

# Traditional Systems for Maintaining Soil Fertility and Adapting Family Rice Cultivation to Water Deficit in the Upper Niger Valley in Dabola

Fatoumata Binta Sombily Diallo<sup>1</sup>, Lucien Solié<sup>1</sup>, Mariétou Diallo<sup>2</sup>, Alpha Issaga Pallé Diallo<sup>1</sup>

<sup>1</sup>Institute of Environmental Research of Guinea, Faculty of Sciences, Gamal Abdel Nasser University of Conakry (UGANC), Conakry, Guinea

<sup>2</sup>Department of Social and Solidarity Economy, University of Labé (UL), Labé, Guinea

Email: bintamosombily@gmail.com, luciensolie012@gmail.com, diallomariatou077@gmail.com, alfadjogalle@gmail.com

**How to cite this paper:** Diallo, F.B.S., Solié, L., Diallo, M. and Diallo, A.I.P. (2026) Traditional Systems for Maintaining Soil Fertility and Adapting Family Rice Cultivation to Water Deficit in the Upper Niger Valley in Dabola. *Agricultural Sciences*, 17, 1-17.  
<https://doi.org/10.4236/as.2026.171001>

**Received:** November 22, 2025

**Accepted:** January 13, 2026

**Published:** January 16, 2026

Copyright © 2026 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).  
<http://creativecommons.org/licenses/by/4.0/>



Open Access

## Abstract

The decline in agricultural productivity caused by human activities and exacerbated by climate change remains an undeniable reality in West Africa. Farmers in the region have managed to adapt to these challenges by adopting certain traditional practices that are compatible with changing climatic conditions, which underpins the title of our article: “Traditional Systems for Maintaining Soil Fertility and Adapting Family Rice Farming to Water Deficits in the Upper Niger Valley at Dabola.” Our specific objectives are as follows: (i) To identify the major climatic shocks indicating climate change in the Upper Niger Basin at Dabola; (ii) To determine the current and potential impacts of climate change on rice production in the area; (iii) To analyze the adaptation strategies implemented by local communities to sustainably mitigate the impacts of climate change on rice production. To achieve these objectives, we employed the following methods: literature review, and field surveys using direct observation, semi-structured interviews, and questionnaires. The main results indicate that the edaphic and climatic characteristics of the area divide it into five agroecological zones: (i) The Woulada plateau; (ii) The Foutanian piedmont; (iii) The Fria hills and plateau; (iv) Natural reserves (classified forests). Farm sizes are relatively small, ranging between 0.4 and 1.5 hectares, and yields are also low, at 0.5 t/ha on slopes and mountains compared to 1.5 t/ha on plains and lowlands. The rate of change in rainfall between 1950 and 2010 is -5.68%, corresponding to a decline in normal levels over these sixty years. The impacts of climate change on water resources in the area are both envi-

ronmental (drying up of watercourses during the dry season, resulting in reduced water availability) and socioeconomic (disruption of the agricultural calendar and a significant decrease in crop yields). Household adaptation strategies to climatic shocks are based on food security, economic measures, and ecosystem management. To deepen the understanding, a socio-economic study should be conducted in the area to better illustrate the deficits associated with climatic shocks and to identify appropriate measures for addressing these recurrent challenges in the Upper Niger Valley at Dabola.

### **Keywords**

Traditional System, Soil Fertility, Climate Adaptation, Rice Cultivation, Upper Niger Valley

---

## **1. Introduction**

This article forms part of our interdisciplinary doctoral thesis in environmental sciences. The research project that led to this article is funded by the PPAAO and the CÉRE through the FORESGUI. This program aims to increase land productivity to improve the living conditions of producers. The increase in agricultural productivity is constrained by climate change and land degradation. For this reason, the third priority area of the FAO in Guinea focuses on “Strengthening the resilience of the country and vulnerable populations in the face of food crises, disasters, and climate change” [1].

According to Doukpolo (2014), the growing global warming of planet Earth constitutes a serious threat to humanity (GIEC, 2007). Among the most pressing issues of our time are climate change, population growth, and environmental transformations (deforestation, land degradation, etc.). The questions of vulnerability and adaptation of food crop agriculture are particularly urgent. It is within this context that, during the World Summit on Agricultural Production and Food Security, the FAO (1996) set itself the objectives of combating the effects of climate variability and reducing world hunger by half by 2015. Despite this ambition, the situation remains concerning today, and the risks of exacerbation remain noteworthy given the recurrence of climate shocks (droughts and floods) and their devastating consequences for agriculture in tropical Africa [2].

The issue of the impact of climate change on agricultural production has already been the subject of numerous scientific studies worldwide, across various regions and countries (FAO, 1997). According to Doukpolo (2014), in tropical Africa, rural populations are particularly affected by climate change, since the performance of their production systems is closely dependent on climate (Boko, 1988; Janicot and al., 2004). In this context, the work of several authors has drawn the attention of the scientific community to the challenges posed by climate variability and change. Among these authors are Mouton and Sillans (1954); Pagney (1973; 1986); Boko (1988); Hubert and al. (1989); Sircoulon (1990); Houndenou (1999);

Afouda (2001); Ndjendolé (2001); Ogouwalé (2006). These authors have demonstrated that climate disturbances are spatially extensive in terms of frequency, intensity, and duration. These disruptions have severely affected fragile economies, triggered acute food crises, and hindered the efforts undertaken to achieve food security [2].

Studies conducted in Benin, Senegal, and Niger demonstrate the evidence of climate change and its multisectoral impacts in West Africa, particularly on agriculture and food production. According to Doukpolo (2014), authors such as Ogouwalé (2004; 2006) and Issa (2012) have highlighted the impact of climate change on food security in Benin. In Senegal (Seck *et al.*, 2005) and Niger (Salack *et al.*, 2006), agricultural yields have experienced drastic declines resulting from the effects of climate change. Moron (1993) and Morel *et al.* (2008) report that rainfall decreased significantly around 1970, causing a decrease in agricultural production. According to Sarr and Salack (2007), these fluctuations in rainfall reduced crop yields for staple foods by more than 60%. Export crops that were profitable before 1970 are no longer so, as they have become poorly adapted to the new climatic conditions.

According to IFPRI (1995); Hunt *et al.* (1998); Harrison *et al.* (2008) as cited by Doukpolo (2014), several studies indicate that climate change has caused a shift in seasonal patterns in tropical regions. In Cameroon, the Central African Republic, and Côte d'Ivoire, the main rainy season, which previously began in early March, is increasingly occurring in May (Sultan *et al.*, 2004; Brou, 2005; Tsalefac *et al.*, 2007). In recent years, the onset and end of the rainy seasons have become generally less predictable for farmers, thereby making agricultural planning more uncertain (Diop *et al.*, 1996; Houndenou *et al.*, 1998). This seasonal shift leads to repeated sowing, resulting in reduced income, rural exodus, famine (prolongation of the lean season), seasonal migration of farmers, and changes in farming practices. Additionally, there has been a trend toward a shortening of the Crop Growing Period (CGP) since the late 1960s, correlating with the aridification of the Sudano-Sahelian regions (Diop *et al.*, 2000). The reduction of this period, which is favorable for plant development and maturity, negatively affects crop productivity (Thornton *et al.*, 2006), especially for upland and mountain rice [2].

According to Doukpolo (2014), a study on climate scenarios and future agricultural yields showed that by 2025, climate change will lead to a significant decrease in the yields of major crops in sub-Saharan Africa (Zhao, 2005). This situation is attributed to variability in agro-climatic indices that directly affect agricultural yields. Among these indices, the most critical is the humidity index; its decline reflects a reduction in climatic water supply, due to worsening potential evapotranspiration and decreased cumulative rainfall (Berger, 1992) [2].

According to Doukpolo (2014), agricultural potential is deteriorating due to climate change and various socio-environmental shifts. Indeed, disruptions in the growth stages of rice plants, the precariousness of rice farmers' production re-

sources, rain-thermal stress, and the proliferation of crop pests are among the phenomena induced by climate change that are likely to impede rice productivity. Variations are already evident in rice cropping calendars, including: (i) Delayed or shifted sowing dates; (ii) Delays, shifts, or shortening of flowering dates; (iii) Water and/or heat stress during critical stages of growth or maturation. Adaptation of upland and mountainous rice farming to climate change requires strengthening the resilience of the sector, improving production systems, and enhancing existing adaptive strategies (IPCC, 2007; Boko, 2009; IPCC, 2012; Doukpolo, 2014). This underscores the need to help identify climate shocks, understand their impacts on rice yield, and identify traditional systems for improving soil fertility and adapting to water deficits for their wider dissemination. This is the aim of the present research, conducted in the upper Niger basin in Dabola (Guinea), a savanna zone dominated by upland and mountainous ecosystems that are sensitive to water deficits and thermal stress [2].

With a rural population estimated at 80% of the total population, Guineans derive most of their income (79%) from agricultural activities (Ministry of Agriculture *et al.*, 2017a; FAO, 2018). According to IFAD (2017), in 2010, family farming in Guinea accounted for 74% of jobs, more than 60% of the population, and 95% of cultivated land. It is dominated by cereals (rice, maize), and rainfed crops account for 95% of sown areas; farms are small, ranging from 0.1 to 0.3 hectares, and 95% of production is for household consumption. In 2014, rice production reached 1.6 million tons of paddy, involving 80% of farms, covering 67% of cultivated land, meeting 65% of cereal needs, employing 37% of the active population, and accounting for 23% of primary GDP [3].

In this regard: (i) The National Agricultural Investment and Food Security Plan 2013-2017 (PNIASA) gives top priority to the “Program for Sustainable Development of Rice Farming”; (ii) The National Economic and Social Development Plan 2016-2020 (PNDES) considers rice to be one of the priority actions for the promotion of crop value chains; (iii) The National Agricultural Development Policy 2016-2025 (PNDA) ranks first the “Program for the Development of Food Crop Production, notably rice within the framework of sustainable production systems”; (iv) The National Agricultural Investment, Food and Nutrition Security Plan 2018-2025 (PNIASAN) considers “Rice production as one of the sectoral objectives by 2025” (Ministry of Agriculture, 2012; Ministry of Planning and International Cooperation MPCI, 2016; Ministry of Agriculture *et al.*, 2017a; 2017b) [4].

Given the central role of rice in the diet of Guinean populations, with an average annual per capita consumption of 125 kg (Ministry of Agriculture *et al.*, 2017a), national agricultural policies have been implemented through the development of the National Rice Development Strategy (SNDR). This strategy aimed to improve (i) the effectiveness and efficiency of family farms and (ii) the self-sufficiency rate in rice, increasing from 74% in 2008 to 132% in 2018 [4].

However, as in the rest of the country, rice production in the upper Niger val-

ley—located in Upper Guinea and one of the two priority areas for rice cultivation development in Guinea—continues to face agronomic constraints. These constraints include: (i) Poor soil fertility; (ii) Water deficits; (iii) Rainfall variability; (iv) Rising temperatures. These findings are consistent with regional trends observed in several studies on the West African climate [5] [6]. These changes directly affect agricultural yields and food security [7].

In the upper Niger Valley at Dabola, rice yields have declined in recent decades. This decrease is primarily due to water deficits resulting from low rainfall and/or the premature cessation of rain. The National Climate Change Adaptation Plan (PANA-CC) indicates that by 2100, temperatures in Upper Guinea are projected to rise by approximately 4.8°C, with rainfall decreasing by as much as 40% (MAEEF, 2007; ECOWAS, 2017). According to the results of food security surveys conducted by WFP in 2009, 32% of households in this region are food insecure [8] [9]. This rainfall variability is also documented in the Sahelian and Sudano-Guinean regions [10] [11]. Recent land use dynamics also confirm growing pressure on natural resources [12].

African communities possess traditional nature conservation practices that are still implemented in certain areas. If properly recognized, these practices can make a substantial contribution to these communities' adaptation to climate change. Thus, the present study aims to identify, characterize, and analyze the sustainable traditional practices for maintaining soil fertility and adapting to water deficits in rice cultivation on hillsides and mountains in the upper Niger valley in Dabola, with a view toward their dissemination. Its specific objectives are as follows:

- Identify the indicators of climate change shocks in the upper Niger basin at Dabola;
- Determine the current and potential impacts of climate change on upland and mountain rice production in the area;
- Analyze the adaptation strategies implemented by communities to sustainably reduce the impacts of climate change on upland and mountain rice production.

## 2. Methodological Framework

Document analysis, field observation, and surveys were employed for data collection. Document analysis provided scientific information to establish the current state of knowledge on the research topic. It also facilitated the collection of geographic, demographic, biophysical, and socio-economic data related to the study area.

Conducted during site visits alongside the survey, on-site physiognomic observations enabled the identification of hillsides, mountains, and local agricultural practices. These observations were carried out in two districts: Koumarella in the urban commune (CU) of Dabola, and Koolo Hindé in the rural commune (CR) of Dogomet.

Site selection was conducted using purposive sampling. Given that the Dabola

Prefecture straddles both Middle and Upper Guinea, the primary selection criterion was the location of sites within either of these two natural regions, each characterized by distinct edaphic and climatic features. Consequently, the Koumarella district, representative of Upper Guinea, and the Koolo-Hindé district, characteristic of Middle Guinea, were chosen. The second criterion for site selection was the practice of rice cultivation on mountains and/or hillsides.

Prior to the main survey, an exploratory visit and a pilot survey were conducted in parallel to gain an understanding of the selected sites and to test the questionnaire and interview guide. Subsequently, both qualitative and quantitative methods were combined. The qualitative approach aimed to understand farmers' social perceptions of climate change, climatic shocks, and the impacts of these changes on upland and hillside rice cultivation. This phase primarily utilized semi-structured interviews. Simple random sampling was applied based on a list of resource farmers owning fields on hillsides and/or mountains. The quantitative approach, in turn, enabled the assessment of the types and extent of traditional climate-compatible practices. Additionally, it allowed for an evaluation of the cultivated areas per household and per year, as well as rice yields in fields where sustainable traditional soil conservation systems are implemented and in fields where such systems are not used. The survey involved the use of a questionnaire along with simple random sampling.

The study covers a population of 67,657 inhabitants, comprising the population of the Urban Commune (CU) of Dabola (38,617 inhabitants) and the Rural Commune (CR) of Dogomet (29,040 inhabitants) [Ministry of Planning, 2015]. The interview guide and survey form were administered to a sample of 90 individuals: the questionnaire was administered to 70 individuals (30 prefectural officials and 40 farmers), and the interview guide to 20 farmers. This sample consists of two categories of actors: (i) Prefectural officials in agriculture, livestock, and the environment; (ii) Rice producers on mountains and hillsides who constitute the farmers. The 30 prefectural and sub-prefectural officials are distributed as follows: (i) Prefectural department of agriculture (agriculture and AMPROCA) and agricultural advisors of the sub-prefectures: 17 experts; (ii) Prefectural department of environment, water and forests, and forestry brigades: 11; (iii) Prefectural department of livestock: 2.

The survey covered the following topics (or types of information):

- public awareness of the phenomenon of climate change;
- The impacts of climate change on agriculture in general, and on upland and mountain rice cultivation in particular;
- the impacts of climate change on upland and mountain rice cultivation;
- the traditional soil fertility maintenance systems practiced there;
- traditional soil conservation systems used on hillsides and mountains;
- traditional systems implemented to adapt family rice farming on hillsides and mountains to water shortages.

In addition to field data, training materials are drawn from Groupe GDT—Ag-

roforestry (1999); Jan Willem Molenaar and Jan Joost Kessler (2008); Hanspeter Liniger, Rima Mekdaschi Studer, Christine Hauert, and Mats Gurtner (2011); and the World Future Council Foundation (2017).

The data were compiled, entered, and processed using Microsoft Excel 2013, then analyzed and interpreted. Following the literature review and field investigations (observations and surveys).

### 3. Presentation and Interpretation of the Results

#### 3.1. Land Use and Land Cover in the Upper Niger Valley at Dabola

Physiognomic observation of the structural characteristics of the landscapes, supplemented by documentary analysis, reveals that land use in the upper Niger valley at Dabola is characterized by 12 units grouped into eight major classes: (i) Inhabited territory or urban and village areas; (ii) Cropland and recent fallows; (iii) Rocks and other bare lands including the bowé; (iv) Grass savanna; (v) Wooded and shrubby savannas; (vi) Dry dense forest; (vii) Gallery forest; (viii) Watercourses and bodies of water.

Classification based on edaphic-climatic and social characteristics indicates that the upper Niger Valley in Dabola is structured into four agroecological zones: (i) The Woulada Plateau; (ii) The Foutanian Piedmont; (iii) The hills and plateau of Fria; (iv) Natural reserves (protected forests).

**The Woulada plateau area:** This region is characterized by a seasonality consisting of five rainy months and six ecologically dry months, with a growing period (DPV) of 190 days, annual rainfall ranging from 1400 to 1600 mm, and an average altitude of 300 m. The soils are ferrallitic and weakly developed, interspersed with patches of hydromorphic and alluvial land lying atop a granitic-gneissic geological basement. Vegetation consists of a mosaic of wooded savannas, dry forests, and gallery forests. The main crops are groundnuts, rice, maize, and cotton.

**The Foutanian piedmont area:** This mountainous region is characterized by an equal distribution between the rainy and dry seasons. It comprises three DPV zones (180, 190, and 200 days) with rainfall ranging from 1400 to 1800 mm. In terms of topography, elevation varies from 300 to 914 m. Granito-gneiss is the predominant geological formation, with ferrallitic and weakly developed soils, lateritic crusts resulting from bowalization, and in some places, hydromorphic soils in depressions (valleys) and alluvial soils along riverbanks. The main crops are groundnut, rice, cassava, cotton, and maize. The area is also an important livestock breeding region.

**The hills and plateau zone of Fria:** is characterized by a rainfall index of “4-3-5”, a growing period (DPV) of 200 to 210 days, and annual precipitation ranging from 1600 to 1800 mm. The rugged terrain includes summits reaching 460 m. Soils in this area are primarily ferrallitic and weakly developed on plateaus and uplands, while hydromorphic and alluvial soils predominate in valleys and along waterways. These soils rest upon a geological substrate dominated by granito-gneiss. The vegetation consists mainly of wooded savannas interspersed with post-

forest shrub regrowth. The main crops in this zone are groundnuts, rice, and cassava, while maize, cotton, and fonio are of secondary importance.

**The area of nature reserves:** this area concerns classified forests, such as those of Sincéry-Oursa and Balayan-Souroumba, which are distinct ecological entities with limited areas. The primary management challenge is the sustainable conservation of biodiversity.

### 3.2. Family Farm Size and Average Yields

In Dabola, as throughout Guinea, the size of family farms remains small. More than 80% of these farms cover an area between 0.4 and 1.91 ha. In addition to rice, the main crops grown are maize, cassava, fonio, groundnut, market gardening crops, perennial crops, and cash crops (banana, cotton, cashew, avocado, etc.). Essentially, farming methods include crops on hillsides, mountainous areas, plains, lowlands, etc.

Rice yields are low, ranging from 0.5 t/ha on hills and mountains to 1.50 t/ha on plains and lowlands. The low yield is attributable to poor cultivation practices, insufficient use of improved plant material, limited application of chemical and organic fertilizers, and adverse climatic conditions, particularly the increase in temperatures and the decline in precipitation. Therefore, intensification and restoration of natural soil fertility present themselves as alternatives for increasing production. However, the restoration of natural soil fertility through fallow duration is becoming increasingly difficult due to high demographic pressure.

### 3.3. Variation in Rainfall at Dabola and Its Impacts

#### 3.3.1. Variation in Rainfall from 1950 to 2010

The assessment of the vulnerability of water resources to climate change is based on the examination of normals. During the period 1950-2010 selected for several studies, the examination of normals (1951-1980, 1961-1990, 1971-2000, 1981-2010) indicates a generalized downward trend in the upper Niger valley at Dabola. **Table 1** presents the mean normals and the rates of change in rainfall over the period 1950-2010 (a span of 60 years).

**Table 1.** Rate of change in the normal average rainfall, expressed as a percentage relative to the mean rainfall for the period 1950-2010.

	Periods			
	1951-1980	1961-1990	1971-2000	1981-2010
Dabola	5.34	-7.02	-7.43	-5.68

Source: Data extracted from MEEF (2018).

#### 3.3.2. Impacts of Climate Change on Water Resources

In the upper Niger valley at Dabola, the current water deficit has environmental and socio-economic consequences that are expected to intensify in the future (see **Table 2**). The decrease in rainfall leads to:

- land conflicts due to the reduction of arable land and pastures;
- the migration of populations to urban centers, resulting in increased unemployment;
- insecurity and health problems;
- the frequency of floods resulting from an increase in the occurrence of heavy precipitation events, leading to economic losses.

**Table 2.** Impacts of climate change on water resources at Dabola and their manifestations.

Impacts	Manifestation
Environmental impacts	<ul style="list-style-type: none"> <li>▪ Drying up of small streams during the dry season</li> <li>▪ Pronounced low water levels in major rivers</li> <li>▪ Intensification of water erosion and its aggressiveness</li> <li>▪ Decrease in the availability of water resources</li> <li>▪ Decline in water quality (pollution)</li> <li>▪ Decrease in soil moisture</li> <li>▪ Degradation of the vegetative cover</li> <li>▪ Soil drying and degradation</li> <li>▪ Biodiversity degradation</li> <li>▪ Increase in forest fires</li> </ul>
Socio-economic impacts	<ul style="list-style-type: none"> <li>▪ Reduction of cultivated areas following desiccation</li> <li>▪ Disruption of the agricultural calendar</li> <li>▪ Significant decline in crop yields</li> <li>▪ Decline in population income</li> <li>▪ Rural exodus towards urban centers and an increase in unemployment</li> <li>▪ Increasing socio-land conflicts in plains, lowlands, and protected areas</li> </ul>

Source: MEEF (2018) and field investigations conducted as part of this study.

### 3.4. Exposure to Natural Shocks and Food Insecurity

Based on evidence of adverse environmental changes and erosion propensity, as established through literature review and field investigations conducted in this study, drought, floods, landslides, and land degradation are identified as the principal natural shocks in the upper Niger valley at Dabola. The risks of flooding and landslides are moderate, whereas the risks of drought and land degradation are high.

Analysis of the recurrence of food insecurity indicates that the Upper Niger Valley in Dabola experiences a moderate level of insecurity. Among households affected by a shock in 2018, 30.7% suffered a loss of more than 50% of their income, 43.1% lost between 25% and 50% of their monetary resources, and 26.2% experienced a decrease of less than 25%.

The research has highlighted that households in the upper Niger valley in Dabola primarily experience environment-related shocks, including delayed or insufficient rainfall, droughts, or floods. While the impact of a shock on households varies depending on its type and frequency, the intensity of the shock was also taken into account. For instance, bushfires and fires resulted in a loss of more than half of income for 30.6% of affected households. Late rainfall, floods, drought, soil erosion,

and the shortened rainy season due to premature cessation of rains affected over 40.3% of households, resulting in income losses exceeding 50%, whereas soil depletion impacts 29.1% of households. These figures demonstrate that environment-related shocks have a significant effect on reducing income levels.

### 3.5. Description and Analysis of the Resilience and Adaptation Strategies of the Populations of Dabola to the Impacts of Climate Change

The description and analysis of the resilience and adaptation strategies of the populations in the upper Niger valley at Dabola to the impacts of climate change, which enable them to withstand climate shocks, plan productive agricultural seasons, and manage risks, as presented in the following subsections, are based on the survey, field observations, and document analysis.

#### 3.5.1. Perception of the Populations of the Upper Niger Valley in Dabola Regarding the Main Manifestations of Climate Change: Flooding and Drought

The survey indicates that the populations of the Upper Niger Valley in Dabola are familiar with the main phenomena through which climate change manifests itself in their area. These phenomena include flooding, drought, and land degradation. The names of these phenomena in the dialects of the region's major ethnic groups are presented in **Table 3** below.

**Table 3.** Terms used for flood and drought in the dialects of the main ethnic groups of Dabola.

Terms used to refer to flooding and drought			
Dialect	Flood	Drought	Land degradation
Pulaar	Waamè	Hokkèrè (Yooroungal)	Mettou-Leydi (Leydindin metti)
Maninkakan	Karifoo	Kofoo	Dougou Gbouya (Ka Dougou Gbouya)

Source: Survey conducted as part of the present study.

#### 3.5.2. Livelihoods and Economic Resilience of Communities in Coping with Climate Shocks

Survey and documentary data (Republic of Guinea, 2019) illustrate how shocks can impact households in the Upper Niger Valley in Dabola depending on the most critical periods of the year, as well as inform the selection of livelihood program interventions. The main livelihoods in this area are rice, cassava, groundnuts, maize, and livestock. In terms of economic resilience, 11.0% of households report having fully recovered from the primary shock experienced over the past year, 77.2% state they have only partially regained their previous level, and 11.8% of households have not recovered at all.

#### 3.5.3. Community Adaptation Strategies to the Impacts of Climate Change

In response to the shocks, they experience and considering their available re-

sources, households in the Upper Niger Valley at Dabola implement adaptive strategies. This capacity to cope with difficulties through adaptation is summarized by the indicator of adaptation strategy (Coping Strategy Index), referred to as Coping Strategy Index (CSI). This indicator takes three forms:

- a Reduced Food-related Coping Strategies Index (rCSI) or reduced Coping Strategy Index, focused on food-related coping strategies adopted by a household;
- an adaptation strategy indicator based on the implemented economy;
- an indicator of ecosystem-based adaptation strategy.

#### **Diet-related adaptation strategies**

Based on the survey, the food-related strategies are as follows:

- consumption of less preferred or less expensive foods;
- borrowing food or requesting assistance from a friend or relative;
- limiting the amount of food during meals;
- reduction in the quantities consumed by adults and mothers in favor of children;
- reduction in the number of meals per day.

The survey results indicate that the most adopted coping strategy among households is the consumption of less preferred or cheaper foods, accounting for 34.3%. At certain times of the year, households therefore turn to more accessible food items. To a lesser extent, 19.2% limited the quantities consumed during meals, 17.8% reduced the number of meals, 15.5% chose to decrease adult food portions in favor of children, and 13.2% borrowed food or sought it from others. Households experience food stress, with a score of 4.75.

#### **Economic adaptation strategies**

The strategies are categorized into three groups, as shown in **Table 4** below.

**Table 4.** Details of the various adaptation strategies.

<b>Strategy</b>	<b>Actions</b>
No strategy	<ul style="list-style-type: none"> <li>▪ Households have not adopted any coping mechanisms.</li> </ul>
Stress	<ul style="list-style-type: none"> <li>▪ Borrowing money</li> <li>▪ Spending of savings</li> <li>▪ Sale of more (non-productive) animals than usual</li> <li>▪ Sending household members to eat elsewhere</li> </ul>
Crisis	<ul style="list-style-type: none"> <li>▪ Withdrawal of children from school</li> <li>▪ Reduction of healthcare and education expenses</li> <li>▪ Reduction in expenditures on agricultural inputs</li> <li>▪ Consumption of seed stocks</li> </ul>
Urgency	<ul style="list-style-type: none"> <li>▪ Sale of house or land</li> <li>▪ Sale of the last female animals</li> <li>▪ Begging</li> </ul>

Source: Combination of documentary research and survey methods within the framework of this study.

According to the survey conducted in this study and the review of documentary

sources (WFP Guinea, 2018), 47.4% of households did not implement adaptation strategies, 30.6% developed stress strategies by borrowing money or food, 16.5% used their savings to cope with the situation, 2.4% reported having withdrawn their children from school, 2% sold their productive assets, and 1.1% resorted to begging.

#### **Ecosystem-based adaptation strategies of local communities**

##### **a. Ecosystem-based adaptation strategies for communities facing the impacts of climate change on water resources**

The main strategies for enabling the adaptation of communities in the upper Niger Valley in Dabola require actions that facilitate a better understanding of water resource trends in the short, medium, and long term, such as:

- rehabilitation and reinforcement of networks for meteorological measurement, hydrological and piezometric;
- implementation of an integrated system for data processing and information dissemination;
- strengthening the management capacities of monitoring networks;
- development of systems for forecasting and managing climatic hazards;
- popularization of legal texts related to water resource management and raising awareness among various stakeholders (populations, decision-makers, and local elected officials) regarding the content of these texts and their applicability;
- protection of water against pollution;
- strengthening of sub-regional cooperation in the management of transboundary water resources;
- restoration of springheads and riparian forest corridors in degraded areas;
- use of short-cycle varieties and varieties with low water requirements.

##### **b. Traditional, improved, and transferred ecosystem-based adaptation practices in the agro-pastoral sector to climate change**

In the upper Niger valley at Dabola, several measures and adaptation strategies have been developed and practiced by local populations. These measures are not based on risks but rather on impact. Thus, various adaptation methods are observed, including: the development of lowlands, the use of fertilizers, the modification of planting dates, the abandonment of late-maturing varieties in favor of early-maturing, high-yielding types, the use of improved varieties, and livestock feeding (see [Table 5](#)).

Agro-climatic disturbances have had significant impacts on farming practices. To address these challenges, farmers have developed adaptation strategies. Strengthening farmers' adaptive capacities requires planned public adjustments and private initiatives. Among the identified adaptation practices, the diversification of farming activities, support for income-generating activities, and livelihood support are the most effective and should be reinforced in response to climate stimulus.

Traditional sustainable practices for adapting to climate change include soil protection techniques, climate-smart agricultural practices, soil restoration, and water conservation. The ecosystem-based strategies for adapting agriculture to the effects of climate change, which were disseminated through the training of 10 lead

farmers, five (05) of whom were women, focused on the following systems:

- the systematic management of mountains and hillsides;
- agroforestry and agricultural intensification;
- farmer-assisted natural regeneration (FANR);
- the agroforestry parkland system and the *Grevillea*-based agroforestry system;
- anti-erosion embankments;
- the combination of extension, intensification, and diversification on steep slopes;
- the integration of nitrogen-fixing crops.

**Table 5.** Ecosystem-based adaptation through traditional, improved, and transferred practices.

Agriculture	Forestry	Livestock farming
Development of lowlands and plains	Community forestry Agroforestry	Creation of improved pastures
Introduction of the concept of complexes shallow areas	Improved cookstoves Fencing off land	Modulation of pastures Pastoral wells
Introduction of improved varieties of food crops	Brotherhood of Hunters Forest groups	Holding pens Pastoral fences
Adoption of crop rotation	Totemism and sacred forests	Animal tagging
Indication of dates and doses of sowing.	Associations for nature conservation (Waton and Taton)	Breeding improvement Vaccinations
Application of the use of agricultural inputs (timing and rates of fertilizer and pesticide application)	for fire management, etc. Early bushfires Environmental education	Establishment of cane rat farming cooperatives to reduce pressure on wild populations
Promotion and support of farmers' organizations	Organization and monitoring of operators in the wood sector Promotion of lesser-known species	Pastoral fires Fishing
Structuring of rice production sectors	Windbreaks	Regulation of mesh sizes in nets
Micro-credits	Prohibition of cutting certain trees during agricultural clearing,	Organization of fishers
Use of pestle mills for cereals (rice) and shellers for peanuts	either because of their fruits (nééré, gobi, shea), or due to particular beliefs	Popularization of fish farming
Promotion of arboriculture;	Shea butter production	
Use of incubators	Dye Production of black soap	

#### 4. Discussion of the Main Results

The size of family farms ranges from 0.4 to 1.91 ha, with an average yield of 0.5 t/ha in hills and mountainous areas. These figures are slightly lower than the national averages reported by Diallo (2019). According to this author, 64% of family farms have an area between 0.5 and 2 ha, 30% are between 1 and 2 ha, and only 4% have more than 7 ha. Yield ranges from 0.7 t/ha to 2 t/ha for rice and from 1.5 to 1.61 t/ha for maize.

The impacts of climate change are among those identified by the Ministry of

Agriculture, Livestock, Environment, Water, and Forests (2007); Ministry of Environment, Water, and Forests (2018) and Diallo (2019). The natural shocks to which populations of the upper Niger valley in Dabola are exposed are those observed by République de Guinée (2019) and Diallo (2019), namely drought, flooding, land degradation, and landslides. Research findings indicate that among households affected by a climate shock in the upper Niger valley in Dabola, 30.7% experienced a loss of more than 50% of their income, 43.1% of households lost between 25% and 50% of their monetary resources, and 26.2% saw a decline of less than 25%. These results are similar to those of République de Guinée (2019) and Diallo (2019), which indicate that among households affected by a climate shock in Guinea in 2018, 32.7% experienced a loss of more than 50% of their income [13]-[15].

The adaptation strategies employed by communities in the upper Niger valley in Dabola to address the impacts of climate change are the same as those identified in Guinea by Diallo (2019). These strategies include food-based adaptation strategies, economy-based adaptation strategies, and ecosystem-based adaptation strategies. These adaptation practices are widely recognized as effective strategies in West African family farming systems, as noted by Reij & Tappan (2011), Altieri (2018), and Pretty (2008). These practices are part of an agroecological approach that strengthens the resilience of farms in the face of climate hazards [15]-[18].

Joint analysis of agroecological zones, climate impacts, and adaptation strategies reveals a strong correlation between the environmental constraints specific to each zone and the responses developed by producers. In the five agroecological zones described, adaptation strategies are not uniform: they reflect the diversity of climate pressures and local potential. For example, in plateau areas that are more exposed to drought and soil degradation, producers favor water and soil conservation techniques, such as intensive use of organic fertilizer, stone barriers, or agroforestry. Conversely, in lowland areas with higher residual moisture, strategies rely more on community water management, crop diversification, and adjusting planting schedules to take advantage of local microclimates. These differences show that climate impacts are not uniform across the study area and that rural communities adapt their practices to specific agroecological conditions. They also highlight the key role of local knowledge in selecting the most appropriate strategies for each area, reinforcing the relevance of a territorialized approach to climate adaptation [19] [20].

Cross-analysis of the results with regional adaptation policies shows alignment between local initiatives and the strategic orientations promoted by ECOWAS, CILSS, and UEMOA. These regional programs emphasize sustainable land management, improving the productivity of rain-fed systems, disseminating drought-tolerant varieties, and promoting local knowledge. The practices observed in Dabola confirm that rural communities already have adaptation levers that are compatible with existing institutional frameworks. This consistency opens up significant opportunities for consolidating integrated adaptation strategies. Finally, the re-

sults call for further research on the relationship between traditional knowledge, technical innovations, and public policies in order to better support the transition to agricultural systems that are more resilient, sustainable, and adapted to the ecological and socio-economic realities of West Africa [21]-[24].

## 5. Conclusions

The implementation of the project on traditional soil fertility management systems and the adaptation of family-based hillside and mountainous rice cultivation to water deficits in the upper Niger valley at Dabola has made it possible to identify adaptation strategies to climate change. Dabola, situated at the intersection of the mountainous Fouta-Djalou region and the Sudanian savanna zone, is characterized by a climate influenced by both agro-climatic zones.

In this region, climate change is evident, most notably for upland and hillside rice farmers, who face disruptions to the agricultural calendar, recurrent floods, drought, and soil degradation. These factors contribute to reduced crop yields and, in some cases, the loss of part of their agricultural production.

The project enabled the identification, together with rice farmers, of the various climatic hazards and the assessment of their impact on food security in the districts of Koumarella and Kolo Hindé. Adaptation strategies to climate change are economic, food-related, and ecosystem-based. Economic and food adaptation strategies include reducing portion sizes at meals, decreasing the number of meals, prioritizing children's food intake over that of adults, and borrowing or requesting food from others. Ecosystem-based adaptation strategies involve ecosystem restoration, the use of short-cycle crop varieties, and varieties resistant to water scarcity.

After this study, a training session on "Traditional soil conservation systems, maintenance of soil fertility, and adaptation of hillside and mountain family farming to water scarcity" was provided to 10 resource or lead farmers, including five (05) women. The selection of these individuals was based on their ability to transmit the training they received to other farmers. To ensure the sustainability of the project's outcomes, this training also included the two Prefectural Directors of Agriculture and Environment.

The results of this study clearly highlight the importance of integrating local ecological knowledge into formal climate adaptation planning to strengthen the coherence between farmers' knowledge and regional public policies and to sustainably consolidate the resilience of agricultural systems in the face of growing environmental pressures.

## Acknowledgements

We express our gratitude and thanks to the Agricultural Productivity Program in West Africa (PPAAO/WAAPP 1C FA Guinea and to the Center for Environmental Study and Research (CÉRE) of Gamal Abdel Nasser University of Conakry (UGANC), which funded this research through the Foundation for Scientific Re-

search in Guinea (FORESGUI). We thank the authorities of Dabola and the populations of the Upper Niger Valley in Dabola for their hospitality, our field guides, the interviewees, and other stakeholders involved in the implementation of this research for their availability. We would like to express our deepest gratitude and sincere thanks to all.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

### References

- [1] FAO (2018) Évaluation du programme pays de la FAO en Guinée 2013-2017. 84 p.
- [2] Doukpolo, B. (2014) Climate Change and Agricultural Production in Western Central African Republic. Master's Thesis, University of Abomey-Calavi.
- [3] FIDA (2017) Investing in Rural Populations. Republic of Guinea: Country Strategy Note, Main Report and Appendices. FIDA, 15 p.
- [4] Ministère de l'agriculture (2012) National Agricultural Investment and Food Security Plan 2013-2017 (PNIASA). Ministry of Agriculture, Republic of Guinea, 101 p.
- [5] Sultan, B. and Janicot, S. (2003) The West African Monsoon Dynamics. Part II: The "Preonset" and "Onset" of the Summer Monsoon. *Journal of Climate*, **16**, 3407-3427. [https://doi.org/10.1175/1520-0442\(2003\)016<3407:twamdp>2.0.co;2](https://doi.org/10.1175/1520-0442(2003)016<3407:twamdp>2.0.co;2)
- [6] IPCC (2022). Sixth Assessment Report (AR6): Impacts, Adaptation and Vulnerability Intergovernmental Panel on Climate Change.
- [7] Challinor, A.J., Watson, J., Lobell, D.B., Howden, S.M., Smith, D.R. and Chhetri, N. (2014) A Meta-Analysis of Crop Yield under Climate Change and Adaptation. *Nature Climate Change*, **4**, 287-291. <https://doi.org/10.1038/nclimate2153>
- [8] ECOWAS (2017) Atlas de l'eau du massif du Fouta-Djalon: The Water Tower of West Africa. CEDEAO, 114 p.
- [9] MAEEEF (2007) National Adaptation Programme of Action (NAPA) to Climate Change of the Republic of Guinea. National Environmental Council, Ministry of Agriculture, Livestock, Environment, Water and Forests, Conakry, 118 p.
- [10] Nicholson, S.E. (2013) The West African Sahel: A Review of Recent Studies on the Rainfall Regime and Its Interannual Variability. *ISRN Meteorology*, **2013**, Article ID: 453521. <https://doi.org/10.1155/2013/453521>
- [11] Hulme, M. (2001) Climatic Perspectives on Sahelian Desiccation: 1973-1998. *Global Environmental Change*, **11**, 19-29. [https://doi.org/10.1016/s0959-3780\(00\)00042-x](https://doi.org/10.1016/s0959-3780(00)00042-x)
- [12] CILSS (Permanent Interstate Committee for Drought Control in the Sahel) (2016) Atlas of Land Use and Land Cover Dynamics in the Niger Basin. CILSS.
- [13] Ministry of Agriculture, Ministry of Livestock and Animal Production, Ministry of Fisheries, Aquaculture and Maritime Economy, and Ministry of Environment, Water and Forests (2017) National Agricultural Development Policy (PNDA). Republic of Guinea, 69 p.
- [14] ministère de l'environnement, des eaux et forêts (2018) Seconde Communication Nationale à la Convention cadre des Nations Unies sur les changements climatiques. Rapport final, Ministère de l'Environnement, des Eaux et Forêts (MEEF), République de Guinée, 162 p.
- [15] Diallo, A.I.P. (2019) Étude sur l'impact du changement climatique sur les filières pri-

- orbitaires du PPAAO/WAAPP 1C-FA Guinée. Rapport final de recherche réalisée pour le compte du Programme de Productivité Agricole en Afrique de l'Ouest (PPAAO 1C/WAAPP 1C-FA), Ministère de l'Agriculture, 117 p.
- [16] Reij, C. and Tappan, G. (2011) Agroenvironmental Transformation in the Sahel: Another Kind of 'Green Revolution.' IFPRI Discussion Paper 01116. International Food Policy Research Institute.
- [17] Altieri, M.A. (2018) *Agroecology: The Science of Sustainable Agriculture*. CRC Press.
- [18] Pretty, J. (2008) *Agricultural Sustainability: Concepts, Principles and Evidence*. Earthscan.
- [19] Zougmore, R., Partey, S., Ouédraogo, M., Omitoyin, B., Thomas, T., Ayantunde, A., *et al.* (2016) Toward Climate-Smart Agriculture in West Africa: A Review of Climate Change Impacts, Adaptation Strategies and Policy Developments for the Livestock, Fishery and Crop Production Sectors. *Agriculture & Food Security*, **5**, Article No. 26. <https://doi.org/10.1186/s40066-016-0075-3>
- [20] Morton, J.F. (2007) The Impact of Climate Change on Smallholder and Subsistence Agriculture. *Proceedings of the National Academy of Sciences of the United States of America*, **104**, 19680-19685. <https://doi.org/10.1073/pnas.0701855104>
- [21] ECOWAS (2015) ECOWAP/PRID: ECOWAS Agricultural Policy—Regional Agricultural Investment Program. ECOWAS.
- [22] CILSS (2019) Regional Initiatives for Climate Resilience in the Sahel. CILSS.
- [23] UEMOA (2014) Regional Spatial Planning Program (PRAT). West African Economic and Monetary Union.
- [24] African Union (AU) (2020) Great Green Wall Initiative: Progress Report. African Union.