

# Adaptation to Climate Change through Environmental Management Systems (EMS) in the Rural Communes of Albadariah, Sangardo and Gbangbadou Kissidougou—Guinea

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**Abstract:** This study analyzes the causes and effects of climate change in the upper Niger River basin and the implementation of local adaptation strategies based on EMS (Environmental Management Systems). It aims to strengthen ecological resilience and sustainable natural resource management practices through training, awareness-raising, and community participation. The work was conducted in three rural communes in the Kissidougou prefecture, located in the Faranah administrative region. Data collection and analysis tools included questionnaires, GPS devices, digital devices, laptops, and Excel and SPSS software. The methodology employed a participatory and multidisciplinary approach combining a literature review, surveys of 163 respondents, semi-structured interviews with 16 key informants, training for 218 technical staff and local elected officials (30% of whom were women), and awareness-raising activities for 1,800 participants in local languages. Five community forests covering 443.58 hectares were integrated into management plans, concerted, under the coordination of the NGO APARFE. The results show an increase in average temperature (+0.8 °C since 1960), a decrease in rainfall (-5.3 mm/month), and increased vulnerability of populations dependent on agriculture. The integration of the EMS (Environmental Management System) has led to improvements in environmental governance, community forest management, awareness of sustainable agricultural practices, and the inclusion of women (51% of participants). In short, the EMS is an effective tool for strengthening community resilience and environmental sustainability.

**Key words:** Climate adaptation, Environmental Management System, community resilience, sustainable management, Kissidougou.

## 1. Introduction

Climate change is one of the major environmental challenges facing the planet today. It manifests itself in a global increase in temperatures, greater variability in rainfall, and a rise in extreme weather events such as droughts and floods. These climatic upheavals threaten ecological balance, water resources, and global food security. According to IPCC (Intergovernmental Panel on Climate Change) [1], the observed rise in average temperature since the mid-20th century is very likely

linked to the increase in concentrations of anthropogenic GHGs (Greenhouse Gases).

In West Africa, climate change poses a major obstacle to sustainable development. Research by Descroix, Guiguemde and Sighomnou [2] has shown that regional rainfall decreased by approximately 20% between 1968 and 1995, leading to significant mortality of natural vegetation and degradation of mangroves. This trend is accompanied by significant spatial and temporal variations in rainfall patterns [3] and exacerbates the

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vulnerability of key sectors such as agriculture, water resources, and the environment [4]. According to Dezetter, Girard and Servat [5], climate change and its socio-environmental impacts have become a central concern for research and public policy due to their effects on health, food security, and economic stability.

In Guinea, widespread environmental degradation, linked to population growth, human pressures, and climate variability, compromises the sustainability of natural resources [6]. The country, described as the “water tower of West Africa” by FAO (Food and Agriculture Organization) [7], nevertheless sees its water resources threatened by overexploitation, pollution, and erosion. A study conducted by Loua, Traoré and Diallo [8] highlighted a significant increase in surface temperatures at several Guinean stations, including Kissidougou, over a 57-year period. This trend exacerbates the vulnerability of rural populations dependent on rain-fed agriculture.

In the forest region of Guinea, particularly in the rural communes of Albadariah, Sangardo, and Gbangbadou (Kissidougou Prefecture), the effects of climate change are especially visible. Since the 1990s, these areas have experienced accelerated land degradation due to a combination of natural and human-induced factors: deforestation, slash-and-burn agriculture, unregulated sand mining, extensive livestock farming, bushfires, and unplanned urbanization [9]. These practices exacerbate the loss of vegetation cover, soil erosion, and the continued decline in rainfall, directly impacting agricultural productivity and local water resources.

According to Burton [10], the adaptive capacity of communities to climate change depends on their socio-economic and institutional environment. In Guinea, the UNDP (United Nations Development Programme) [11] initiated a project aimed at strengthening climate resilience in the forest region, illustrating the national commitment to promoting local adaptation policies. These initiatives are part of a decentralized environmental governance framework in which municipalities play a central role.

In this context, the Environmental Management System (EMS), inspired by the ISO 14001 standard, appears as a relevant tool for structuring local environmental management. According to Díaz de Junguitu and Allur [12], the EMS promotes better identification of environmental impacts, effective planning of corrective actions, and continuous improvement of environmental performance. However, the adoption of this system in developing countries remains limited by a lack of resources, training, and institutional support. Experiences conducted in Morocco, notably by Bakkass [13], show that the application of the EMS improves regulatory compliance, reduces environmental impacts, and promotes sustainability.

Furthermore, World Bank [14], through the Environmental and Social Management Framework (ESMF) of the WARDIP project in Guinea, emphasizes the need to integrate environmental and social management into municipal programs, highlighting the weakness of local capacities. Thus, the integration of a municipal EMS constitutes an innovative and sustainable approach to improving the resilience of the municipalities of Albadariah, Sangardo, and Gbangbadou to climate change.

Once rich and varied, the vegetation of the Kissidougou prefecture is now subdivided into a wooded savanna in the north and the remnants of dense forests remain in the south. This transformation is the result of progressive degradation caused by bushfires, slash-and-burn agriculture, charcoal production, over-logging, and increasing population pressure. Nearly 85% of the local population depends on forest resources for agriculture, timber and charcoal production, traditional medicine, hunting, and grazing. However, logging, often uncontrolled and illegal, has intensified due to insufficient administrative oversight, low public awareness, and prolonged failures of state authority. This situation has led to a significant reduction in vegetation cover, exacerbated by shifting cultivation, the production of fired bricks, and charcoal production. Consequently, the forests have been profoundly altered and the water regime disrupted, impacting biodiversity and the livelihoods of the local

population. Faced with these environmental and socio-economic challenges, the implementation of relevant actions and the mobilization of all local stakeholders appear essential to restore and sustainably manage natural resources.

This study is part of this dynamic. It aims to diagnose the causes and effects of climate change in the upper Niger River basin, while also proposing solutions. local adaptation strategies through the implementation of an Environmental Management System (EMS). More specifically, it aims to:

- strengthen ecological resilience and sustainable land use practices through an ecosystem-based approach;
- train agents of decentralized technical services, teachers and students on the causes of climate change and adaptation measures;
- organize community meetings to raise awareness and provide information on climate change and adaptation measures;
- raise awareness among local organizations and

traditional communicators about environmental management and sustainable adaptation practices.

## 2. Materials and Methods

### 2.1 Materials

#### 2.1.1 Presentation of the Faranah Administrative Region

Figure 1 shows the Faranah administrative region with the study area Albadiyah, Sangardo and Gbangbadou /Kissidougou red dot.

In the context of resource management, we chose the Faranah administrative region due to its significant agropastoral potential due to the presence of the Niger River.

This administrative region occupies the central part of Guinean territory, representing the transition zone between Middle Guinea, Upper Guinea, and Forest Guinea. The Faranah administrative region is located between 8°50' and 12° North latitude and 9°15' and 11°29' West longitude.

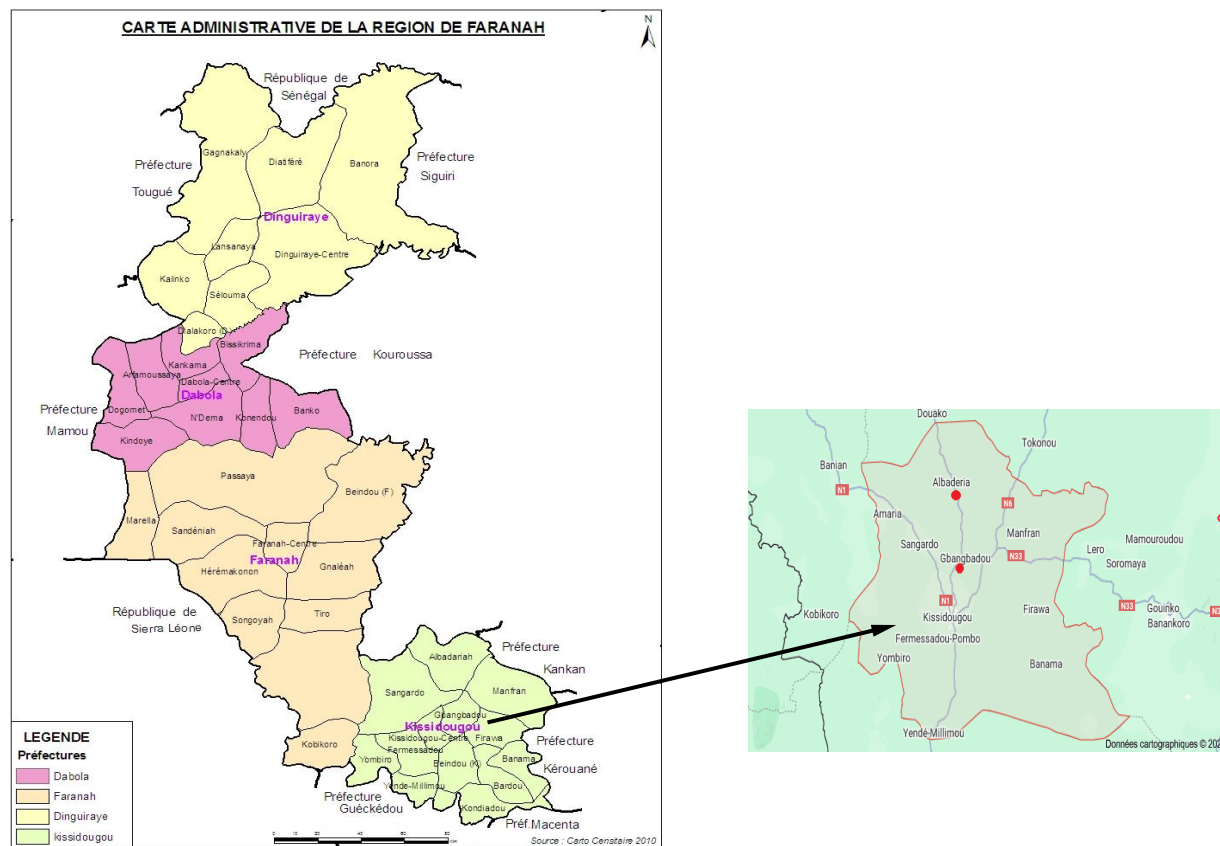


Fig. 1 Carte de la Région administrative de Faranah et Zone d'étude à Kissidougou (Albadariaya, Gbangbadou et Sangardo).

It comprises 4 prefectures: Dabola, Dinguiraye, Faranah and Kissidougou, subdivided into 42 communes, including 4 urban and 38 rural communes, 470 districts and 53 neighborhoods.

#### 2.1.2 Presentation of the Prefecture of Kissidougou

Kissidougou is one of the four (4) prefectures of the Faranah administrative region. It is located in the southern part of the country, 595 km from the capital Conakry and 137 km from the administrative center of Faranah. It is bordered by:

- North, via the Prefectures of Faranah and Kouroussa,
- South via those of Guéckédou and Macenta,
- to the East by those of Kérouané and Kankan, and to the West by those of Gueckedou and Faranah.

It covers an area of 8,872 km<sup>2</sup> with a total population of 302,211 inhabitants, representing an average density of 24 inhabitants per km<sup>2</sup>. It is subdivided into twelve (12) sub-prefectures, including:

Kissidougou Centre, Albadaria, Banama, Bardou, Beindou, Fermessadou Firawa, Gbangbadou, Kondiadou, Manfran, Sangardo, Yendé-Millimou and Yombiro; 69 districts and an urban commune which has twenty-four (24) quarters.

Our area of intervention is specifically the rural communes (CR) of Albadariah, Gbangbadou and Sangardo. Albadariah is located in the North, 55km from the capital of the prefecture, which comprises 7 districts; Sangardo is located in the Northeast, 30 km from Kissidougou, with 4 districts; and Gbangbadou is located in the East, 17 km from the capital of the prefecture, which comprises 9 districts.

#### 2.1.3 Inhabitants

Kissidougou is composed of: Kissians, Leles, Kourankos, Malinkes, Peuls, Guerzes and Tomas.

#### 2.1.4 Relief

The terrain is more rugged in the south and west. In the central and eastern regions, the average elevation varies from 660 to 700 meters, while it exceeds 100 meters in the west. The mountains are part of the Mount Daro massif, which features some notable peaks from west to south. Vast plains are found in the north, central,

and eastern regions. Environmentally, the Kissidougou prefecture is covered by wooded savanna.

#### 2.1.5 Fauna

The fauna is rich and varied; one encounters monkeys, chimpanzees, warthogs, buffalo, deer, eels, duikers, mongooses, porcupines, squirrels, rabbits, kingfishers, moorhens, ruffed lemurs, wildcats, owls, Gambit rats, cane rats, pangolins...

Most of these animals are threatened by population pressure, bushfires, poaching, and vegetation devastation.

#### 2.1.6 Rainfall

Enjoying a sub-equatorial Guinean climate, the prefecture of Kissidougou is characterized by two seasons: a dry season from December to March, and a rainy season from April to November with rainfall varying from 1,500 to 2,500 mm of water per year.

#### 2.1.7 Hydrography

The prefecture of Kissidougou is watered by numerous watercourses including: the Niandan, the tributary of the Niger which originates at Kobikoro (Faranah) and flows into it at Babila (Kouroussa), after having received in its course various watercourses which are: Dolé, Falinha, Bodouo, Gbangban, Mafou, Kambo, Faranissa, Waou and Doffé.

The Niger River crosses our study area; it travels 27 km; Table 1 specifies the total area of the Niger River watershed.

- History of the Niger River:

The Niger River is an important economic resource for our country. Its water flow was significant, and the river was quite rich in fish. The Niger provided an ideal and undisturbed habitat for animals.

Like the Niger Riverbed, the banks were also very rich. Almost all rupicolous and aquatic plant species could be found there. There were few brick quarries, and the banks were subject to little human activity. In previous years, the right bank was more threatened than the left, but since the 1990s, due to strong population growth, the return of exiles, and rapid population increase resulting from wars in neighboring countries (Liberia, Sierra Leone, Guinea-Bissau, Ivory Coast),

**Table 1** Summary of the areas of the Niger River basin in the countries.

No.	Country	Basin area in countries (km <sup>2</sup> )	% of the basin in the country
1	Guinea	130,000	6.5
2	Mali	490,000	24.5
3	Ivory Coast	20,000	1
4	Upper Volta	75,000	4
5	Niger	430,000	21.5
6	Nigeria	650,000	32.0
7	Cameroon	90,000	4.5
8	Chad	10,000	1
9	Benign	45,000	2
10	Algeria	60,000	3
Total		2,000,000	100%

Source: National Directorate of Hydraulics 2021 [15].

**Table 2** Equipment used.

No.	Designation	Quantity	Use
1	Toyota land cruiser	1	To reach the study areas
2	Backpack	5	For useful purposes
3	Bic	10	Note-taking
4	Notepad	5	Note-taking
5	GPS	1	Geographic coordinates
6	Digital device	2	Taking field images
7	PC (Laptop)	1	Data processing
8	Geolocation (software)	1	Site knowledge
9	Investigation sheets	-	For the investigations

degradation has gradually reached the left bank, while that of the right bank has exceeded the tolerance threshold. With significant watercourses on both banks,

#### 2.1.8 Climate

The climate is of the Sudanian-Guinean type, characterized by two distinct seasons: a rainy season and a dry season, with the hottest temperatures occurring in March. During this period, the grasses wither and become susceptible to bushfires. The rainy season extends from May to October, with rainfall varying in frequency and severity.

The observations on climatic elements for 12 years (2011 to 2022) are: the average monthly values were 1,679 mm; 72%; 20 °C; 24 m/s; height; humidity; temperature; wind speed.

#### 2.1.9 Rural Development

The Kissidougou prefecture is primarily an agropastoral area. Its agricultural population is estimated at around 85%. Cultivated land consists of lowlands, plains, and

hillsides with a diverse range of crops (rice, cassava, maize, peanuts, beans, and vegetables, etc.).

The soils are relatively rich in some areas. The diversity of plantations (palm trees, coffee trees, avocado trees, kola trees, citrus trees, rubber trees, etc.) is a reality. Classified forests are not uncommon. Small ruminant farming is dominant, and fish farming is thriving. All these agro-pastoral and forestry activities are overseen by groups and unions assisted by technical services from the DPA (Department of Agriculture and Livestock) and the DPE (Department of Environment and Planning).

To carry out this diagnostic, training, information and awareness-raising activity for the target populations, the team of facilitators will use the materials indicated in Table 2.

### 2.2 Methods

#### 2.2.1 General Approach

The methodological approach adopted is based on a

participatory, multidisciplinary, and integrated approach, combining: documentary research to establish the conceptual and contextual framework of climate change; the collection of field data through surveys, interviews, and direct observations; training, awareness-raising, and environmental communication with local stakeholders; and the processing and analysis of quantitative and qualitative data. This combination made it possible to integrate scientific knowledge and local knowledge, while fostering community ownership of the actions undertaken.

### 2.2.2 Data Collection

#### a. Documentary review:

A literature review was conducted to identify key concepts (vulnerability, resilience, adaptation, mitigation, and risk) as defined by the IPCC, and to establish the global, regional, and national context of the issue. This review covered scientific and institutional reports (FAO, IPCC, UN Environment), national environmental and agricultural management policies in Guinea, and regional experiences of integrating climate change into agricultural practices.

#### b. Surveys and polls:

A survey was conducted with 163 respondents, including teachers, students, researchers, representatives of farmers' organizations, and institutional actors in the agricultural and environmental sectors. The questionnaires gathered information on local perceptions of climate impacts, adaptation strategies, agricultural practices, and natural resource management.

#### c. Semi-structured interviews:

In-depth interviews were conducted with 16 key informants from the Ministries of Agriculture, Environment, Forestry, Research, and Education, as well as from partner farmers' organizations and NGOs (Non-governmental Organizations), and donors working on climate resilience. These interviews aimed to analyze the level of integration of climate change into sectoral policies and local practices.

### 2.2.3 Implementation of Training and Awareness-Raising Activities

Community workshops were organized in the two

targeted municipalities. These activities included training for 218 technical staff and local elected officials (30% of whom were women) on the causes of climate change and adaptation measures; awareness-raising sessions for 1,800 participants conducted in local languages (51% of whom were women); the production and distribution of adapted educational materials (picture boxes, fact sheets, brochures); and training for primary and secondary school students and teachers on climate issues. The participatory approach aimed to ensure the long-term retention of knowledge and to strengthen local environmental governance.

### 2.2.4 Implementation of Adaptation Actions

Under the coordination of the NGO APARFE, the activities focused on the collaborative management of community forests in three rural communes. Five community forests, totaling 443.58 hectares, were integrated into participatory management plans. The main activities consisted of maintaining firebreaks and plantations, training management committees (43 members from various socio-professional categories), and raising community awareness about the ecological, economic, and social value of community forests. These interventions were documented through interim and final reports illustrated with digital photographs.

### 2.2.5 Data Analysis and Processing Tools

Quantitative data were entered and analyzed using Microsoft Excel and SPSS software, allowing for the production of descriptive statistics on participation, gender representation, and community dynamics. Qualitative data from interviews and observations were analyzed using a thematic approach, promoting triangulation between documentary sources, interviews, and survey results.

### 2.2.6 Validation and Quality Assurance

The results obtained underwent participatory validation through feedback workshops involving local stakeholders, administrative authorities, and technical partners. This step ensured the reliability, relevance, and ownership of the data produced before its integration into the final reports.

### 3. Results

#### 3.1 Climate Impacts in the Municipalities Studied

Analyses of available climate and environmental data indicate:

- Temperature: increase of 0.8 °C since 1960, with projections of up to 3.0 °C by 2060 and 5.3 °C by 2090, particularly rapid in northern Guinea.
- Rainfall: average decrease of 5.3 mm per month (3%) per decade for the April-May-June period since 1960.
- Hot days: projected increase of 21-52% by 2060 and 27-78% by 2090.

These climate changes, combined with deforestation (0.5% for 2010-2020) and a strong dependence on agriculture (76% of jobs in 2021), increase the vulnerability of rural populations to environmental impacts. a 2% decrease in agricultural yields between 2010 and 2021, a deforestation rates among the highest (0.5% for 2010-2020) and one high frequency of bushfires (25 fires/100 km<sup>2</sup>/year).

- Vulnerability: strong dependence on agriculture and forests, high deforestation, high frequency of bushfires.

##### 1. Training and awareness-raising activities:

As part of the SME (Sustainable Management of Environment) project, several activities were carried out to strengthen local capacities:

- Training for technical staff and local elected officials: 218 participants, including 36 decision-makers (30% women), were trained on the causes of climate change and adaptation measures.
- Community awareness: 1,800 participants were involved in meetings in local languages, 51% of whom were women.
- Education: Primary and secondary school students and teachers received training on climate issues and adaptation practices.
- Educational materials: production and distribution of picture boxes, technical sheets and brochures

adapted to different audiences.

- Community forests: 5 forests in 3 rural communes, total area 443.58 ha, 43 members in the management committees.

These activities have promoted the adoption of adaptation measures and the active participation of communities.

#### 3.2 Adoption of Adaptation Measures

Observations and surveys within the communities have shown that:

- Sustainable agricultural practices are beginning to be adopted by farmers.
- Community forests are seen as an important lever for food security and water regulation.
- The involvement of women and young people in training and forest management activities has been significant, which strengthens inclusivity and community resilience.

#### 3.3 Implementation of Adaptation Activities by the NGO APARFE

Within the framework of SME activities, operational results include:

- Production of communication materials: brochures, technical data sheets and picture boxes adapted to different audiences.
- Training of technical agents and local elected officials: 218 agents trained, including 36 decision-makers (30% women), on the causes of climate change and adaptation measures.
- Community awareness: meetings with 1,800 participants, 51% women, conducted in local languages.
- Training of communicators and traditional organizations, including brotherhoods of hunters, fishermen, beekeepers, farmers, blacksmiths and herders.
- Training of primary and secondary school students and teachers in rural communities.
- Implementation reports, documented by digital photos and made available to the project.

**Table 3** Distribution of community forests and management committees in the rural communes of Albadariah, Gbangbadou and Sangardo (Kissidougou prefecture).

Prefecture	CR	District	Sector	Name of the community forest	Area (in hectares)	Number of management committee members		
						Man	Women	Total
Kissidougou	Sangardo	Foréah	Kensardou	KONGBARAN	129.80	10	1	11
			Beindou	WAKALI	48.08	9	0	9
		Subtotal			177.88	19	1	20
	Albadariah	Yassardou	Damania	BENKADI	32.48	7	0	7
			Yassardou Center	SABARI	47.72	8	1	9
		Subtotal			80.20	15	1	16
	Gbangbadou	G. Center	Dandou Faramaya	BAWA	185.50	6	1	7
					Subtotal			185.50
Total Kissidougou					443.58	40	3	43

These activities are in line with the principles of the SME, promoting participatory planning, community resilience and the sustainability of natural resources.

### *3.4 Management of Community Forests within the Framework of Adaptation*

The implementation of joint management plans for five community forests in three rural communes of Kissidougou has enabled:

- Maintenance of firebreaks and plantings.
- The training of young plants and the maintenance of forests.
- Raising awareness among communities about the benefits of community forests, in relation to food security and climate resilience.

The activities supported the implementation of participatory management plans for five community forests in three municipalities:

- Total area: 443.58 ha.
- Management committees: 43 members representing different socio-professional groups (farmers, fishermen, beekeepers, hunters).
- Activities carried out: maintenance of firebreaks, planting and monitoring of seedlings, raising awareness among communities about the ecological and socio-economic benefits of community forests.

These initiatives have helped to strengthen the resilience of populations and the sustainability of local forest resources.

Table 3 shows the distribution of community forests

identified in the rural communes of Albadariah, Gbangbadou, and Sangardo, as well as the area concerned and the composition of the management committees according to the gender of the members.

These initiatives confirm that the concerted management of community forests is an important lever for strengthening the resilience of populations to climate change, as also observed by FAO (Food and Agriculture Organization of the United Nations) [16], on the socio-economic and ecological value of community forests.

## **4. Discussion**

The results obtained show that:

- Training local stakeholders and raising awareness among communities improve understanding of climate issues and the adoption of sustainable practices.
- The integration of the SME allows for better planning and effective monitoring of adaptation actions.
- The community forests contribute to water regulation, erosion prevention and the provision of sustainable forest resources.

These results are consistent with the work of Díaz de Junguitu and Allur [12], which emphasizes the importance of structured environmental management to strengthen ecological and social resilience. They also align with the conclusions of McSweeney, New and Lizcano [17], on Guinea's increased vulnerability to climate impacts and the need for local adaptation

The high level of female participation observed



(51%) demonstrates that the inclusion strategies implemented, particularly the use of local languages and peer facilitation, help reduce sociocultural barriers. These results confirm the findings of IPCC [18], highlighting that community participation and a gender-sensitive approach are essential drivers for sustainable adaptation.

Capacity building has enabled the creation of a network of key stakeholders capable of disseminating the acquired knowledge. The use of visual and interactive tools has enhanced understanding, in line with the FAO [19], recommendations on climate-sensitive agricultural extension.

Integrating environmental education into schools is a strategic lever for sustainability. Students become information carriers within their families, promoting the horizontal dissemination of knowledge, in accordance with UNESCO (United Nations Educational, Scientific, and Cultural Organization) [20].

Communities perceive the effects of climate change through disruptions to their agricultural activities. However, limited scientific understanding calls for strengthening information and outreach mechanisms, particularly through rural radio stations and local structures.

The lack of inter-institutional coordination limits the effectiveness of adaptation policies. Strengthening synergies between ministries, NGOs, and donors is essential to ensure integrated governance, as recommended by the OECD (Organisation for Economic Co-operation and Development) [21].

The sustainability of the achievements depends on the empowerment of local communities. Beneficiaries, as active participants in the implementation process, demonstrate greater autonomy and capacity to maintain the results, confirming the principle of community-based management of natural resources.

## **5. Conclusion and Recommendations**

### **5.1 Conclusion**

The study on integrating climate change into

agricultural education programs and natural resource management highlighted perceptions, constraints, and local initiatives undertaken in the rural communes of Albadariah, Sangardo, and Gbangbadou. The results show that while the majority of rural stakeholders recognize the adverse effects of climate change on agriculture, they still possess limited knowledge of its causes, mechanisms, and sustainable adaptation options.

Training and awareness-raising activities have helped strengthen local adaptation capacities by fostering an understanding of the links between climate change, agricultural practices, and food security. The participatory approach adopted has effectively mobilized community stakeholders, educational institutions, local authorities, and farmers' organizations.

Thus, this study constitutes an essential step towards the effective integration of climate issues into agricultural education policies, territorial planning and rural development practices.

The integration of the SME (Sustainable Management of Environment) approach in the rural communes of Albadariah, Sangardo, and Gbangbadou has improved community resilience and the sustainable management of community forests. The combination of training, awareness-raising, and participatory management constitutes an effective strategy for climate change adaptation and environmental sustainability.

### **5.2 Recommendations**

- Continue training and raising awareness among local stakeholders and communities.
- Strengthen the sustainable and participatory management of community forests.
- Ensure regular monitoring and evaluation of SME actions to adjust strategies according to local needs.

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