Adaptations of Swamp Rice Farmers to the Effects of Climate Change in Ndop Sub-divison, Cameroon

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Abstract: **Farmers in the rain-fed agriculture in equatorial regions are highly exposed to the adverse effects of climate change due to complete reliance on rainfall which has become unpredictable. Planned and spontaneous adaptation in such conditions becomes crucial to remain in farming in climate change regime. In the rural settings of the less-developed areas, farmers mostly adapt to risks posed by climate change individually. The present study investigates different adaptation strategies of farmers using cross-sectional data collected from Ndop sub-division of the Ngoketunjia division in the North West region of Cameroon. The study examines the role of socio-economic characteristics of farmers on adaptation to climate change. Plant level, farm level and farmers level of adaptations were examined and barriers to adoption of effective adaptation strategies. Data collected through questionnaire and direct field observation were analyzed using frequency counts, percentages and mean distribution. Data was collected from 200 respondents through stratified random sampling. Plant level, farm level and farmer's level of adaptation were assessed to be inefficient to mitigate the effects of climate variability and reduce vulnerability of swamp rice production in this sub division. This is especially at the level of traditional farms. Adaptation strategies are therefore ineffective as yields of 6 tons per hectare have never been attained. Adopting the NERICA specie, converting traditional fields into developed fields, increasing farmer's awareness on the effects of climate change and strengthening the agricultural extension service of the UNVDA amongst others will increase resilience and improve on production hence increasing rice yields.**

Keywords: **Adaptation, Climate Change, Rice Production, Ndop sub-division**

I. INTRODUCTION

Food security and environmental protection remain key preoccupations to many individuals, multinational firms, governments and non-governmental organizations. According to a report co-written by the Food and Agricultural Organization (FAO) and World Food Program (WFP) in 2003 on the state of food security in the world, about 805 million persons were living under chronic food insecurity conditions(1). Sufficient food production is among the principal challenges facing many developing countries. These challenges arose due to population growth, climate change and myriads of other environmental constraints (2). Importantly, the recent argument on climate change has led to reawaken attention on climate change effects on agriculture. Increasing temperatures (a sudden hot spell or cold snap) and variations in rainfall patterns (a lengthy period of insufficient or excessive rainfall) impact negatively on agricultural yields of both rain-fed and irrigated crops (3). These effects are manifested through water availability, crop growing stress and yields, water availability, pests and disease, animal health and other biophysical factors. (4).However, for century's rural farmers have evolved various survival strategies to combat the adverse effects of climate change on crop production. Some of these schemes are multiple cropping systems, cropping drought resistant or drought tolerant crops and diversification of livelihood activities (5)

Cameroon is one of the countries in the world that has the potentials to produce rice in larger quantity (6). Similarly, Ndop sub-division has a vast swampy land suitable for the production of rice and other varieties of agricultural produce under the Upper Noun Valley Development Authority (UNVDA). (7). However, in Cameroon, rice production is already under pressure on the demand side due to population growth, whereas the supply side is further exposed to natural pressures through climate change. There is therefore a prevailing demand-supply gap.

Several studies (8; 9; 10; 11) have examined the effects of weather variations on crop production including rice and various adaptation practices of farmers in Sub-Saharan Africa (SSA) and beyond. However, the outcome in a given location depends on the magnitude of these changes, the response of the particular crops and location-specific management strategies. In the case of rice production in Ndop sub-division, expected yields of at least 6 tons per hectare has never been achieved because of ineffective adaptation strategies. Hence, to understand location specific adaptation strategies and barriers, it is pertinent to investigate at plant level, farm level and farmer's level of adaptation using field level survey data. This is the rationale for this present study: Rain fed rice farmers' Adaptation Strategies to the observed Effects of Climate Variability on Rice Production in Ndop sub-division had the following objectives:

I. Identify the socio-economic characteristics of rice farmers in the study area
II. Assess the adaptation strategies employed by farmers at different levels to ameliorate climate related constraints to rice production
III. Investigate the barriers to effective adaptation practices in the study area.

II. PHYSICAL BACKGROUND OF THE STUDY

Ndop Sub-Division is located between latitude 5º 37' N to 6º-14'N of the equator and between longitudes 10 º 23'E to 10 º 33'E of the Greenwich Meridian. This area is found in the North West region of Cameroon. It is precisely within the Ngoketunjia Division of the western high plateau agro-ecological zone of Cameroon.

This subdivision is made up of 4 rice agro-ecological zones which are Bamunka, Bamali, Bambalang and Bamesseng. Average temperature is about 26^{o}c with an average maximum daily temperature of about 27.22°c and minimum of between 11^{o}c to 14 ^{o}c which fluctuates rapidly than the maximum. The hottest months are December, January, and February with maximum average daily temperatures going up to 30°c. (12). Ndop plain receives between 1524mm and 1770mm of rainfall per year because of its site, at the leeward side of Sagba hill and Bamboutos mountains (12). Ndop falls within the hot wet tropical climate zone with two seasons (dry and rainy seasons) which occur at distinct periods of the year. These two principal climatic resources have favored the growing of rain fed rice since the semi aquatic plant thrives best under certain rainfall and temperature threshold values which are all present in this sub division. This area is a highland plain with an average altitude of about 1200m above sea level and its part of the Upper Nun Valley which is an open highland ensconced within the volcanic landscape of the North West region of Cameroon (13). The drainage of this region is largely influenced by the relief which tends to increase in altitude towards the north of the sub-division. This high relief forms the major watersheds which constitute the major sources of rivers like Noun, Mukie, and Tembu which are major sources of irrigation for rice production. The north and south combination of hills and mountain chains are separated by the Ndop flood plain. This plain is studded by numerous marshes or swamps into which a host of tributaries unite to form the river Noun proper downstream (14). Of importance is the fact that with a “vast water empire” in Bambalang known as the Bamendjin Dam, irrigation is highly favored. Also, the alluvial plains (900-1200m) in Ndop present meandering patterns with ephemeral ox-bow lakes (12) which all provide the wetlands and favorable soils used for swamp rice production. The high population of over 100 000 inhabitants provide cheap and abundant labor. The existence of wetlands, plains and highlands has greatly influenced agricultural land use patterns of which rice cultivation stands out as the main economic activity (15). However, recent studies indicate that this sub division suffers much from increasing intensity and frequency of flooding at downstream farms of river Noun and hydrological and agricultural droughts at upstream of Noun which seriously affect rice production in this subdivision (16).

III. MATERIAL AND METHODS

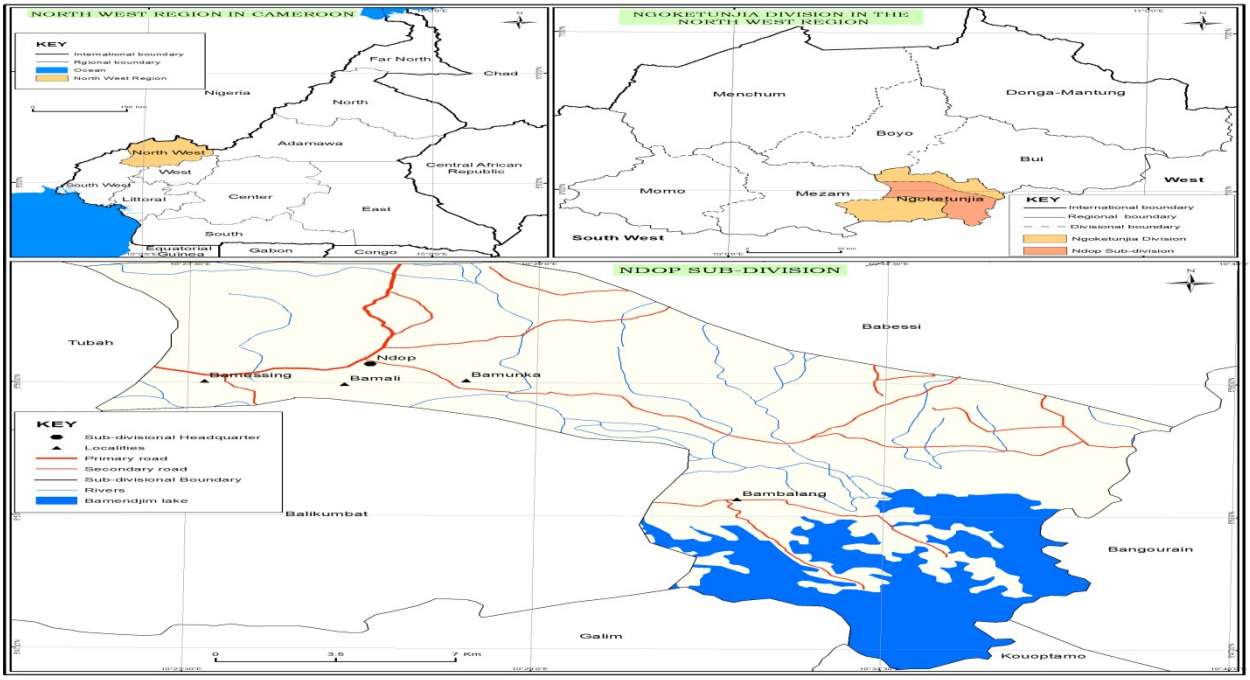
This study was conducted in 4 communities of Ndop Sub division of the Ngoketunjia division in the North West region of Cameroon. The communities were purposively chosen because of the prevalence of rain fed rice production and their high vulnerability to flooding in the downstream communities of Bamali and Bambalang and to droughts in the upstream communities of Bamunka and Bamesseng (16). The second stage involved a simple Stratified random selection of 50 farmers from each of the 4 communities. However, in the selection of farmers, the researcher took into consideration longevity of farmers in the activity which was at least 20 years who mastered changes in adaptation practices in the past and present.

Both primary and secondary data were used for this study. Primary data were collected through the use of a structured questionnaire administered to rice farmers in the study area, while secondary data came from the Upper Nun Valley Development Authority (UNVDA), Divisional and sub divisional delegation of agriculture and Rural development, relevant texts, journals, proceedings and bulletin on both climate change and rice production. The secondary data provided information on history of rice farming in the study matrix, its economic importance and challenges facing its production. The secondary data were used to for literature review and to corroborate information gathered from primary data. The questionnaires were given to educated farmers of at least 20 years of experience to fill while uneducated ones were interviewed orally with the help of trained research assistants.

For the analytical techniques,

Objective 1: Information elicited from respondents on socio-economic characteristics was analyzed using descriptive statistics such as frequency counts and percentages.

Objectives 2 and 3: Respondents’ responses to questions on Likert scale for agreement levels (1 = strongly agree, 2= agree, 3= disagree, 4 = strongly disagree) were analyzed using mean distribution. The values of the four responses were added to get 10, which was divided further by 4 to get a mean of 2.5. Therefore, variables with mean of 2.5 and above were regarded as significant adaptation strategies undertaken by farmers in the study area and vice versa. Data were presented using tables, graphs and pictures.



Source: Atlas map of Cameroon 2008

Figure 1: Location of Study Area

Photo a, b; Water management technique in a developed farm by UNVDA

Photo c: water management technique in an undeveloped farm

Source: field work 2020

Table 1. Adaptation strategies at different levels

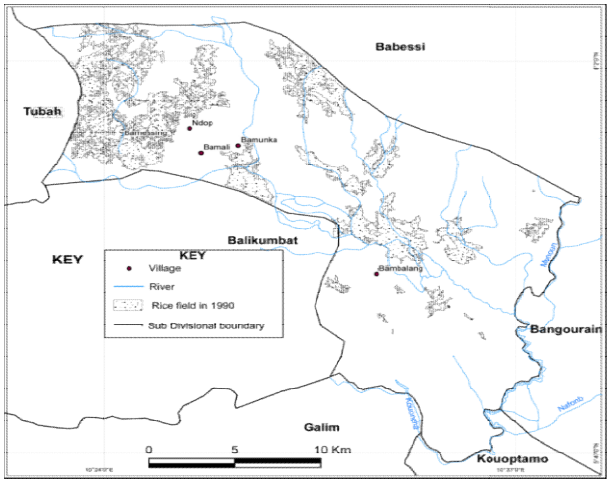
Level of Adaptation	Adaptation strategies	Mean
Plant level	Short cycle varieties	3.2*
	Drought resistant varieties	1.2
	Flood resistant	1.6
Farm level	Increase water conservation techniques	2.8*
	Control flood waters by building of drainage canals	1.4
	Increase land size cultivated	2.6*
	Improved irrigation efficiency	2.1
Farmers level	Planting dates have become later	2.9*
	Planting dates have become earlier	2.2
	Planting of different varieties	3.1*

*Mean ≥2.5 Source: Field Survey, 2020.

Table 2. Barriers to implementing effective adaptation measures

Barriers to effective adaptation	Mean
Insufficient knowledge on climate change	3.2*
Lack of knowledge on resistant varieties	2.9*
Scarcity of resistant varieties	2.4
Low subventions on necessary inputs	1.2
High rate of illiteracy	1.6
Insufficient credit, money, savings	2.8*
Lack of land and storage facilities	1.4
Lack of adequate irrigation facility	2.6*
Inadequate access to extension services	3.1*
Lack of storage facilities	2.9*

*Mean ≥2.5 Source: Field Survey, 2020.



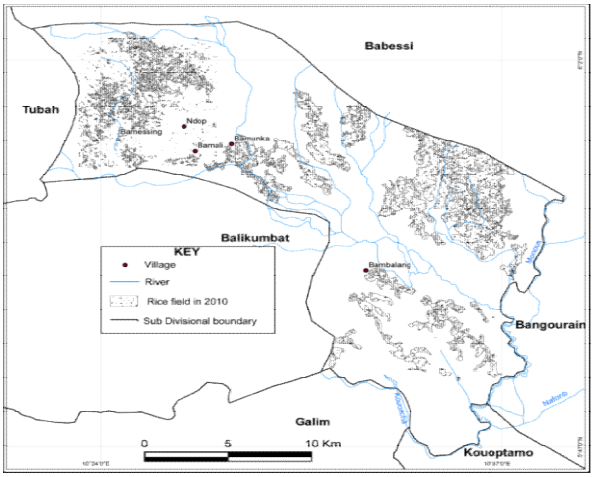


Figure 1a: presentation of rice farming surface area by the year 1990 Figure 1b: presentation of rice farming surface area by year 2020
Source: Adapted from nkiene et al

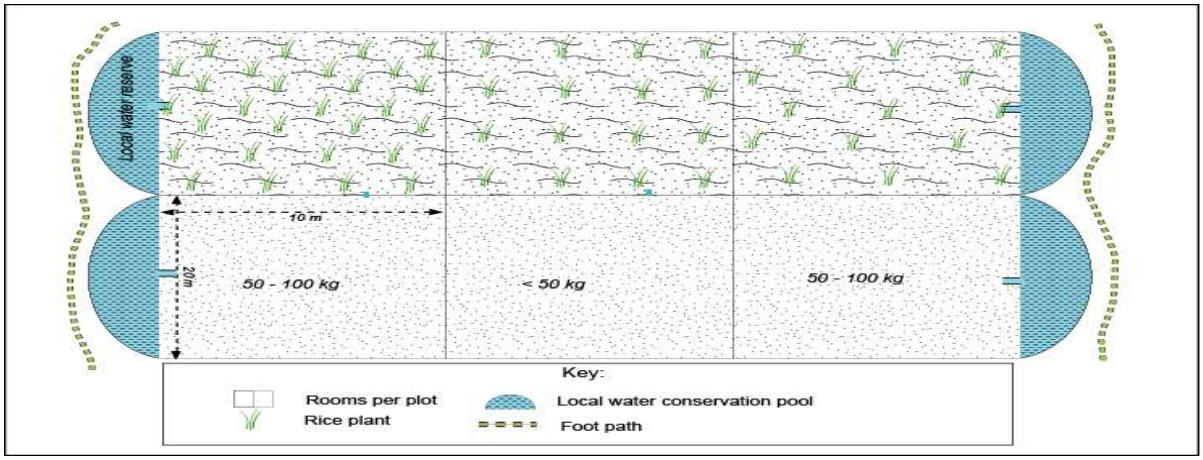


Figure 2a: presentation of adaptation method in a traditional farm

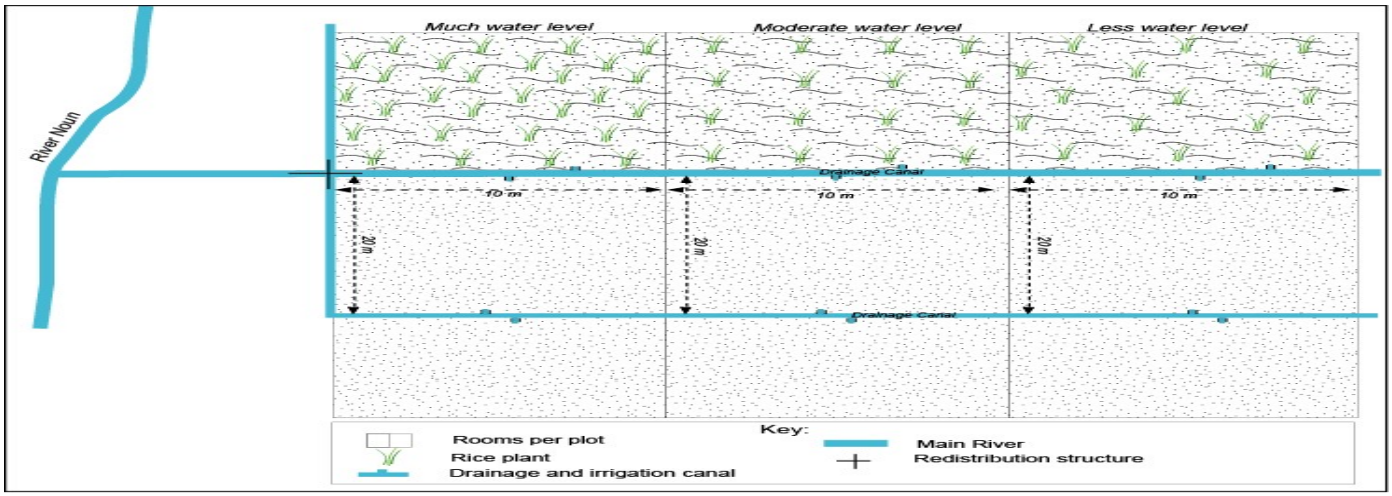


Figure 2b: presentation of adaptation method in a developed farm

Source: field work 2020

IV. RESULTS AND DISCUSSIONS

Adapting to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. The Intergovernmental Panel on Climate Change (17) defines adaptation as adjustments in natural or human systems in response to actual or expected climatic stimuli or effects, which moderates harm or exploits beneficial opportunities. It also refers to actions that people, countries, and societies take to adjust to climate change that has occurred. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities (17).

a. The Socio-economic characteristics of the farmers

Analysis from questionnaires indicates that majority (48.3 %) of the respondents were between the ages of 30-45 years with a mean age of 37.5, larger proportion (58.8%) of rice farmers were females. In addition, majority (49.2%) of the farmers had a household size of 5-8 members, 45% earned between 20 000-45000 francs cfa annually and a larger proportion (38.8%) of the farmers had primary education indicating inadequate education among rice farmers in the study area.

The low educational level of most can hamper comprehension of necessary rice production technologies and agricultural extension programs on climate change. (18) Identified formal education as a way to increase farmers' adaptive capacity to climate change. The low income level of most farmers annually could impact negatively on their aspiration to acquire improved varieties and other inputs required for adaptation to climate change. This is consistent with (19) who found a positive strong correlation of farm income and probability of adoption of climate change adaptation and resilient strategies in south west region of Cameroon. This investigation reveals that there is adequate labour for rice production activities in the study as indicated by the large family sizes which reduces labour constraints. On farming experience, about half of the sampled farmers had experience of between 30-40 years implying that the farmers have sufficient knowledge of rice production and impacts of climate change on rice production in the study area. The result corroborates finding from (20) who reported that long farming experience is an advantage for increase in farm productivity since it encourages rapid adoption of farm innovation.

b. Adaptation strategies to the observed effects of climate change in Ndop Sub-division

In an attempt to reduce the adverse impacts of the observed effects of climate change and variability which were increasing frequency in the intensity of droughts and floods, increase in dry spells (16) , households in Ndop sub division employ several strategies to cope with the observed effects of climate change and variability. Table 1 shows that at the micro-level, adaptation strategies implemented were at plant level, farm level and farmer's level of adaptation which were either spontaneous or planned.

➢ *Plant level adaptation*

At the level of adapting the rice plant, very little has been done based on the results from the questionnaires and interviews. The drought and flood resistant specie called NERICA (NEW RICE FOR AFRICA) was introduced but very few educated farmers had adopted it by 2019. Interviews to key resource persons such as the chief in charge of production at the UNVDA explained that varieties under cultivation have been varied over time due to differences in their water requirement and consequently yield per hectare. Varieties have varied from short grain (Taina T5) to medium size grain (Variety 14) and finally to long grain variety (Tox X3145). These are the main varieties cultivated in this sub division. The main reason for the change in variety from Taina to V14 was due to the fact that it yielded just 1 ton per hectare while V14 was replaced by X3145 because though V14 yielded about 5 tons per hectare, it required much water

on the fields which was not always constant in supply. Finally Tox yielded 6 tons per hectare and did not require much water on the fields like the V14. As a worker at IRAD explained,

"*nerica takes only three months from when it is planted to when it is harvested. Because its roots do not sink deep, it can grow on dry land. It needs no irrigation because Cameroon's abundant rainfall is enough. Standing only 60-70cm tall, this variety can also adapt to any ecological condition and easily integrate existing planting seasons and practices. In summary, its advantages are that; little work, no irrigation, yields up to 4 tons of high quality per hectare*."[1]

- *Farm level adaptation*

Farm level adaptation was classified into the regulated farms and unregulated farms. The regulated farms (planned strategy) were under the UNVDA and it was more of autonomous than spontaneous. Based on field observation and respondents view**,** 38.8% of respondents indicated an increase in water conservation techniques, 23.3% indicated an increase in farm sizes under cultivation, 7.7% indicated a move to different site, 22.5% indicated an increase in irrigation and finally 7.7% indicated control of flood waters through building of drainage canals due to the influence of the agricultural extension service operating in this area (UNVDA)(figure 3b)

In the unregulated farms, the local farmers often conserve water at their banks in a locally made water conservation pool (photo 3, figure 3b) with the intention to regulate inflow and outflow as an adaptation strategy to the constant hydrological droughts especially in the upstream farms.

- *Farmers level of adaptation*

At the level of farmer's adaptation, 65.6% vary their planting dates while 34.4% adapt but varying the varieties under cultivation. The varying of planting dates was observed to be more of late planting than early planting due to unreliability in the onset, duration and termination of the rainy season in this sub-division (16,21). Farmers besides varying planting dates have also varied the varieties of growing Taina to tox(X3145) and V14. Very few farmers in 2019 were informed of the new variety called NERICA which was introduced by IRAD. Very few farmers adopted the innovation.

c. Barriers to Adaptation Practices.

In an attempt to understand what restricts farmers from implementing effective adaptation strategies, farmers were asked to identify key barriers to the effective implementation of adaptation measures to the observed effects of climate change. Barriers, therefore, are defined as factors, conditions or obstacles that reduce the effectiveness of adaptation strategies (21). The most commonly identified barriers which had mean scores greater than or equal to 2.5 were: insufficient knowledge on climate change ($\bar{\chi}$=3.2), Lack of knowledge on resistant varieties ($\bar{\chi}$=2.9), insufficient credit/money/saving facilities ($\bar{\chi}$=2.8), inadequate access to extension services ($\bar{\chi}$=3.1). Other hindrances which had mean scores of less than ≤ 2.5 included; low subventions on necessary inputs ($\bar{\chi}$=1.2), high rate of illiteracy ($\bar{\chi}$=1.6) and lack of land and storage facilities ($\bar{\chi}$=1.4), scarcity of resistant species ($\bar{\chi}$=2.4). This investigation is substantiated by (22) who reported that financial barriers due to lack of credit facilities are one of the most important obstacles hindering the implementation of appropriate climate adaptation strategies by rice farmers in Nigeria. Furthermore,(23) suggest that inadequate information and awareness on climate change could potentially serve as barrier to successful implementation of adaptation practices.

V. CONCLUSIONS AND RECOMMENDATIONS

This study identified the various climate adaptation strategies used by rice farmers in Ndop sub-division of the Ngoketunjia division of the North west region of Cameroon. This is followed by the examination of the factors that impede the adoption of effective climate change adaptation strategies. The study also provided a description of the farmers' socioeconomic characteristics. The primary data used in this study were collected through structured questionnaires administered to 200 stratified randomly selected rice farmers. The data was analyzed using mainly descriptive statistics. The descriptive statistics includes frequencies, percentages and means. Analysis from questionnaires, interviews and direct field observations indicate that majority (48.3 %) of the respondents were between the ages of 30-45 years with a mean age of 37.5, larger proportion (58.8%) of rice farmers were females. In addition, majority (49.2%) of the farmers had a household size of 5-8 members, larger proportion (38.8%) of the farmers had primary education and majority (45%) earned between 20,000-45,000 cfa francs annually. Results demonstrate that rice farmers adopted the following climate change adaptation strategies: use of short cycle varieties (($\bar{\chi}$=3.3), late planting of rice ($\bar{\chi}$=2.9), increasing water conservation techniques ($\bar{\chi}$=2.8), increase land size under cultivation ($\bar{\chi}$= 2.6), planting of different varieties ($\bar{\chi}$=3.1) among others. Barriers to adaptation strategies identified include; insufficient knowledge on climate change ($\bar{\chi}$=3.2), inadequate access to extension services ($\bar{\chi}$=3.1), lack of adequate irrigation facility ($\bar{\chi}$=2.6), insufficient credit, money and savings ($\bar{\chi}$=2.8), lack of storage facilities ($\bar{\chi}$=2.9) and lack of knowledge on resistant varieties ($\bar{\chi}$=2.9).

Based on these barriers to the effective implementation of adaptation strategies, the following actions are recommended to address these gaps:

i. Inadequate information on climate change and its effects is identified as a barrier to adaptation strategies. Hence, Government and other development actors should create useful meteorological centers in the rural areas to make accessible climate information to farmers via radio and television (interpretations in the

[1] As explained by Madeleine Akoa a worker at the rice unit of IRAD on August 04-2013 at 3:08pm, in the 2013 edition of the national science and innovation exposition.

language useful to farmers/rural communities). This will reinforce farmers' adaptive capacity to climate change.

ii. Inadequate agricultural extension services and poor knowledge of mitigation are noted as impediments to adaptation measures. Consequently, extension workers should be adequately trained in research centers and extension organizations on the complexities of climate change and their services should be made available to farmers.

iii. Government should introduce improved rice variety such as the NERICA variety and the innovation should be diffused to all farmers that can enable them adapt to varying environmental changes, able to adjust to drought and cope with flood as well as variations in temperatures in the study area.

iv. Government and NGOs should boost rice production in the study area by carrying out maintenance on the irrigation as well as the drainage structures. For example, the artificial dykes and the redistribution channels have to be built with concrete materials and properly maintained and raised to prevent sudden breakage or collapse as well as over flowing of flood waters over them.

v. Farmer's ability to purchase resistant and quality varieties have to be improved upon by the government, NGO's, and others. This will increase their coping range and consequently yields will be improved upon.

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