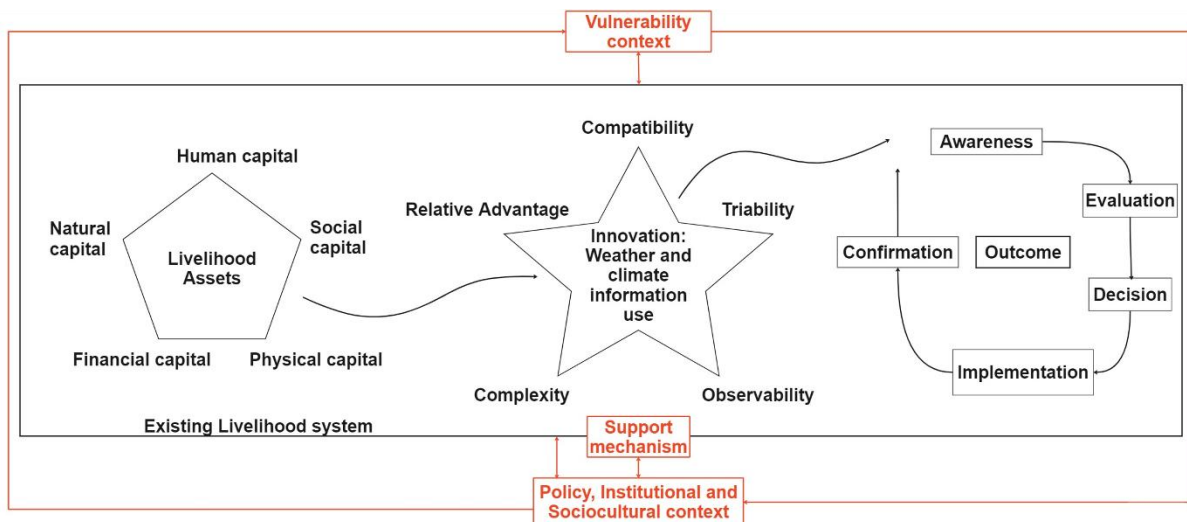
Illustration 8: Situating the analysis (discussed elements highlighted in red)

5.1.1   The vulnerability context

Over the past 12 years, annual precipitation levels in Tattaguine have varied drastically interanually around the average of 548 millimeters per year and peaks doubling it. The precipitation levels also exhibit great variability between localities in the Tattaguine district (KI3). These interannual differences combined with rather stagnant and low rainfall days per season as illustrated below indicate the prevalence of heavy rainfalls and rainfall pauses, causing difficulties for agricultural production.

21 out of 36 respondents report problems of increased weather variability, flooded fields, and rainfall breaks negatively affecting their production but also impacting their natural and physical capital by killing livestock (P17) and destroying houses (P15).
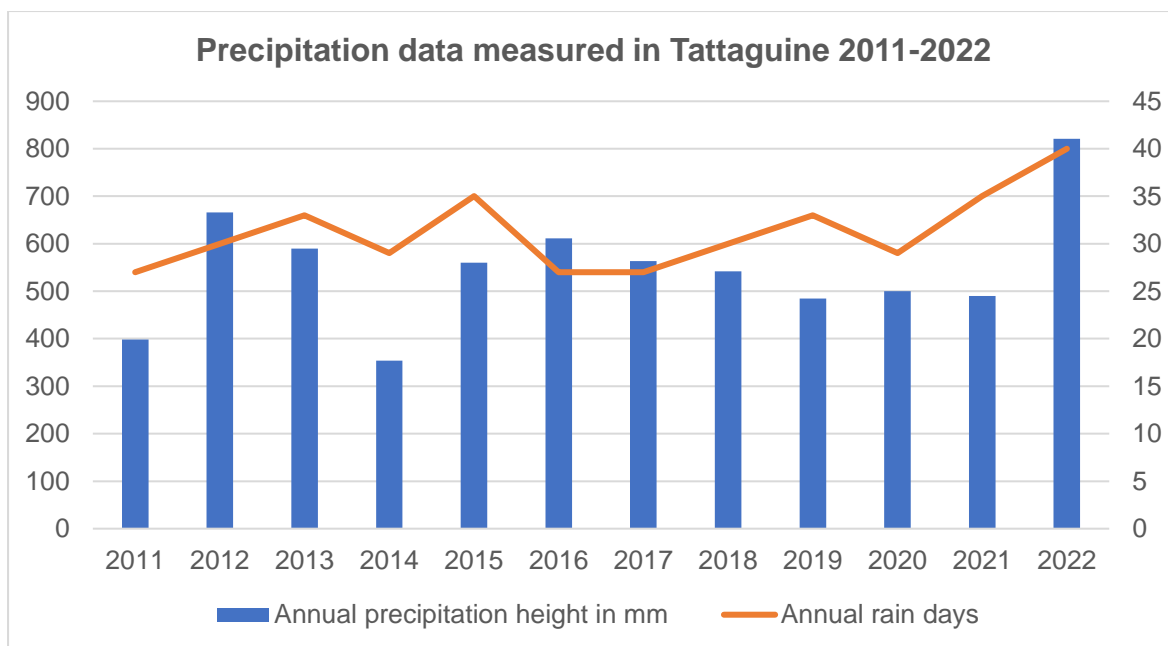
Illustration 9: Interannual differences in annual precipitation based on data provided by ANACIM Fatick

Another long-term trend negatively influencing agricultural production in the Tattaguine district is the 'weak' (Levard and Mathieu, 2018, p. 9) fertility and increasing salination of the soil. This trend of advancing salination since 1994 (highlighted in red in C and D) is visualized in illustration 10 below (Faye et al., 2019) and an employee of the project Provale CV[11] confirms that it poses a challenge to agricultural development in the region (KI6)[12].
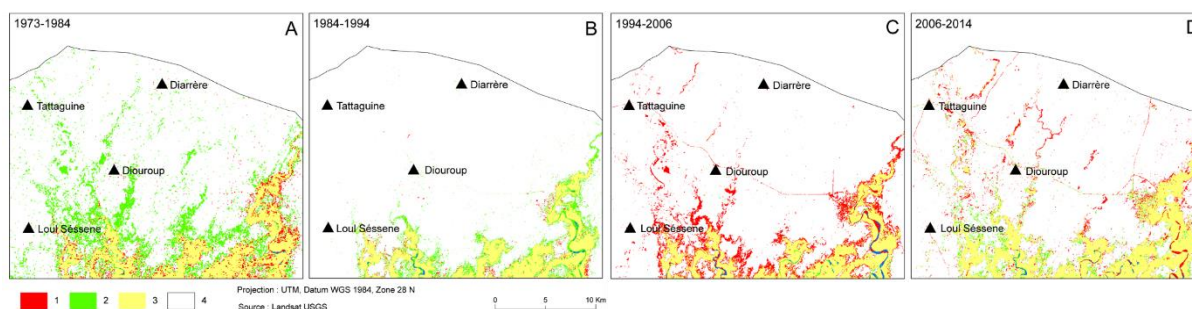
Illustration 10: Historic development of the salination of soils in the Fatick sub-region (Legend: Red: Soils becoming salty; Green: Desalinated soil; Yellow: Constantly salted soil) taken from (Faye et al., 2019, p. 7)

When asked about challenges in their agricultural production, two-thirds of the participants brought up the lack of fertilizers and soil infertility. Research participant 23 further illustrates

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[11] Original designation*: PROVALE-CV (Projet de Valorisation des Eaux pour le Développement des Chaines de valeur) fr.* A partially state-funded value chain development and irrigation project
[12] KI6 = Key informant 6. More details on the key informants can be found in the Annex. To protect their anonymity, their names and exact positions are not revealed and throughout the text only male pronouns are used in relation to key informant's responses.

the impact on his production stating that *'the other part without fertilizers does not give a good harvest.'*

Combined, the climate variability and degraded land led to overall steadily decreasing harvests in the past years observed by the research participants resulting in *'increasing difficulties to feed the family'* (P24). The exceptionally unfavorable conditions of the last rainy season have further exacerbated these difficulties by driving up prices for food and seeds. Some families face the problem of not being able to afford groundnut seeds – the main cash crop cultivated in the region – depriving them of potential future income and perpetuating the vicious cycle (f.i. P9, P18, P34). In total, more than one-third of the interviewed farmers reported problems accessing seeds as a result of the bad harvest in the last years.

Lastly, according to World Bank research (2023), inflation reached a record high of 14,1% in November 2022, mainly driven by food and energy price inflation and international trade restrictions as consequences of the conflict in Ukraine. This further aggravated the pressures on smallholder farmer households.

5.1.2 The policy, institutional and sociocultural context (PISC)

After exploring the vulnerability context, this section illustrates the PISC starting with policies.

Policies

While a wide range of policies influences the livelihoods of farmers in the Tattaguine district, I limit myself to policies concerning agriculture, climate change adaptation, land governance, and inflation.

Firstly, the national development strategy (PSE[13]) adopted in 2014 shifted the role of agriculture from poverty reduction to transforming Senegal into an emerging country by 2035 by increasing productivity and *'restructuring'* family-based subsistence agriculture (MEFP, 2018, p. 64). While it might address the lack of opportunities outside of agriculture and the rural exodus of the youth (f.i. P6, P11, P13), it risks leaving smallholder farmers struggling to keep up with the transformation.

Secondly, the PSE acknowledges the climate change threat to agriculture and envisions the promotion of *'intelligent technologies'* to increase the resilience of farmers against climate change (MEFP, 2018, p. 66). This creates a supportive environment for the further development of WCIS production, diffusion, and use in Senegal.

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[13] Original signification : *Plan Sénégal Émergent* fr.

Thirdly, the complex land governance system in Senegal poses a challenge for smallholder farmers, as its legal foundation – a post-independence law[14] that transformed about 95% of the land into a national domain – is contested by traditional customs in the attribution and inheritance of land. The arable land of the national domain has been assigned to rural assemblies on the communal level which attribute untransferable use rights to its inhabitants. Although the sale of the land is prohibited, in practice legislation is bypassed by selling trees or construction on the land (Cottyn et al., 2018). In combination with fragmented systems to register land titles and the influence of the mentioned traditional customs claims overlap and lead to the loss of land (P10). Moreover, land transactions can be unilaterally decided by the government if in the public interest (IPAR et al., 2019) causing the insufficiently compensated loss of land for the construction of a road of one of the research participants (P36).

Lastly, the Senegalese government reacted to the international trade restrictions and the resulting food and energy price inflation with subventions to temper their social consequences (IMF 2022). This illustrates the reactivity of the different elements of the theoretical framework.

Institutions

The two decisive institutions in the production, diffusion, and support of the utilization of WCIS are ANACIM and the national agency for agricultural extension ANCAR[15]. Hence, their institutional challenges and development will be presented below.

ANACIM started producing and diffusing WCI in 2009 and the start of a research program including a pilot in the Kaffrine region was a decisive step in the preparation for the national scale-up after 2015. Since then, the range of forecast products and diffusion methods has increased and the quality of the forecast significantly improved. This can be attributed to the capacity development of the staff, research collaborations with international institutions[16] to improve the forecasting models and, lastly, the improvement of the equipment which just in 2019 has been strengthened by the acquisition of a supercomputer[17]. While the means still rest limited, it has allowed ANACIM to move from predictions for agricultural zones, partially encompassing multiple regions, to predictions on sub-regional levels, and further advancements are planned (KI9).

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[14] law no.64-46 of 1964
[15] Original signification: *Agence Nationale de Conseil Agricole et Rural (ANCAR) fr.*
[16] Such as Columbia University
[17] Financed by a USAID project

ANCAR was created in 1999 in the context of the World Bank project PSAOP[18] and further supported to establish its presence nationwide (Faye, 2005). The end of project funding created the need to acquire funding from state- or externally financed projects and lead in combination with the introduction of WCIS to institutional development and increased operational efficiency. Although the financial situation has improved in the last few years, it is still insufficient to pay for all the equipment necessary. Currently, the funding allows ANCAR only to cover 73% of the communes with their support, and not everybody in the communes is reached (KI8).

To increase the reach, ANCAR and ANACIM have launched an interactive application combining WCIS with actionable advice and started training farmers on its utilization (KI8). However, since the application requires access to a smartphone and French reading comprehension, it risks benefiting only relatively privileged farmers and leaving vulnerable groups behind. To circumvent this, ANCAR plans to establish a data center to provide support in more accessible formats such as vocal messages once they have acquired funding (KI8).

Sociocultural context

This section illustrates the implications of the sociocultural context for decision-making and access to land as well as resources.

In the rural area, traditional customs regarding decision-making and land governance often follow Muslim traditions with the usually male[19] household head being in charge (Cottyn et al., 2018). If several adult men live together due to land scarcity, the oldest man assumes the role of the household head. He takes the decisions in agriculture, but everybody who is old enough[20] supports the work in the field.

Labor in agriculture is often gendered by activity and crop type. Millet, the main stable crop, is handled by the men, and hibiscus, cowpeas as well as rice are considered the *'crops of the women'* (P16). Groundnut, the main cash crop, is sometimes cultivated by both genders. However, following tradition, the household head's field will always be prioritized for input and machine use and the sale of groundnut, even if cultivated by the woman, will be undertaken by the household head (f.i. P19, P24). Those gendered responsibilities and

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[18] Full name: *Programme de services agricoles et organisation de producteurs* (PSAOP) fr.

[19] According to national statistics, 92% of the households in the Fatick region are headed by men (DAPSA, 2022).

[20] The concept of age and who is old enough to work differs drastically between households. This is highlighted by 70% of all child labor worldwide taking place in agriculture (Greenfield, 2022). The extent to which households depend on their children depends on the household assets, in particular, the available labor but also financial pressures.

different labor involvements for crop types have been already observed by Carr et al. (2016) for the Wolof ethnic group.

The responsibility for household chores is highly gendered with the wives being in charge and supported by their daughters. A woman can only become the household head if her husband is working in another city or dead. But even as household heads they have to do *'the work of the men but also the work of the women in the house'* (P2) resulting in a double burden.

Women do not directly inherit the land. They can only access it through their sons until they are old enough themselves to take over the responsibility. If the husband had brothers, they will also claim a part of the land (P30). However, because access to the inheritance is not well enough ensured, widows are disadvantaged in claiming the land from the brothers of the husband and sometimes even years after their husband's death without land to provide for their family (P8). This is reflected in the statistics with only 3,1% of land title holders in the Fatick region being women, well below the national average of 8,9% (DAPSA, 2022).

5.1.3 Support mechanisms in the Fatick region

After introducing the PISC, this section concludes the context analysis with a presentation of actors and channels producing and/or diffusing WCIS.

A central actor is the regional multi-disciplinary working group (MWG) of Fatick, which was initially created in 2015 and regroups several organizations including state and non-state organizations as summarized in the table below (KI1).

Organizational Group	Organization	Interviewed?
Representatives of decentralized state agencies and ministries	Regional Directorate for rural development of the Fatick region (DRDR)[21] (attached to the Ministry of Agriculture)	No, as the SDDR often replaces the DRDR and both represent the same ministry.
	Service for rural development for the sub-region of Fatick (SDDR)[22] (attached to the Ministry of Agriculture[23])	Yes
	Rural Agricultural Council[24] of the Fatick region (attached to the National Agricultural Extension Service ANCAR[25])	Yes
	Regional Weather Station Fatick	Yes

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[21] Original signification : Direction régionale du développement rural (DRDR)

[22] Original signification : *Service départemental du développement rural (SDDR) fr.*

[23] Original signification : *Ministère de l'Agriculture, de l'Equipement rural et de la Souveraineté alimentaire (MAERSA) fr.*

[24] Original signification : *Conseil agricole et rural (CAR)* fr.

[25] Original signification : *Agence Nationale de Conseil Agricole et Rural (ANCAR) fr.*

	(attached to ANACIM)	
	Veterinary Service (attached to the Ministry of Livestock and Animal production[26]	No, the work of the agency is out of the scope of this research.
	Regional Directorate for the Water and the Forests (attached to the Ministry of Environment)	No, the work of the agency is out of the scope of this research.
	Regional office of the National Agency of Food Security (CNSA)[27]	No, the work of the agency is out of the scope of this research.
Local press	Community radio Ndef Leng	Yes
Projects / NGOs	Project Provale CV	Yes
Producer organizations	Regional coordination commitée of producer organizations[28]	No (listed in an internal document, but not mentioned in the key informant interviews)
Representatives of the population	Mayors of the communes	No (listed in an internal document, but not mentioned in the key informant interviews)

Table 5: Tabular overview of the composition of the MWG Fatick

During the rainy season, the MWG meets on a 10 day-basis and each of the state agencies gives a sector update. Based on the first seasonal forecast provided by ANACIM, representatives of the Ministry of Agriculture will decide on the provision of subventioned varieties and inputs adapted to the coming rainy season (KI1). Throughout the rainy season, the occurrence and impact of different weather events and their implications for agriculture are discussed.

The discussions of every meeting including recommendations for agriculture are summarized and shared with several actors after every session via email and Whatsapp groups (KI1, KI2). However, not all organizations involved in agricultural development seem to receive it and its very technical French complicates comprehension for untrained readers. An example of the 'bulletin' of October 2022 is attached in Annex 7.

Three region-specific channels diffuse WCI in the research context.

Ndef Leng is the most important diffusion channel in the region because it is the only mass media channel diffusing the WCI and MWG meeting outcomes in the local languages Sérère and Wolof (KI1). It combines the advantages of a mass media channel to increase the awareness for WCIS but at the same time promotes interaction and hosts discussions on WCIS necessary to provide listeners with evaluative information to decide on their use (Rogers, 2003). This is further enhanced by joint training organized with agents of ANACIM

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[26] Original signification : *Ministère de L'Elevage et des Productions Animales (MEPA)* fr.

[27] Original signification : *Conseil national de la sécurité alimentaire (CNSA)* fr.

[28] Original signification : *Conseil régional des Coopérations des Ruraux (CNCR)* fr.

in selected communities that are broadcasted on the radio. However, several key informants acknowledge that funding for those activities is insufficient despite their high utility (KI3, KI4).

The second regional channel is ANCAR agents who accompany the farmers with their agricultural advice, reply to messages and calls on forecasts and diffuse information via Whatsapp status, group chats, and text messages (KI2, KI5). However, out of my 36 research participants, only one names agents of ANCAR as an information source, and three explained to seek their support regarding advice on seeds and soil types. The majority (55,5%) state that they do not even know ANCAR. While these numbers are not representative of the entire district, they highlight existing coverage gaps in ANCAR's services. A local agent explained that without a motorbike, his mobility in his commune is very limited and he acknowledges being more present in the villages close to the national road (KI5).

Photo 1: Weatherboard provided by WFP and Provale CV to communicate WCIS. Photo taken by Johannes Becker in Senghor.

WCI diffusion by other actors such as relays of the WFP, the farmer organization SAPPATE Tattaguine and Enda Pronat constitutes the third channel. Contrary to other regions, those organizations are not invited to participate in the MWG (KI1), but the WFP is informed about the content due to its affiliation with the project Provale CV (KI6, KI7). They improve overall

access to WCIS by informing producers with radio access about important Ndef Leng emissions, organizing listening groups on the village level, and documenting WCI using Weatherboards (see photo above) (KI7). Unfortunately, their training on WCIS including variety selection is focused on rice in line with Provale CV's focus.

Enda Pronat follows a different approach and diffuses WCIS relying on relays on the village level, who have been trained to understand and communicate the information. Although they still report limits in understanding the information and are only able to reach about 80% of the inhabitants, they combine information with advice on its use and are highly trusted by the respondents (FGD). Naturally, as a consequence of the sampling strategy, this channel is one of the most important information channels with 19 out of 36 reporting to receive WCIS from it. However, the percentage of farmers on the district level receiving such external support is significantly lower with the two organizations covering less than 20% of the villages in the district (FGD, KI7).

Additionally, an array of national channels such as television, national radio channels as well as SMS, voice messages, and other reception formats for mobile devices exist. However, besides the radio (20/36), the coverage of the other national channels was relatively low as illustrated by the table below.

Lastly, the social network is an indirect but for half of the participants additional and some producers even the only access channel and, therefore, needs to be mentioned.

Identifed WCI Diffusion channel	National / region-specific	Access type (direct/ indirect)	Reported as an information source by # farmers
Community radio Ndef Leng	Region-specific	Direct	15 / 36
Bulletin of the MWG of Fatick	Region-specific	Direct	0 / 36
Training on WCIS use and seasonal forecasts implemented by a technician of ANACIM and hosted/funded by a diverse range of organizations	Region-specific / national	Direct	6 / 36
ANCAR agents spreading agricultural information accompanied by technical advice	Region-specific / national	Direct	1 / 36
NGOs/projects/farmer organizations relaying WCIS to farmers and providing training	Region-specific / national	Direct	19 / 36
Radio (nationwide available channels such as RTS)	National	Direct	20 / 36
Television	National	Direct	6 / 36
Mobile devices (SMS, phone calls, vocal message in local language, Whatsapp	National	Direct	6 / 36

groups, Access to internet radio/TV, Access to Weather Forecast applications, New application of ANCAR)			
Emails by ANACIM	National	Direct	0 / 36
Website (www.anacim.sn)	National	Direct	0 / 36
Social Network	Community level	Indirect	18 / 36

Table 6: Tabular overview of identified WCIS diffusion channels based on key informant interviews and structured interviews with smallholder farmers

5.2 Status Quo of WCIS use and influencing factors (RQ1)

This section presents the findings related to RQ1 by illustrating first general observations on the extent of WCIS use before diving into influencing conditions and looking at gender-based differences.

5.2.1 General observations

The findings demonstrate very high overall access to WCIS (97%) and 27 out of the 36 participants have access to at least one of the direct WCIS diffusion channels. This can be partially explained by the sampling strategy as well as the time that passed since the scale-up of WCIS diffusion to the Fatick region in 2015 (Rogers, 2003).

Based on the answers given in the interviews, I classified the WCIS use of every research participant as either systematic, limited, rudimentary, or no use. A systematic user of WCIS uses both seasonal and weekly/daily forecasts consistently, while a limited user of WCIS already implements certain adaptive actions but not consistently. Rudimentary users follow WCIS, but it seems not to be decisive for their decision-making in agriculture and lastly, some participants did not use WCIS at all. The classification definitions and their frequencies are summarized in the table below and further information on the classification of the interviews is provided in Annex 5.

Classification	Definition	# / %
Systematic use	The farmer uses consistently both seasonal and weekly/daily forecasts to plan the different agricultural operations including but not limited to: preparations, selection of adapted variety, strategic planting by avoiding flooding-prone areas in high precipitation seasons, sowing date adaptation, weeding, fertilizer use, plowing, harvest date adaptation, conservation techniques	16/36; 44,44%
Limited use	The farmer recognizes the importance of adaptive action and adapts certain operations, but not consistently.	11/36; 30,56%
Rudimentary use	The farmer explains to follow the information, but WCIS does not seem to be decisive in his agricultural decisions	3/36; 8,33%
No use	The farmer does not rely at all on WCIS for his agricultural production	6/36; 16,67%

Table 7: Tabular overview of use type classification, their definition, and their frequency

75% of the participants use WCIS at least in a limited manner indicating that the farmers overall perceive the received information as useful and decided to act on it. However, even in a sample with comparatively high access to WCIS more than half of the producers are not using the information systematically illustrating the need of the population for technical advice on how to use the WCI.

Comparing the three communes, 58% of the participants from Tattaguine and 45% from Diarrère but only 30% from Diouroup systemically used the WCIS, indicating differences on communal level. Moreover, in villages accompanied by Enda Pronat, 80% used the information at least in a limited manner, compared to only 63% in not accompanied villages. This is in line with findings on improved access due to external support (Diouf et al., 2019; Ouedraogo et al., 2021).

When looking at use types through a gender lens, great differences become apparent. All non-users of WCIS are women (6/16) and only 12,5% systemically used WCIS compared to 70% of the men. The following section will utilize the two groups – men and women – as an illustrative case to employ the theoretical framework and explain differences in use types.

5.2.2 Explaining gender differences in use types

Differences in use types are the result of a wide range of factors and individuals are likely unevenly affected by the different aspects of the context. In the following section, I will zoom into the micro level and limit myself to the results of the interplay between the vulnerability context, the PSIC, and the individual capacity to adapt to it, which are reflected in the livelihood assets.
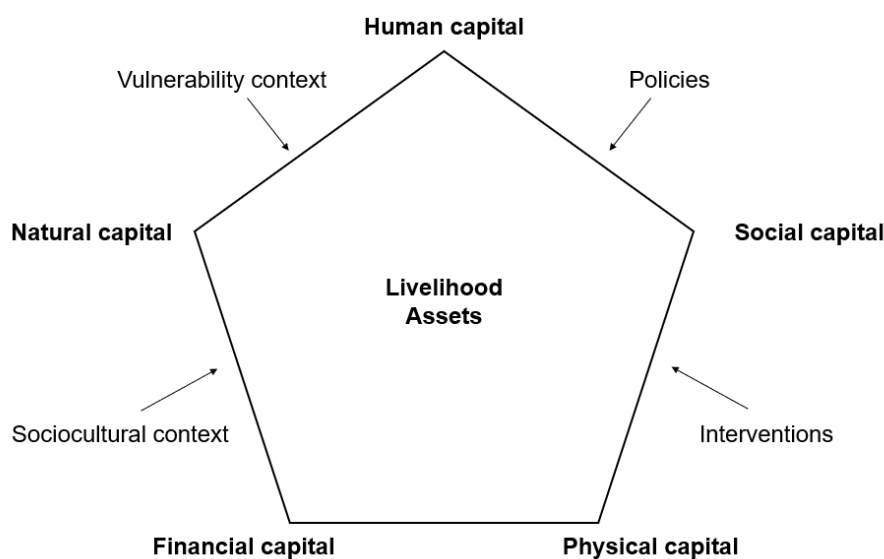
Illustration 11: The Livelihood Assets – result of several influences

Differences in livelihood assets

In the following paragraphs, I map out an estimated average of the asset composition of male and female-headed households and highlight the differences.

Female household heads in my sample have higher illiteracy rates (62,5% vs. 55%), lower French comprehension skills (18,75% vs. 35%) and their households have a significantly lower adult/dependent ratio (0,97 vs. 1,5) than their male counterparts resulting in an overall lower human capital[29]. The low available labor is further aggravated by the double labor burden and can lead to insufficient completion of agricultural activities such as weeding reflected in a lower harvest (P17, P35). Moreover, it restricts the time available to access WCIS (P35) in line with the findings of McOmber et al (2013).

This trend is continued for physical capital. Female-headed households have significantly lower ownership rates of a complete set of agricultural machines (16,67% vs. 50%) and of devices to access WCIS such as radios (42% vs. 65%), phones (25% vs. 45%) and television (8% vs. 25%) in comparison with male-headed households. This is equally reflected in the use rate of the most important WCIS channel Ndef Leng (33,33% vs. 60%). Overall these ownership differences result in significantly lower direct access to WCIS in line with the findings of Diouf (2019). Moreover, the lack of machines leads to a decreased independence in the planning of agricultural operations due to the need to borrow machines.

Social capital was the most difficult asset to compare. Farmers depend on community members to exchange favors such as borrowing machines but also to share information. Due to their weaker asset composition and lower direct access to WCIS, women in my sample seem to be more dependent on their social network with one-third of them relying on it as the only WCIS source. This high importance of social networks as information channels for women is in line with the findings of Diouf (2013) and McOmber et al. (2013). However, individuals differ in their position within networks and in the number of stronger and weaker ties to people in and outside of their immediate community (Granovetter, 1973). Within my research sample, men are more often in influential positions as religious or spiritual leaders (P4, P32), community representatives (P13), presidents of local saving groups (P16, and relays of NGOs (P17, P21, P36), resulting in a slightly higher rating.

Female-headed households report on average that their harvest lasts them only 4 months compared to 9 months of their male counterparts. Hence, they face higher expenses to feed their families and can keep less to invest in their production and other income-generating

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[29] Educational level would have been equally interesting to consider in the human capital measurement. However, the overall education level in my sample is so low (75% have not attended or finished primary school) that literacy is the better-suited variable to explain differences in access to information.

activities. Looking at additional income sources, both female and male household heads are regularly engaged in secondary activities (68,7% vs. 75%). However, while women often practice small commerce such as preparing sandwiches or selling chickens, men are sometimes able to invest in small irrigation systems and practice market gardening or engage in livestock production and sale on a bigger scale. In total, this results in a significantly lower financial capital of female-headed households.

Lastly, the natural capital of female-headed households is likewise lower. Not only do they have on average way smaller plots (2 vs 4 hectares) due to the described inheritance patterns, but they also have a lower possession rate of tractional animals for their machines (50% vs 95%) and if they own livestock, it is usually limited to local chickens, pigs, and 1 or 2 goats. If men are engaged in livestock, they tend to own at least a small herd of sheep and goats and sometimes even cows, often used for wealth accumulation in rural settings. The lower availability of livestock in female-headed households and thereby, lower availability of organic fertilizer, is particularly detrimental to agricultural production in the context of the infertile soil illustrated in the section on vulnerability.

To conclude, the analysis revealed that female-headed households have on average a lower possession of each asset type as visualized in illustration 12 below. This has direct implications on their capacity to access and use WCIS which will be further discussed in the following sections.
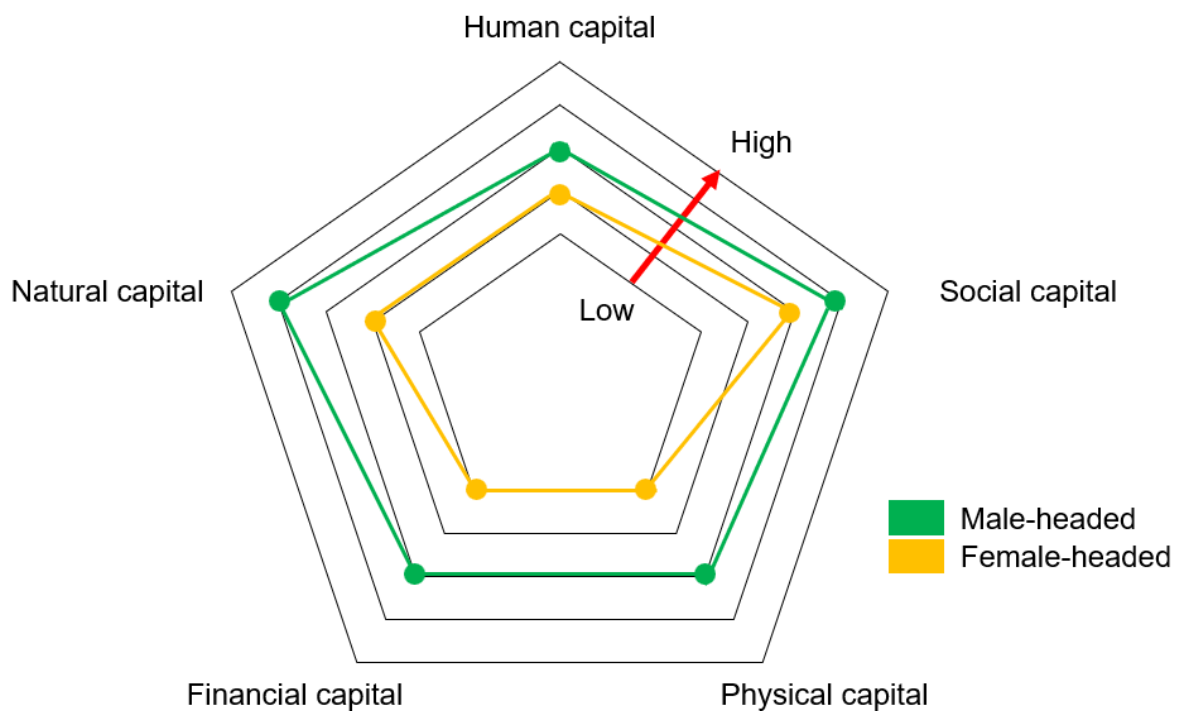
Illustration 12: Visualization of differences in the average asset composition of male- and female-headed households

How do the asset composition differences affect the evaluation process?

After identifying the differences in the asset composition of male and female-headed households, this section zooms in on their implications for the evaluation stage of the innovation-decision process on WCIS adoption.
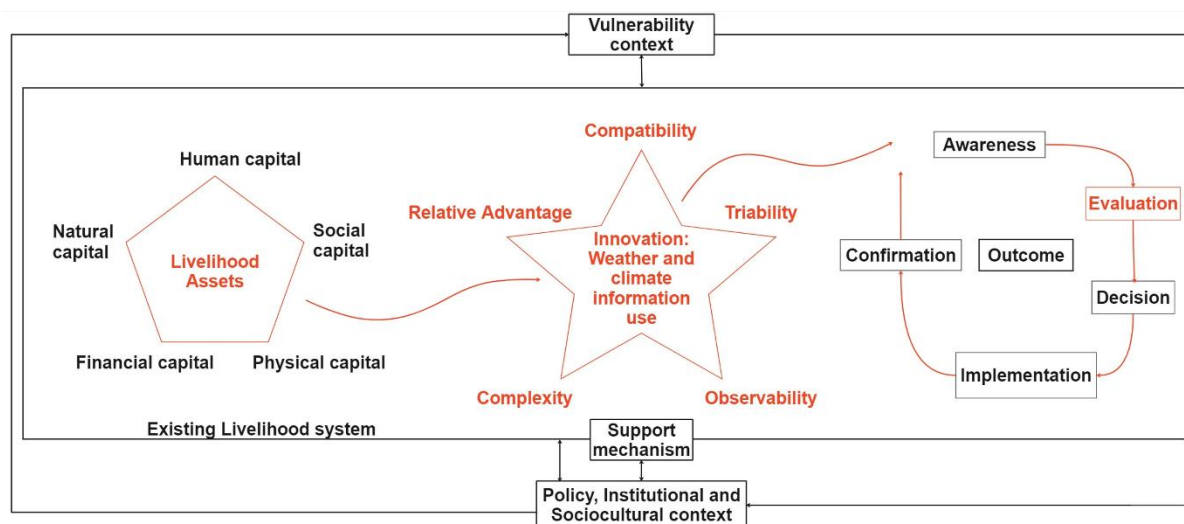
Illustration 13: Zooming in on the evaluation stage (discussed elements highlighted in red)

In my research sample, 6 out of 36 participants, all of them women, decided not to use the information. These non-users of WCIS can be divided into groups of cases seeing a high relative advantage in WCIS use and not seeing one. Members of the first group would like to use WCIS, but cannot do so because their access is very limited and coincidental (P12), they do not have access at all (P35) or they have access but are not the ones taking decisions on its use in agriculture (P19). This indicates that a perceived high relative advantage translates into the wish to use WCIS, but low or no access to the information or decision-making on its use impedes them to become active.

The members of the second group perceive WCIS as difficult and report only accessing it occasionally and mostly in an inaccessible format due to the language barrier (P24, P33) but also general complexity (P2). This leads to low trust in the information (P24) and no interest in further pursuing it (P2, P33) as illustrated by the following quote:

> *'P33: (...) sometimes the information is not very easy to understand so she doesn't waste her time listening to the information.'*

Time constraints (P2, P33) and the existence of a valued alternative – traditional forecasting (P2) – further amplify this.

To conclude, access to WCIS in an accessible format depends on both human and physical capital and seems to impact not only the possibility to use it but also perceived complexity and in turn perceived relative advantage. Female-headed households have not only an on average lower asset composition, but gender roles also result in a high workload and them not being in the position to take the final decision. Hence, it is not surprising that women are more likely to be non-users.

By looking at interviews with users of WCIS further insights on the evaluation stage can be gained. WCIS use seems to be a highly triable innovation since the information can be used by participants limited to selected agricultural operations as demonstrated by the overall high percentage of limited users. An example of this behavior is Participant 11 who started using WCIS to plan fertilizer use to avoid waste.

Moreover, WCIS use seems to be highly observable and farmers compare the results between users and non-users as illustrated by the following quote.

> '*P29: He said that last year the weather forecast predicted that the rain will be early and there will be a lot of water this year, and he said that he was quicker, those who planted early had a good harvest but those who did not could not harvest.*' (P29)

Support mechanisms used this comparability of WCIS use by setting up demonstration plots to convince farmers of its relative advantage and to boost the uptake of WCIS use (KI1, KI2, KI5, KI8).

Like the non-users, users report that perceived complexity largely depends on the access format and language barriers. In this context, two patterns can be observed. Direct and regular access seems to reduce the perceived complexity with only around 26% judging the information as difficult to understand compared to 50% with indirect access. This can be explained by farmers getting used to the dissemination formats by regularly repeated exposure. On the other hand, cases of WCIS users with direct access outline difficulties to understand the information provided in French or Wolof occur, while users who exclusively rely on their peers to access the information judge it as easily comprehensible. However, several farmers detail issues with accuracy and a lack of trust in WCI provided by members of their social network, especially if they do not listen to WCIS regularly (f.i. P23, P28). This illustrates the importance of enhancing direct access to accessible diffusion formats in the local language.

Lastly, a range of producers reported concerns with the inaccuracy of the received information leading to a reduction of trust and the perceived relative advantage of WCIS. Asked whether she trusts the weather forecast, research participant 27 responds that '*sometimes the weatherman says things that she doesn't see'* lowering her trust in the forecast. This illustrates the need for high forecast quality at the most local level possible but also to sensibilize farmers for currently existing limitations.

What are the implications of differences in assets and evaluation outcomes for the implementation stage?
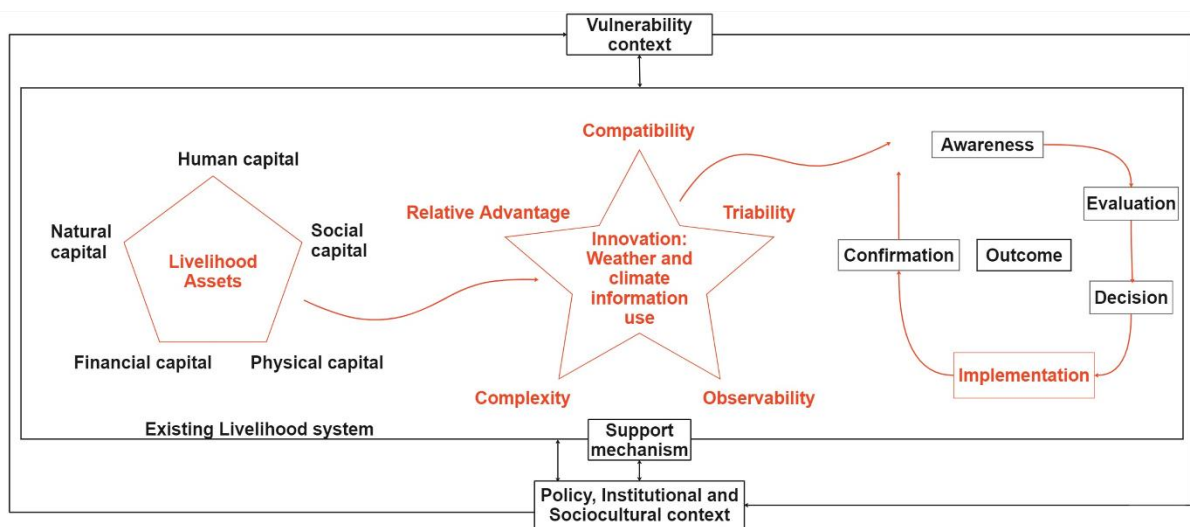
Illustration 14: The implementation stage (discussed elements highlighted in red)

After deciding on WCIS, smallholder farmers implement the received information in different ways. Key differences between systematic users and limited users are their use of the seasonal forecast for strategic planning, the overall level of comprehension of the information, and their consistent use across all agricultural operations. While a few farmers simply did not have access to the seasonal forecast (P22, P28) or low access to WCIS in general (P4, P14), another did not react to it in time because they were surprised by its accuracy (P18). This indicates that improving access to the seasonal forecast in particular and to WCIS in general, might improve the percentage of systematic users.

However, other farmers receive the forecast but are not able to consistently act on it because of comprehension difficulties (P4, P25, P27), limited physical capital (P9, P11), or because they are overworked and exhausted (P15). While not only female research participants describe those concerns, there is a gender dimension to it with women having lower human capital, having lower access to complete machines and other agricultural inputs, and bearing the double charge of agricultural work and chores.

Besides factors contributing to a less systematic use, the great majority of farmers, including systematic users, report challenges in the utilization of the WCIS impeding them to realize the innovation's full potential.

Firstly, as outlined earlier, many smallholder farmers and especially women do not have a complete set of machines or are deprioritized in accessing them for their plots. This reduces their ability to react to weather forecasts and independently adapt sowing and harvest dates. Moreover, it causes them general delays in the production process which in turn, in case of a short rainy season, leads to a lower harvest. However, even farmers with a complete set of machines face challenges because most of their machines are very old, in bad condition, and need to be repaired before every agricultural season.

Photo 2: Old plowing machine. Photo taken by Johannes Becker in Mbassis
Photo 3: Granary for seed conservation. Photo taken by Johannes Becker in Senghor

Access to adapted varieties poses another challenge for farmers. While some farmers have advanced granaries (photo 3) and can conserve both short- and long-cycle varieties of their major crops, most farmers rely on a single variety for each crop. Due to the short rainy season in the past years, many farmers changed to a short-cycle variety. However, faced

with a long rainy season like in 2022, farmers experience high difficulties both to find and to afford adapted varieties (P6, P13, P15, P29). Moreover, several farmers exhibit low trust in varieties bought on the markets due to the low-quality seed mixtures in circulation (P22, P23). This illustrates the need for interventions by trusted actors to provide varieties and to support farmers in conserving seeds of different cycles adapted to the forecast.

Thirdly, farmers describe the dilemma of receiving WCI that suggests the rainy season is not yet over, while their crops are ready for harvest. On the one hand, delaying the harvest can lead to significant losses due to crop falling or pest attacks. On the other hand, since farmers lack sufficient storage facilities, they risk losing their harvest if the rains continue. Although research participants mentioned a strategy of piling up and covering the millet, adaptation options for groundnut harvesting are limited. Despite being aware of the potential consequences, farmers' ability to adapt to this challenge remains highly restricted.

Lastly, several farmers are aware of their limitations in using WCIS and have requested extra training, orientation on appropriate varieties, and consistent support to access WCI. This indicates that they have acknowledged the significance of the information and are determined to utilize it to the best of their abilities.

What were the outcomes of WCIS use?

The utilization of WCIS has resulted in predominantly favorable outcomes for users, despite the challenges. Users have reported improved capacity to plan agricultural operations and over two thirds of them have experienced reduced harvest loss and/or improved agricultural production. However, some research participants noted that their production outcomes did not change significantly as they were already well-organized but emphasized the need for additional means to improve the harvest. (P10, P21).

5.2.3 Conclusion on the extent and conditions of WCIS use

The research findings show that a significant number of smallholder farmers in the Tattaguine district, Senegal, have access to and use WCIS. However, less than 50% of my sample and probably even less in the Tattaguine district use WCIS systematically, and technical advice is necessary. My research also demonstrates that the asset composition, influenced by vulnerability context, PISC as well as the presence of support mechanisms, has a strong influence on who accesses WCI, who perceives it as complex or useful, and in turn, who decides to use it. The respondents' capacity to systematically implement WCI and realize its potential is equally restricted by the limits of their asset composition. This results in weaker access, use, and systematic use rates among women and female-headed households.

5.3   The role of traditional beliefs and forecasting systems (RQ2)

Farmers around the world have always depended on the weather. Hence, the existence of systems reducing the uncertainty is not surprising. To answer the second research question, I will give an overview of the different practices employed by the research participants, the extent of their use, and their role in the adoption of WCIS use.

5.3.1   Traditions in agricultural practice

The first group comprises traditional agricultural practices based on the lived experiences of the farmers and their ancestors. One example of such a practice is the dry sowing of millet. Based on tradition, the sowing of millet is always done around May 15th (P1) and has to be done before the first rain falls because the land is not adapted to the wet sowing of millet (P21). While the practice of dry sowing is potentially a good idea, due to climate change the onset of the rainy season can change drastically from year to year. Hence, strictly following this tradition of sowing the millet in May without considering the WCIS can in case of a delayed onset of the season lead to many difficulties.

A second example is the sowing of groundnut directly after the first rainfall. While this is practiced to ensure a sufficiently long growth period, an unsufficient quantity of rainfall (P17) or heavy rainfalls shortly after the sowing (P1) can lead to a failed production. Thus, it is essential to consider the weather forecast for the upcoming period and confirm that the rainfall received is adequate for crop production to prevent any problems caused by blindly adhering to traditional practices.

However, some farmers still refuse to consider WCIS in the sowing decision.

> 'P10: We, if it rains today even if they have said you should not you should not sow we will sow' (P10)

5.3.2   Natural indicators

The second group of practices encompasses empirically observable natural indicators that are empirically observable. Apart from one (P10), all respondents believed in and utilized these indicators to inform their decision-making in agriculture. He motivates this choice with the words *'a Muslim does not do this'* (P10). Interestingly, all other Muslims in the sample, including an Imam, do not share this view.

Natural indicators are predominantly used to predict the onset of the rainy season. However, some are also used to identify weather changes during the season. Two participants also reported methods to acquire information on the duration and rainfall quantity of the upcoming rainy season (P26, P30).

A detailed overview of the different mentioned natural indicators is provided below:

Indicator	Type	Meaning	#
The flowering of the Tamarinier tree	Seasonal	Indicates that the onset of the rainy season is very close	21
The Faidherbia albida tree starts losing its leaves	Seasonal	Indicates that the onset of the rainy season is very close One farmer also reports that he starts the weeding of his field based on this indication to be ready to sow (P36).	18
The flowering of the Baobab tree	Seasonal	Indicates that the onset of the rainy season is very close (general use) If the Baobab starts flowering from the top, the onset of the rainy season will be late, if it starts from the bottom it will be early. If the baobab loses a lot of leaves, this can indicate a lot of rainfall in the rainy season (P30). One research participant explains to be able to see whether the rainy season will come with a lot of rainfall or not based on a secret indicator appearing close to the trunk of the tree on the ground. However, he refused to explain it in greater detail (P26).	15
Temperature change accompanied by a lot of humidity and dew	Seasonal	If this happens in the month when the rainy season is supposed to start, this indicates that the rainy season is very close.	4
'When the moon kills the ants' (P1)	Seasonal	Indicates the time to sow the millet close to the onset of the rainy season	3
Reaction of the soil after pouring water on it	Seasonal	If small plants start to grow after one has poured water on the ground, the onset of the rainy season is close.	2
Appearance and disappearance of certain birds near the sea	Seasonal	Indicate that the onset of the rainy season is very close Indicate that the rainy season is over	2
Reaction of the soil after pouring water on it	Seasonal	If small plants start to grow after one has poured water on the ground, the onset of the rainy season is close.	2
Diola fruit (photo 6 below)	Seasonal / rainfall	According to P5, it is a Diola tradition from the Casamance to observe this fruit. When the fruit opens up just before the rainy season, closes when it won't rain for a few days, closes entirely at the end of the rainy season	1
When the fruits of the fromagier tree open	Seasonal	Indicates that the onset of the rainy season is very close	1
Spider webs on the roadside	Seasonal	Many spider webs on the roadside indicate the end of the rainy season.	1
Certain cloud formations	Weather change	Indicate that it will rain soon	7
Rise of sea water level	Weather change	Indicates that it will rain soon	1

Table 8: Tabular overview of reported natural indicators, their meaning, and their frequency

The natural indicators most frequently cited by the participants pertain to the Faidherbia Albida tree, the tamarinier tree, and the Baobab tree. They describe that the loss of leaves and flowering of these trees signal the imminent onset of the rainy season, thereby indicating the appropriate time to prepare the fields (P36).
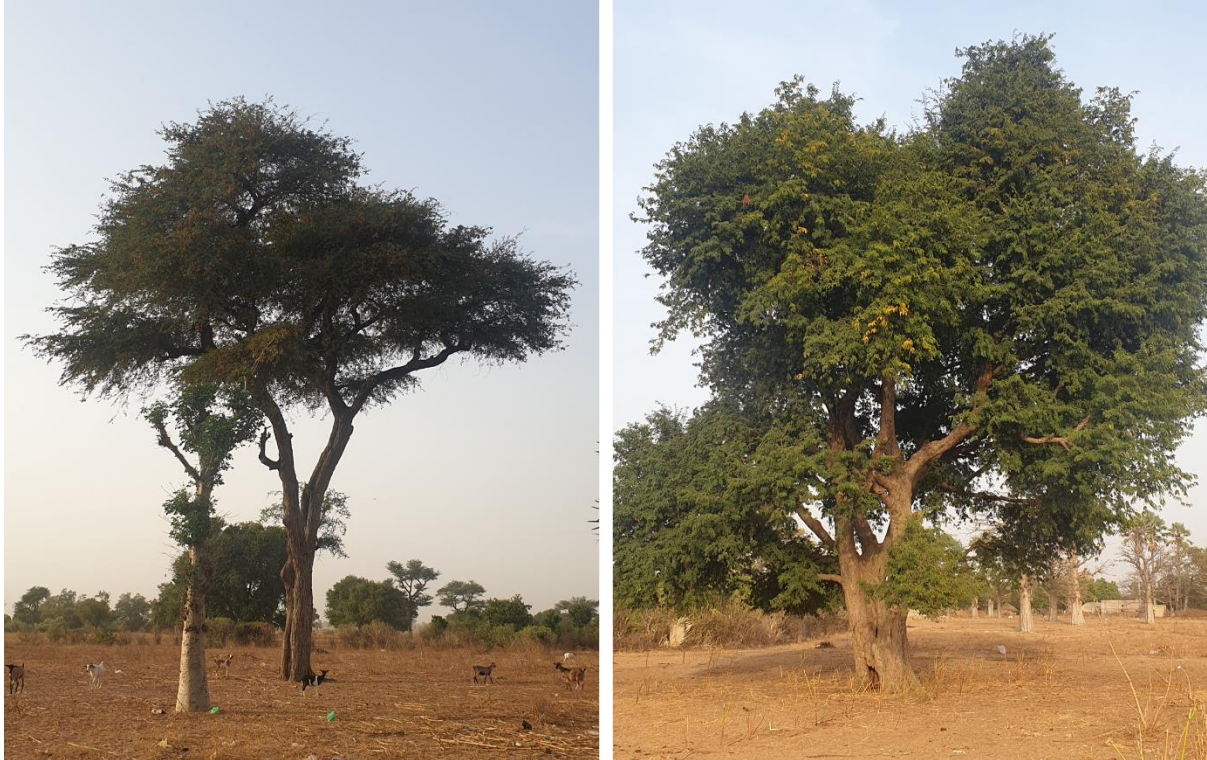
Photo 4: Faidherbia Albida and Photo 5: Tamarinier, both used as natural indicators for the arrival of the rainy season. Photos taken by Johannes Becker

In addition to trees, certain birds and insects, as well as the moon and star constellation, are utilized to anticipate the onset of the rainy season - some of which overlap with natural indicators previously mentioned in a report on the initial WCIS pilot in the Kaffrine region (Ndiaye, 2011).

To monitor weather changes throughout the year, cloud formations are observed by several participants. One participant even procured a fruit from a tree in the Casamance region of Senegal, which, according to the Diola tradition, slowly opens up before the onset of the rainy season and closes at its conclusion. By carefully observing the movements of the fruit, the participant claims to be able to predict rainfall within the following days (P5).

Photo 6: Diola fruit - Tool for traditional forecasting. Photo taken by Pierre Dione, Enda Pronat in Mbassis.

5.3.3 The Saltigué

The Saltigué and their predictions on the upcoming rainy season were unsurprisingly known to all of my research participants[30]. However, participants differentiated between the highly mediatized predictions of certain Saltigué and the local Saltigué of a village. The opinion on the Saltigué seems to be divided. While one-half of the research participants reported not believing in them, the other half still follows their predictions. Interestingly, many farmers reported having stopped believing in the Saltigué when they realized that the WCIS are more accurate as illustrated by the following quote:

> *'P1: Saltigué, there were years. But that's not what we do anymore. Because of what? The truth is coming out. ANACIM is the main Saltigué now.'*

The belief in the Saltigué seems not to be equally distributed by gender with 66,67% of the women believing in them compared to 45% of the male respondents. Moreover, while 75% of the participants in the Tattaguine commune reported believing in the Saltigué, the percentages in the other communes and especially in Diarrère (25%) are significantly lower.

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[30] All members of the Sérère ethnic group

The village of Senghor marks another hotspot of beliefs in Saltigué with a ritual closed for the public taking place every year just after Easter (P34, P36).

However, among farmers still following the Saltigué one has to distinguish between farmers that just continue to listen because of tradition (11/18) and the ones, that still use their predictions in agriculture (7/18). With less than 20% (7/36) of the research participants still using the predictions of the Saltigué in agriculture, their importance is, therefore, lower than expected based on the findings of Manga et al. (2009) and CRS (2018), indicating a decline in belief in the past years.

5.3.4 Do traditional beliefs and forecasting systems affect perceived relative advantage and compatibility?

Building on the mapping of practices, this section provides an answer to the second research question, examining how traditional beliefs and forecasting systems influence the perception and uptake of WCIS in agricultural decision-making, with a separate analysis for each group.

Traditions in agricultural practice are widespread among the interviewed smallholder farmers. While some consider WCIS in their decisions and illustrate its potential compatibility, others prefer not to deviate from tradition by considering WCIS (P10, P20). Hence, compatibility depends on the individual farmer.

Natural indicators were used by almost all farmers and did not significantly affect the adoption of WCIS. Many farmers reported using both sources of information together without perceiving any contradiction. While most participants had greater trust in WCIS, one research participant preferred natural indicators, relying on them for planning the agricultural season, and WCIS for day-to-day weather information (P26). This emphasizes the overall compatibility between the use of WCIS and natural indicators, indicating that incorporating natural indicators does not diminish the perceived benefits of WCIS.

In 2023, 8 years after the introduction of the WCIS in the region, the great majority of the research participants are convinced of the relative advantage of WCIS compared to the Saltigué. The arrival of this innovation seems to have marked the end of a belief in the tradition for many participants illustrating the incompatibility of the two forecasting systems. This indicates that the Saltigué belief is not a barrier to WCIS adoption due to the high perceived relative advantage. However, an ANCAR employee states that the strong belief in the Saltigué slowed down the uptake of WCIS in the beginning. She explains that only by acknowledging the existing beliefs and making the relative advantage of WCIS observable by using demonstration plots, the resistance has decreased (KI5).

6. Concluding remarks

This research had the overall aim of better understanding the extent to and the conditions under which smallholder farmers make use of WCIS (RQ1) and the role of traditional beliefs and forecasting systems in the process (RQ2).

My findings on use extent (RQ1) demonstrate that overall use among my research participants is relatively high with only 6 out of 36 participants not using the WCIS at all. However, less than 50% of my research participants systematically use the information and the percentage of systematic WCIS users of all farmers in Tattaguine district is likely to be even lower. Disaggregating the data by gender reveals strong differences between male and female-headed households, with women having lower at least limited use rates and all non-users being women.

The context analysis highlights the difficult conditions for smallholder farmers both, due to aspects of the vulnerability context, such as increasing salination and soil infertility as well as high climate variability, but also due to a strategy change for the agricultural sector from poverty reduction to productivity and value chain promotion for economic growth. These conditions shape the assets and viable livelihood strategies of farmers in the Tattaguine district. The strong presence of traditional customs in land governance and gender norms structurally disadvantage women's access to decision-making, information, and resources of all kinds. This was reflected in an analysis of the average asset composition of male-headed and female-headed households of my sample revealing that women own fewer assets of all categories compared with their male counterparts.

Further, my findings demonstrate how the asset differences, especially in human and physical capital, lead to lower direct access to WCIS, especially to the very important channel Radio Ndef Leng delivering WCIS in Sérère, and in turn to a higher perceived complexity equally reflected in the less systematic use of WCIS. The consequences of the capital difference are further aggravated by the double burden of household chores and engagement in agriculture of women, leaving them with no time or too exhausted to access and use WCIS.

Asset differences are equally consequential for the potential of the respective farmer to use the acquired information to its full potential. Central difficulties reported were the lack of machines impeding independent planning of agricultural operations and difficult access to seed varieties in line with the seasonal forecast due to high prices and insufficient availability. Moreover, insufficient storage facilities for harvest and seed conservation, as well as the need for further training and agricultural advice on the use of WCIS impose

further limitations. Despite those difficulties, most respondents report an increased agricultural production and/or reduced harvest loss as well as improved planning of the agricultural activities due to WCIS use.

My findings contribute to existing research by explaining how gendered access to WCIS (Diouf et al., 2019; McOmber et al., 2013) as a result of and in combination with lower assets translates to higher perceived complexity, less systematic use, and potentially contributes to gendered WCIS use outcomes (Diouf et al., 2020b).

To explore the role of traditional beliefs and forecasting systems in the uptake of WCIS (RQ2), this research mapped out three different groups – traditional agricultural practices, natural indicators, and the Saltigué. Traditional agricultural practices such as the dry sowing of millet in the month of May are based on the experience of their ancestors and practiced by almost all smallholder farmers. While some farmers enhance those practices with WCIS use to obtain more precise information, underlining the potential compatibility, others prefer to exclusively rely on tradition for those operations, leading to an inconsistent WCIS adoption and potentially increased weather-induced risks.

Natural indicators encompass empiric observations of changes in the direct environment such as the flowering of certain trees or the appearance of certain birds or insects. They are used by all interviewed farmers with one exception, predominantly to identify the onset of the rainy season. My research highlighted that farmers perceive them as highly compatible with WCIS and use them complementary to it, sometimes to compensate for weaker access to a seasonal forecast. In case of doubt, they prefer relying on WCIS due to the higher precision of the information.

The opinion of Saltigué and their annual predictions seems divided with half of the participants not believing in them at all and the other half still following them either for reasons of tradition or for actual use in agriculture. According to my research participants, they have very low compatibility with WCIS use because both give predictions on the rainy season. Today WCIS use has largely replaced the belief in the Saltigué and does not seem to affect WCIS use anymore. However, key informant insights indicate that the high incompatibility slowed down the initial adoption of WCIS because its relative advantage had to be demonstrated first.

These findings contribute to existing research on the influence of traditional knowledge on innovation introduction (Ziervogel et al., 2005), provide a framework to understand the interaction (Blundo-Canto et al., 2021) and highlight the importance of differentiating between different existing practices and their implications on WCIS use.

Based on my research findings, I have identified entry points to improve the systematic use of WCIS in the Tattaguine district. Extending direct access to WCIS in local languages to vulnerable groups such as female-headed households and stronger connecting WCIS with actionable advice are the most important levers to improve systematic use. However, differences in the outcome of WCIS use will remain high if structural disadvantages for women in accessing land, resources, and information are not addressed by interventions on the local and policy changes on the national level. A digitalization of agricultural advice connected with WCIS as proposed by ANCAR should receive further financing to extend the services and render them more accessible. Nevertheless, the most vulnerable groups need to be systematically identified and supported by extension agents and other organizations to not leave them behind. Lastly, ANACIM should continue its efforts and be supported to further localize the level of prediction to increase the use for the farmers.

A final remark concerns future research on WCIS in Senegal and beyond. Firstly, qualitative approaches are, as demonstrated, essential to understanding the interplay of the various variables rendering possibilities and influencing the decision-making of individuals on WCIS use in the local context. Despite their limited generalizability, they should be employed to complement insights gained from quantitative studies. Secondly, the integrated framework has proven to be very useful to structure the analysis. Hence, it should be replicated to further the understanding of WCIS use in other research contexts such as the role of animist traditions in the Casamance in WCIS uptake. Thirdly, this framework could be equally tested with a quantitative approach. By collecting data on household assets in a format that is easier to quantify, differences in the asset composition of households and their implications on WCIS use and outcomes could be measured on a more granular scale. Lastly, future research on WCIS use should contribute to identifying vulnerable groups that currently do not profit from it to enable systematic targeting by support mechanisms.

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Kory Dione, P. / Enda Pronat, 2022. Geographic locations of the villages

8. Annex

8.1 Annex 1: Interview Guide Structured Interviews with smallholder farmers

Introduction

Good morning,

How are you? How is your family doing?

Thank you very much for taking the time to talk to us today.

My name is Johannes Becker and I am a German student and intern at Enda Pronat.

As I only speak a few words in Wolof/Serere, *name of interpreter* is accompanying me today to help with the interpretations.

Would you prefer that we do the whole conversation in Wolof/Serere or can we do it in French and switch to Wolof/Serere if necessary?

I grew up in a small village in Germany, a bit like your village here, with many people working in agriculture. So I am also interested in issues related to agriculture here in Senegal.

More specifically, I am interested in the role that climate and weather information plays for you as a farmer. With this research, I want to contribute to making the information more useful for you, however, I am not in the position to decide on its use and therefore, I cannot make any promises.

Ethical issues / Informed consent

Are you still willing to share your experience with me? I assure you that I will use it in a way that protects your anonymity - so no one will be able to know that it was you who told me something.

Thank you very much/ Diereudieuf!

I would like to record our conversation with my phone so that I don't miss any of your important words and explanations. After using it for research, I will delete the recording and I will make sure that no one can access it without my permission. Do you agree with the recording?

Option A: Thank you very much/ Diereudieuf! Do you still have any questions? - If not, I will start the recording now. Can you confirm again for the recording that you agree with the recording and participate in my research?

Thank you very much!

Option B: I understand. We will of course respect your wishes. Do you agree that the name of the interpreter and I take notes during our conversation?

Thank you very much/ Diereudieuf!

Biographical questions

To begin with, we would like to learn a little more about you:

1. City, Village:

2. Age:

3. Gender:

4. School level:

5. Origin :

6. Ethnic group:

7. Religion:

8. Head of household: yes   no

9a. Number of persons in the household:

9b. Including, Number of children:

10. Do you all work in agriculture?

11. Distribution of tasks in the household and on the field(s)? Who does what?

12. Is farming the main source of household income?

13. What are the other sources of income?

Questions concerning agriculture in general

14. What is the size/area of the land you farm?

15. Do you own the land you farm?

16. Do you have any equipment (farm machinery) to cultivate the land (for field crops)?

17. Do you raise animals? Which animals and how many? Do you use animals to cultivate the fields?

18. What crops do you grow on your land? Who grows which crop?

19. Are you a member of a farmers' organization? Are you involved in an NGO project?

20. What role do ANCAR staff play in your activities?

21. What are your main challenges in agricultural production?

Transition to questions on climate information services

22. What role do climate or weather projections play in planning your agricultural activities?

23. What sources of weather information do you know?

24. Which of the sources listed is/are the most used? Why or why not?

25. Do you have a radio/phone/TV to access weather information?

26. What role do traditional forecasting techniques such as natural indicators play? What about the Saltigué? How has this changed?

27. What types of weather information do you use in planning your farming activities? (seasonal forecast, weather forecast in the next two days, weather forecast in the next ten days)

28. Which of the information listed is the most relevant? Why or why not?

29. Do you receive the information on time?

30. Is the weather information easy to understand? Are there words used that you don't understand?

31. Is the weather information you receive useful for your farming activities?

32. Do you trust the weather information you receive?

33. Do you see any contradictions between the weather information provided by ANACIM and your traditional knowledge and the forecasts of the Saltigués? Why or why not? Which is the most relevant source of information?

34. Are the weather forecasts valid for your village and your farming activities?

35. Do you make agricultural decisions based on the weather, and if so which ones? (e.g., choice of planting date, choice of harvest date, choice of plant variety, planning fertilizer use, ...)

36. Can you give an example of the information you received and how you used it?

37. Do you have any difficulties in using the information you received? What could help you?

38. Do you have the resources to purchase inputs/varieties adapted to the forecast?

39. What impact has using the information had? (e.g., Increased harvest? Reduced crop losses?)

40. If you have anything else to say about the interview or if you have any questions, don't hesitate!

8.2 Annex 2: Interview Guide Semi-Structured Interview

Depending on the interview partner, his area of expertise, and whether I wanted him to talk about WCIS production and diffusion on the local or national level, I adapted the interview guide. For reasons of conciseness, I included only one version of the interview guide below but the following annex gives an overview of the different key informants and their contributions to this research while protecting their anonymity.

Interview Guide for an interview with a key informant working for ANACIM on the regional level

Introduction

Thank you for agreeing to meet with me today. As discussed beforehand, my research aims to understand factors influencing the use of Weather and Climate Informations Services by smallholder farmers in the Tattaguine district. I have already interviewed several farmers from the three communes and want to complement the insights gained by learning more about the oranizations engaged in the process of producing and diffusing Weather and Climate Information. Do you still have questions regarding the subject of my thesis?

The interview will last approximately 25-30 minutes. Please be assured that all information provided will be treated with the utmost confidentiality and anonymity and will be used for academic purposes only. Do you agree to participate in this research?

I would like to record our conversation with my phone so that I don't miss any of your important words and explanations. After using it for research, I will delete the recording and I will make sure that no one can access it without my permission. Do you agree with the recording?

Interview Questions

1. What is your position?

2. Can you describe your responsibilities in a few sentences?

3. Which structures/institutions are involved in the production and sharing of weather and climate information services in Fatick?

4. Can you describe the role and functioning of the PWG?

5. Apart from the GTP, what other channels for communicating weather information exist?

6. How long has this system been in place?

7.   What types of information are produced by ANACIM in Fatick and how often?

8.   How do you perceive the knowledge of weather and climate information among practitioners involved in dissemination and among farmers?

9.   What activities have been undertaken to increase the knowledge of weather and climate information among practitioners and farmers?

10.   Since the beginning of the activities, have you already observed a positive change? Have farmers integrated the information into their decision making and has this influenced their yields, and household income?

11.   What challenges do you see in the dissemination and adoption of weather and climate information services here in the Fatick/Tattaguine district?

12.   To your knowledge, are there any groups of farmers who do not currently benefit from weather and climate information? (Differences between men and women?)

8.3   Annex 3: Overview of the key informant interview participants

#	Organization	Position[31]	Contribution to this research
1	SDDR	Employee of the departmental service for rural development	• Gave insights on the functioning and actors involved in the MWG, the production and diffusion of WCIS on the regional level, and challenges encountered (Section 5.1.3)
2	ANCAR	Employee of ANCAR on regional level	• Gave insights on the WCI production and diffusion on the regional level, the role of ANCAR in the MWG, and challenges encountered (Section 5.1.3)
3	Radio Ndef Leng	Employee of the Radio Ndef Leng	• Gave insights on the role of Radio Ndef Leng in the MWG, its formats on WCI, and challenges encountered (Section 5.1.3)
4	ANACIM	Employee of ANACIM on regional level	• Gave insights on regional precipitation dynamics, the WCI production and diffusion on the regional level, the role of ANACIM in the MWG, and challenges encountered (Section 5.1.1 and 5.1.3)
5	ANCAR	Field Agent of ANCAR	• Gave insights on the role of field agents in the production, and diffusion of WCIS as well as challenges encountered (Section 5.1.3)
6	Provale CV	Employee of the project Provale CV	• Gave insights on Provale CV's role as sponsor of the MWG at Fatick, challenges for agricultural development in the region, and the Provale CV project (Sections 5.1.1 and 5.1.3)
7	WFP	Employee of the WFP on the local	• Gave insights on WFP's affiliation with Provale CV, WFP's approach to WCIS

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[31] While the key informants provided their exact position in the interviews, I decided not to include it here because one could use this information to identify them.

		level	diffusion, and challenges encountered (Section 5.1.3)
8	ANCAR	Employee of ANCAR on the national level	• Gave insights on the institutional development of ANACIM, challenges encountered, and prospects (Section 5.1.2)
9	ANACIM	Employee of ANACIM on the national level	• Gave insights on the institutional development of ANACIM, challenges encountered, and prospects (Section 5.1.2)

8.4   Annex 4: Interview Guide Focus Group Discussion

Introduction

Thank you for agreeing to meet with me today. As discussed beforehand, my research aims to understand factors influencing the use of Weather and Climate Informations Services by smallholder farmers in the Tattaguine district. I have already interviewed a number of farmers from the three communes and want to complement the insights gained by learning more about the actors engaged in the process of producing and diffusing Weather and Climate Information. As relays of Enda Pronat you were involved in this process and I want to learn more about the process itself, your opinion on difficulties faced as well as whether you see potential to improve it. Do you still have questions regarding the subject of my thesis?

The group discussion will last approximately 75-90 minutes. Please be assured that all information provided will be treated with the utmost confidentiality and anonymity and will be used for academic purposes only. Do you agree to participate in this research?

I would like to record our conversation with my phone so that I don't miss any of your important words and explanations. After using it for research, I will delete the recording and I will make sure that no one can access it without my permission. Do you agree with the recording?

Questions[32]

- Who among you currently uses weather information in your agricultural production?

    o According to the people who use the information / Can you each, one by one, explain how you use it?

    o According to the people who do not use the information themselves - can you elaborate a bit on why you do not use it?

- Who among you has already started to use the weather information before Enda's intervention in the popularization of the information?

    o For how long?

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[32] I established this interview guide for the Focus Group Discussion to have a structure of the topics and questions I want to talk about with them. However, to profit from the format we did not stick to the order and formulation of questions because we followed the flow of the discussion and sometimes many questions were discussed at the same time without being prompted by me.

- Who among you feels that you have the know-how to use weather information 100 percent?

- Who among you feels that you have the know-how to use weather information at a high level?

  - According to the people who said Yes - what would help you achieve this level of knowledge?

  - According to the people who answered No - in which areas do you still lack knowledge?

- Who among you feels that you can explain weather information and its use well?

- What was the content of the training you received?

  - Do you feel you understood and retained all the relevant information from the training?

  - Why yes? No?

- How could the training be improved?

- Did you disseminate the seasonal forecasting information? Was the information accompanied by advice for the respective producer's agricultural production?

- Do you have examples of producers adapting their operations in agriculture according to the weather?

- How did you disseminate the information? Do you feel that the vast majority of households in the village received the information?

- Who did you give the information to? The head of the household? Each producer in the respective house?

- What difficulties did you encounter in disseminating the information?

- In your opinion, what are the main problems producers have in understanding and using weather information?

- In your village, approximately what percentage of farmers have started using weather information?

- How could the dissemination, understanding, and use of weather information be further improved?

8.5 Annex 5: Classification of WCIS use types of farmers in the Tattaguine district

Classification	Definition
Systematic use	The farmer uses consistently both seasonal and weekly/daily forecasts to plan the different agricultural operations including but not limited to: preparations, selection of adapted variety, strategic planting by avoiding flooding-prone areas in high precipitation seasons, sowing date adaptation, weeding, fertilizer use, plowing, harvest date adaptation, conservation techniques
Limited use	The farmer recognizes the importance of adaptive action and adapts certain operations, but not consistently.
Rudimentary use	The farmer explains to follow the information, but WCIS does not seem to be decisive in his agricultural decisions
No use	The farmer does not rely at all on WCIS for his agricultural production

# Participant	Use Type	Justification
1	Systematic use	Strategic use of weather forecast to plan both agriculture and marketing plant rotations, adaptation of agricultural operations in consideration of the forecast
2	No	Has access to WCIS but does not use it because she prefers to rely on tradition
3	Systematic use	Does not always have access to seasonal forecast and relies on Saltigue for that, but uses WCIS to adapt agricultural operations f.i. to adapt to rainfall pauses, adapts variety choice to her information on the rain season
4	Limited use	Has difficulties accessing and understanding the WCIS but with the intense help of Enda he can do so, uses WCIS to plan weeding and to protect his harvest, and also uses WCIS to select varieties
5	Systematic use	Limited access to WCIS that is easy to understand, complimentary use of WCIS and natural indicators, adapts variety selection and crop choice to forecast, also whenever possible tries to adapt operations such as harvest to WCIS
6	Systematic use	Systematic use of WCIS to adapt variety choices when financially possible, strategic planning of agricultural operations such as weeding and harvesting using WCIS
7	Systematic use	Systematic use of WCIS to select appropriate varieties, use of WCIS to plan agricultural operations such as fertilizer use
8	Rudimentary use	Relies on traditional varieties due to financial problems and because of the lack of stockage, tries inconsistently to use WCIS to adapt agricultural activities but is not 100% confident in them
9	Limited use	Relies on traditional varieties, uses WCIS to adapt agricultural planning and to plan harvest
10	Rudimentary	Follows WCIS to prepare for the rainy season but bases

	use	decisions mostly on tradition, example: 'if it rains, we will sow no matter what the forecast says'
11	Limited use	Considers WCIS for fertilizer use, has to always sow with the second rainfall due to insufficient machines, no use of an adapted variety
12	No	Her husband decides on when and what to grow and he follows his traditional knowledge because he has no access to and knowledge about WCIS
13	Systematic use	Strategic use of WCIS, adapts variety choice to seasonal forecast and agricultural operations like fertilizer use or harvest to weather forecast
14	Limited use	Not very systematic access to WCIS, but already used WCIS to adapt variety choice and to start preparations for the season early
15	Limited use	Mentioned adaptation measures to seasonal forecast but also mentioned anecdotes when she did not act on the information because she was too exhausted
16	Systematic use	Systematic use of WCIS to prepare the rain season but also to adapt agricultural operations such as harvesting to the weather forecast, but uses traditional varieties
17	Systematic use	Systematic use of WCIS to select appropriate varieties and to plan agricultural operations
18	Limited use	Received seasonal forecast for the first time but did not react on it timely, used WCIS to adapt agricultural operations such as harvesting and conservation
19	No	She uses WCIS only outside of agriculture, for her plot it is her husband (participant 18) who takes the decision
20	Rudimentary use	Does not have secure access to seasonal forecasts, bases sowing decision on tradition but considers WCIS to plan the harvest
21	Systematic use	Systematic use of WCIS to plan the season and agricultural activities, but prefers to rely on traditional varieties
22	Limited use	Does not have access to a seasonal forecast, uses WCIS to plan his agricultural operations, especially the harvest
23	Systematic	Systematic use of WCIS, active search for information after his radio stopped working, strategic adaptation of sowing date to adapt variety to cycle length of the season
24	No	Does not use WCIS because she doesn't understand it and currently does not see an advantage, moreover, her husband is in charge of the majority of the decisions in agriculture (also for her plot) and he relies on tradition
25	Limited use	Received training on WCIS, applies information on humidity tests after rain falls to plan to sow, adapts selection of rice variety, nevertheless limited comprehension of WCIS
26	Limited use	Relies on natural indicators for seasonal forecast because he perceives them as more exact, strategic selection of sowing date to adapt variety to season, uses WCIS to adapt and plan his agricultural activities during the season
27	Limited use	Difficulties to understand WCIS despite training received, uses different varieties for rice to adapt to the rainy season, adapts harvest date to WCIS, however, didn't follow the recommendation this year

28	Limited use	Limited access to seasonal forecast, but uses WCIS to adapt agricultural operations, relies on traditional varieties
29	Systematic use	Received training on WCIS by a farmer organization, systematically applies WCIS for variety choice, and to plan his agricultural activities like the adaptation of the sowing date
30	Systematic use	Systematically uses WCIS to adapt variety choice but also to adapt operations such as sowing and harvesting to WCIS
31	Systematic use	Uses WCIS to adapt variety choice and to plan fertilizer use and harvest
32	Systematic use	Uses WCIS to adapt variety choice and to plan fertilizer use, to prepare sowing, and plan harvest
33	No	Only indirect access to WCIS does not understand it well and does not see a relative advantage in using it, therefore, she does not use it
34	Systematic use	Uses information systematically to plan his operations such as the harvest date, strategic use of hoeing and weeding to delay growth and adapt variety to the season
35	No	Doesn't have access to WCIS, just tries to follow the behavior of other farmers
36	Systematic use	High belief in both Saltigue and WCIS, in case of contradiction he will follow the Saltigué, but underlines that he also follows the WCIS, systematically adapts his production and varieties to the information available on the weather

8.6 Annex 6: Insights into NVIVO Coding and Analysis

The screenshots of the NVIVO software attached below illustrate the different codes used, how I grouped them into bigger themes in line with theory and their frequency.

Name	Files	References	Created On	Created By	Modified On	Modified By
Vulnerability context	0	0	10/04/2023 17:14	JB	10/04/2023 17:14	JB
Climate	21	26	10/04/2023 17:21	JB	20/04/2023 18:00	JB
Bad harvest in the last year	21	26	10/04/2023 17:54	JB	20/04/2023 18:02	JB
Traditional beliefs and forecasting methods	2	2	10/04/2023 20:19	JB	12/04/2023 17:56	JB
Saltigue	36	54	10/04/2023 20:27	JB	17/04/2023 17:45	JB
Relation with religion	5	6	11/04/2023 13:42	JB	14/04/2023 19:01	JB
Natural indicator	36	50	10/04/2023 20:20	JB	17/04/2023 17:34	JB
Support mechanisms	9	10	10/04/2023 17:14	JB	14/04/2023 17:44	JB
State actors	2	3	11/04/2023 14:25	JB	11/04/2023 15:54	JB
Saving group installed and monitored by Enda	22	22	11/04/2023 13:31	JB	14/04/2023 19:56	JB
Other NGO	11	11	10/04/2023 17:15	JB	14/04/2023 18:13	JB
Farmer organization	4	5	10/04/2023 17:27	JB	14/04/2023 14:37	JB
ENDA	26	50	10/04/2023 17:14	JB	20/04/2023 17:36	JB
ANCAR	35	35	10/04/2023 17:14	JB	14/04/2023 19:56	JB
ANACIM	2	3	12/04/2023 14:47	JB	14/04/2023 19:37	JB

Name	Files	References	Created On	Created By	Modified On	Modified By
Political, institutional and socio-cultural context	0	0	10/04/2023 17:18	JB	10/04/2023 17:18	JB
Tradition	14	17	10/04/2023 17:18	JB	14/04/2023 19:44	JB
Land rights	7	8	11/04/2023 13:57	JB	14/04/2023 19:44	JB
Heritage	29	41	10/04/2023 20:05	JB	14/04/2023 19:55	JB
Gender norms	35	100	10/04/2023 17:18	JB	14/04/2023 19:54	JB
Decision making in agriculture	34	60	11/04/2023 13:26	JB	14/04/2023 19:54	JB
Outcomes of WCIS use	0	0	10/04/2023 17:16	JB	10/04/2023 17:16	JB
Reduced harvest loss	17	17	10/04/2023 17:45	JB	14/04/2023 20:01	JB
No real effect on production	3	3	11/04/2023 14:23	JB	13/04/2023 18:19	JB
Increased production	10	10	10/04/2023 17:45	JB	14/04/2023 19:37	JB
Improved planning of agricultural activities	16	23	10/04/2023 17:45	JB	14/04/2023 19:25	JB
Livelihood assets	0	0	10/04/2023 16:57	JB	10/04/2023 16:57	JB
Social capital	11	14	10/04/2023 16:56	JB	14/04/2023 19:31	JB
Neighbours as information source	17	24	10/04/2023 17:43	JB	14/04/2023 19:59	JB
Informing others about WCIS	4	4	10/04/2023 20:23	JB	14/04/2023 14:55	JB
Borrowing machines and or traction animal	11	11	10/04/2023 17:44	JB	14/04/2023 19:45	JB

Name	Files	References	Created On	Created By	Modified On	Modified By
Physical capital	1	1	10/04/2023 16:56	JB	11/04/2023 19:53	JB
Ownership of television	15	15	10/04/2023 17:42	JB	14/04/2023 19:00	JB
Ownership of radio	26	30	10/04/2023 17:42	JB	14/04/2023 19:47	JB
Ownership of a rain gauge	1	2	10/04/2023 20:16	JB	11/04/2023 13:46	JB
Ownership of a cellphone with internet access	10	11	10/04/2023 17:42	JB	14/04/2023 18:15	JB
Incomplete set of machines	25	31	10/04/2023 17:41	JB	14/04/2023 19:45	JB
Complete set of machines	12	13	10/04/2023 17:41	JB	14/04/2023 19:55	JB
Natural capital	0	0	10/04/2023 16:57	JB	10/04/2023 16:57	JB
Sufficient number of animals for traction	26	27	10/04/2023 17:40	JB	14/04/2023 19:55	JB
Ownership of a plot	33	35	10/04/2023 17:38	JB	14/04/2023 19:55	JB
No ownership of a plot	4	5	10/04/2023 17:39	JB	14/04/2023 19:44	JB
Livestock	33	35	10/04/2023 20:13	JB	14/04/2023 19:55	JB
Insufficient number of animals for traction	8	8	10/04/2023 17:40	JB	14/04/2023 17:55	JB
Human capital	0	0	10/04/2023 16:56	JB	10/04/2023 16:56	JB
Low available labour	15	16	10/04/2023 17:36	JB	14/04/2023 19:54	JB
Literate in local language	14	14	10/04/2023 17:34	JB	14/04/2023 19:41	JB
Literate in french	10	10	10/04/2023 17:34	JB	14/04/2023 19:41	JB

Name		Files	References	Created On	Created By	Modified On	Modified By
Literate in arabe		1	1	14/04/2023 18:31	JB	14/04/2023 18:31	JB
Illiterate		21	21	10/04/2023 17:33	JB	14/04/2023 19:53	JB
High available labour		12	12	10/04/2023 17:36	JB	14/04/2023 19:29	JB
Financial capital		0	0	10/04/2023 16:56	JB	10/04/2023 16:56	JB
No additional source		6	6	11/04/2023 13:27	JB	14/04/2023 17:54	JB
Financial problems		11	15	10/04/2023 17:52	JB	20/04/2023 17:50	JB
Additional source of income		27	38	10/04/2023 17:52	JB	14/04/2023 19:45	JB
Innovation Decision process		0	0	10/04/2023 17:16	JB	10/04/2023 17:16	JB
Implementation		5	6	10/04/2023 17:17	JB	14/04/2023 19:49	JB
Use of varieties adapted to the forecast of the rainy s		33	42	10/04/2023 17:25	JB	14/04/2023 19:56	JB
Difficulties in the implementation		23	32	10/04/2023 17:26	JB	14/04/2023 19:49	JB
Consideration of the forecast for fertilizer use		6	6	10/04/2023 17:48	JB	14/04/2023 19:36	JB
Conservation techniques		5	6	12/04/2023 14:50	JB	14/04/2023 20:00	JB
Adaptation of weeding		4	4	10/04/2023 20:25	JB	14/04/2023 18:40	JB
Adaptation of sowing date		12	14	10/04/2023 17:48	JB	14/04/2023 20:00	JB
Adaptation of harvest date		19	21	10/04/2023 17:48	JB	14/04/2023 20:00	JB

Name		Files	References	Created On	Created By	Modified On	Modified By
Evaluation		2	2	10/04/2023 17:16	JB	14/04/2023 17:58	JB
Confirmation		1	1	10/04/2023 17:19	JB	11/04/2023 14:05	JB
Awareness		1	1	10/04/2023 17:16	JB	12/04/2023 16:24	JB
Only aware of daily weekly WCIS		6	8	11/04/2023 20:14	JB	14/04/2023 16:35	JB
Awareness of all the different information formats		12	12	10/04/2023 20:21	JB	14/04/2023 19:47	JB
Innovation characteristics		0	0	10/04/2023 17:12	JB	10/04/2023 17:12	JB
Trialability		0	0	10/04/2023 17:13	JB	10/04/2023 17:13	JB
Perceived relative advantage		1	1	10/04/2023 17:12	JB	11/04/2023 20:16	JB
No or low perceived advantage		5	7	10/04/2023 17:56	JB	14/04/2023 16:59	JB
Limited perceived advantage		7	11	10/04/2023 17:55	JB	17/04/2023 18:33	JB
High perceived advantage		25	51	10/04/2023 17:55	JB	17/04/2023 18:35	JB
Perceived complexity		1	1	10/04/2023 17:13	JB	11/04/2023 15:14	JB
Medium perceived complexity		6	7	17/04/2023 18:43	JB	17/04/2023 19:01	JB
Low complexity and or sufficient knowledge		19	24	10/04/2023 17:57	JB	17/04/2023 19:06	JB
High complexity and or insufficient knowledge		12	23	10/04/2023 17:56	JB	17/04/2023 19:01	JB

Name		Files	References	Created On	Created By	Modified On	Modified By
Perceived compatibility		3	3	10/04/2023 17:13	JB	14/04/2023 18:17	JB
Low compatibility		2	3	10/04/2023 17:55	JB	12/04/2023 17:58	JB
High compatibility		11	15	10/04/2023 17:55	JB	14/04/2023 19:03	JB
Observability		7	9	10/04/2023 17:13	JB	14/04/2023 17:52	JB
Existing livelihood system		0	0	10/04/2023 17:13	JB	10/04/2023 17:13	JB
Strategies		7	8	10/04/2023 17:14	JB	20/04/2023 18:01	JB
Challenges		36	53	10/04/2023 17:13	JB	14/04/2023 20:01	JB
weed		4	4	20/04/2023 17:23	JB	20/04/2023 17:53	JB
No big problems		1	1	20/04/2023 17:28	JB	20/04/2023 17:28	JB
Low labor		4	5	20/04/2023 17:22	JB	20/04/2023 18:04	JB
livestock feed		2	2	20/04/2023 16:14	JB	20/04/2023 17:25	JB
Lack of Fertilizers		24	24	20/04/2023 16:06	JB	20/04/2023 18:00	JB
Insufficient support		4	4	20/04/2023 16:12	JB	20/04/2023 17:25	JB
Insufficient machines		20	21	20/04/2023 16:07	JB	20/04/2023 18:01	JB
Insufficient land		4	4	20/04/2023 17:34	JB	20/04/2023 18:01	JB
Insufficient agricultural knowledge		1	1	20/04/2023 17:24	JB	20/04/2023 17:24	JB
Insect attacks		7	7	20/04/2023 16:18	JB	20/04/2023 17:59	JB

Name		Files	References	Created On	Created By	Modified On	Modified By
	Infertile soils or soil salinity	16	17	20/04/2023 16:07	JB	20/04/2023 18:02	JB
	Divagation of animals	3	3	20/04/2023 16:06	JB	20/04/2023 17:57	JB
	diseases killing animals	1	1	20/04/2023 17:51	JB	20/04/2023 17:51	JB
	Delays in agricultural production due to lack of machi	4	4	20/04/2023 16:13	JB	20/04/2023 17:49	JB
	Being a widow	2	2	20/04/2023 16:16	JB	20/04/2023 18:04	JB
	Access to seeds	14	14	20/04/2023 16:11	JB	20/04/2023 18:02	JB
Agricultural production		33	37	10/04/2023 20:08	JB	14/04/2023 19:55	JB
Access to WCIS		6	7	10/04/2023 20:29	JB	14/04/2023 17:58	JB
	On time	15	15	10/04/2023 20:29	JB	14/04/2023 19:59	JB
	Coincidental access, no strategic access	13	19	11/04/2023 13:35	JB	14/04/2023 18:37	JB
	Access preferences	12	12	11/04/2023 14:10	JB	14/04/2023 19:47	JB

To facilitate the further analysis of the codes, I transferred the most important information to an Excel table because I am more acquainted with its filtering options. A screenshot of the entire table is provided below.

To illustrate how this looked in detail I equally provided a zoomed version.

8.7 Annex 7: Bulletin of the MWG

The bulletin is a synthesis of the discussion of the MWG Fatick of October 13th. The development of the weather and its implications on agriculture, livestock production, and pastoralism as well as on forestry is discussed.

The following recommendations are provided:

- It is strongly recommended that producers set up secure, fully covered drying basins completely covered with tarpaulins to continue the drying of corn, millet, and sorghum ears that have reached maturity.

- Concerning the first mature peanut seedlings, the practice of "Egoussage en vert" is an alternative to avoid the regeneration of pods especially for early varieties : This option offers producers the opportunity to sell the pods at very profitable prices at market level.

- Take advantage of the rainfall situation of the decade by setting up a second production campaign for haricots and watermelon: This option allows to absorb the losses that will be noted especially on the hay of groundnut due to a lack of good drying in the sun and to generate other income more substantial income as compensation.

- To ask the rice farmers to appropriate this rainfall situation which is favorable to the development of rainfed rice on the plateau as well as in the valleys, whether or not they have been developed.

- To recognize that rice producers are hopeful that the trend will be reversed compared to last year (a decline in the number of rice plants) (a 21% drop in rice production in 2021-2022 compared to the winter season of the Fatick region).

The original bulletin (in French) is attached.

ANACIM

Bulletin N° 13   PROVAL-CV

BULLETIN AGROMÉTÉOROLOGIQUE DÉCADAIRE

Sommaire

- *METEO: POURSUITE TIMIDE DES ACTIVITES PLUVIEUSES*

- *AGRICULTURE : DDEBUT RECOLTE EN VERT*

- *SITUATION PHYTOSANITAIRE: CALME*

- *SITUATION PASTORALE : BIOMASSE FOURNI-MARES REMPLIS-EMBONPOINT MOYEN*

SITUATION METEOROLOGIQUE

Cette première décade du mois d'octobre 2022 a été relativement peu pluvieuse dans la région de Fatick, avec des manifestations pluvio-orageuses modérées à fortes, observées en fin de décade. Le début et le milieu de cette décade a été marqué par une relative accalmie dans la région.

Par rapport à la normale saisonnière, la distribution spatiale des précipitations au cours de cette décade a été satisfaisante. Les cumuls décadaires enregistrés ont varié entre 90.0 mm (Nioro Alassane Tall) et 12.0 mm (Diakhao Sine).

Les pluies de cette décade ont relativement amélioré les hauteurs d'eau recueillies dans les différentes localités, depuis le début de la saison.

CUMUL PLUVIOMETRIQUE AU 13 OCTOBRE 2022
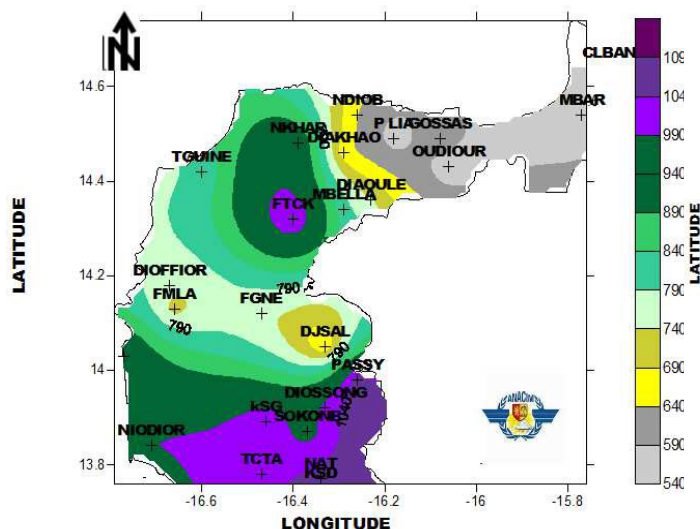

COMPARAISON AU 13 OCTOBRE 2022
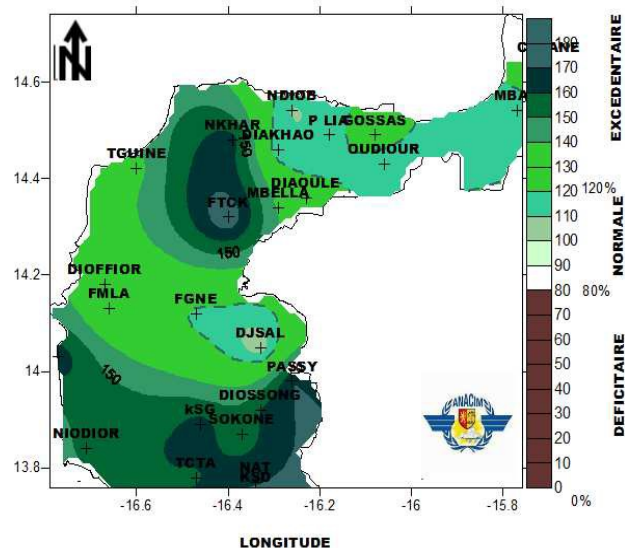
SITUATION METEOROLOGIQUE (suite)

Les cumuls saisonniers enregistrés à cette date la région, varient entre 554.5 mm à Mbar dans le département de Gossas et 1110.5 mm à Keur Saloum Diané dans le département de Foundiougne.

Les pluies de cette décade, bien qu'étant en général faibles à modérée, ont maintenus le niveau des réserves en eau dans le sol dans plusieurs localités, et par conséquent permettront aux derniers semis de boucler correctement leur cycle de développement, par contre ces pluies pourraient avoir un effet néfaste sur les récoltes déjà entamées.

La comparaison de ces cumuls effectuée par rapport à l'année précédente, révèle une situation est largement meilleure et par rapport à la normale (1991-2020), cette situation laisse apparaître des conditions globalement excédentaires dans toute la région.

PERSPECTIVES
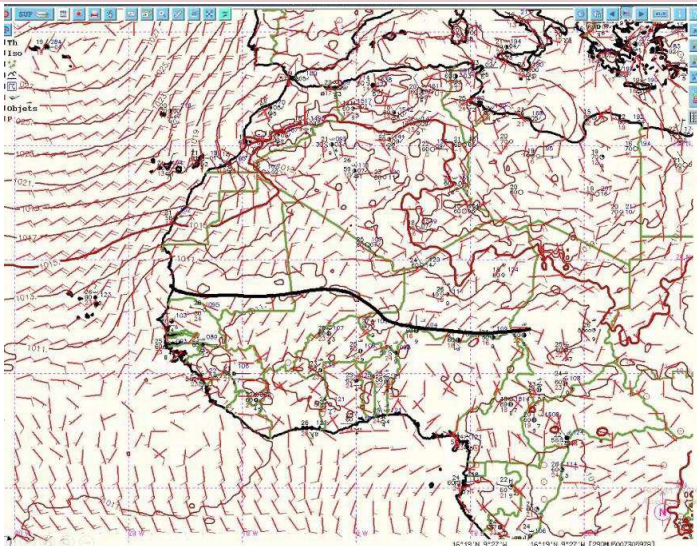
Le Front Intertropical , FIT est entrain d'amorcer son retour et se positionne ainsi sur les latitudes nord Saint Louis centre Mali.

Après consultation des modèles de prévision et en tenant compte de plusieurs paramètres notamment thermodynamique , il est prévu pour la deuxième décade:

Les activités pluvio-orageuses de la deuxième décade d'octobre seront essentiellement notées sur les régions sud du pays.

Seules quelques épisodes localisés pourraient intéresser la centre du pays notamment Kaffrine, Kaolack, Fatick aux dates suivantes: le 14, du 16 au 17 et du 19 au 20 octobre 2022.

SITUATION AGRICOLE

Les opérations de mise en place et de cession des semences, toutes especes confondues ainsi que les engrais mineraux sont presque terminées.

Les taux de cession sont les suivants:

♦ Arachides, sur un quota de 4245tonnes reçues4196 tonnes vendues soit un taux de :98.84%

♦ Mais, sur un quota de 369tonnes reçues, 369 tonnes vendues soit un taux de :100%

♦ Engrais 15-10-10, sur un quota de 1339tonnes reçues, 1339tonnes vendues soit un taux de 100%

♦ Engrais 6-20-10, sur un quota de 2985tonnes reçues, 2985 tonnes vendues soit un taux de 100%

♦ Engrais 15-15-15, sur un quota de 1465 tonnes reçues, 1465 tonnes vendues soit un taux de 100%

♦ Urée, sur un quota de 1510tonnes reçues, 1510 tonnes vendues, soit un taus de 100%

La pluviométrie a été très bien répartie dans le temps et dans l'espace avec des cumuls assez conséquents. Ces importants apports nous ont conduit à la situation phénologique suivante:

Arachide: maturation-égoussage en vert

Mil souna: Récolte et séchage des épis

Maïs: Récolte et séchage des épis

Niébé: maturation-récolte des gousses

Pastèque: maturation-récolte

Sorgho: Récolte et séchage des épis

Riz pluvial: remplissage panicule-stade laiteux

Manioc: phase reproductive– tubérisation-grossissement.

SITUATION PASTORALE

* <u>SITUATION ALIMENTAIRE DU CHEPTEL</u>

<u>Pâturages</u>

La biomasse herbagère est abondante avec une bonne productivité. Dans l'ensemble , les pâturages sont disponibles et valorisés par les gros et petits ruminants.

<u>APPROVISIONNEMENT DU BÉTAIL</u>

La bonne disponibilité du fourrage naturel fait que l'aliment du usiné est utilisé secondairement dans les boutiques, les loumas et les magasins de vente.

<u>Prix aliment bétail dans les loumas</u>

Fane d'arachide	Ripasse	Tourteaux d'arachide artisanale	Maïs	Mil Souna
2500 à 3000 le sac de 25 Kg	250 / Kg	250 F / Kg	400 F / Kg	350 F /Kg

* <u>L'ETAT D'EMBONPOINT DES ANIMAUX ACCEPTABLE AVEC UNE CORPORELLE VARIANT DE 3 A 4.5</u>

* <u>HYDRAULIQUE PASTORALE</u>

Aujourd'hui, le cheptel fréquente les mares et les points d'eau temporaires pour l'abreuvement. Les mares présentent dans l'ensemble un niveau de remplissage satisfaisant.

* <u>MARCHE DU BETAIL</u>

En cette période de l'année, les prix sont encore élevés. Cette tendance se reflète encore sur les prix de la viande qui ont connus une augmentation remarquable. Ces prix varient entre 1100 à 1500 francs le kilogramme vif.

SITUATION PASTORALE(SUITE)

MARCHE DU BETAIL

ESPECES	PRIX MOYEN
BOVINS	175000 – 350000
OVINS	60000 – 85000
CAPRINS	25000 – 60000
EQUINS	175000 – 400000
ASINS	70000 – 110000
VOLAILLE	3000 – 4500
PORCINS	25000 – 60000

SITUATION ZOOSANITAIRE

Pas d'épidémie à l'échelle régionale.

L'état sanitaire des animaux s'améliore et les cas de dermatose nodulaire apparus ont été traités malgré la forte mortalité observées par endroit

SITUATION FORESTIERE

Conformément au décret N°83-751 du 16 juillet 1983 instituant la journée nationale de l'arbre et qui marque le démarrage effectif de la campagne nationale de reboisement au Sénégal, de très grandes campagnes de mobilisation sont menées.

Avec l'appui du programme de l'Etat du Sénégal dénommé kheyou Ndaw gni , des opérations de reboisement à grande échelle sont effectuées   sur toute la région.

SITUATION DE LA PRODUCTION DES PLANTS

Types de pépinières	Nombre	En germination
Régie	16	426096
Villageoise /Communautaire	13	242592
Individuelle/Privée	73	177743
Scolaire	1	168
Total	103	846599

SITUATION FORESTIERE

<u>REALISATIONS</u>

◊   Plantations linéaires

        22,616 km ont été réalisés pour un nombre de plants de 16023plants

◊   Plantations de restauration/ réhabilitation

        84,07ha ont été reboisés pour un nombre de plants de 16279plants

◊   Foresterie urbaine

        554 écoles, mosquées, églises, places publique ont été reboisés pour 38644 plants

<u>RECOMMANDATIONS</u>

♦Il est fortement recommandé aux producteurs de mettre en place des Claies de séchage sécurisés et totalement recouverts de bâches dans les concessions pour poursuivre le séchage des épis de MAÏS, MIL, SORGHO arrivés à maturité .

♦Concernant les premiers semis d'Arachide arrivés en maturité, la pratique de l'Egoussage en vert est une alternative pour éviter la regermination des gousses surtout pour les variétés hâtives : cette option offre aux producteurs l'opportunité de vendre les gousses à des prix très rémunérateurs au niveau des marchés .

♦Mettre à profit la situation pluviométrique de la décade en mettant en place une seconde campagne de production pour le NIEBE et la PASTEQUE : cette option permet de résorber les pertes qui seront notées surtout sur la FANE d'ARACHIDE faute d'un bon séchage au Soleil et d' autre part générer d'autres revenus plus substantiels en guise de compensation .

♦Demander aux riziculteurs de s'approprier de cette situation pluviométrique qui est propice au bon développement du Riz pluvial sur le plateau comme dans les vallées aménagées ou pas ; signaler que l'espoir est nourri par les producteurs de riz qui espèrent renverser la tendance par rapport à l'année dernière (baisse de 21 % enregistrée en 2021-2022 par la production rizicole comparée à l'hivernage 2020-2021 par la région de Fatick) ;

le GTP local a pour objectif de contribuer à l'alerte précoce pour la sécurité alimentaire en fournissant des information complètes sur la campagne agricole. Sa coordination technique est assurée par l'Agence Nationale de l'Aviation Civile et de la Météorologie ou une autre institution (cas ou l'ANACIM n'est pas représenté) . Le groupe composé des services intervenant dans le domaine de la production agricole (Agriculture, Protection des Végétaux, Elevage, Commissariat à la Sécurité Alimentaire, ...) publie à la fin de chaque décade un Bulletin Agro météorologique Décadaire destiné aux autorités locales, nationales, aux bailleurs de fond et aux techniciens) .

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DIOKONDIAL A PAAKH