Original Article

Factors Determining Small-Scale Farmers' Adoption of Climate Adaptation Methods in Jubek State, South Sudan.

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ABSTRACT

Agricultural production in South Sudan has experienced climate variability, the erratic occurrence of climate phenomena affects land use through frequent drought and flooding hence needs climate adaptations. There is less information about factors determining farmers adopting climate change adaptations in South Sudan. Therefore, the current research aimed at exploring factors that influence the adaptation measures taken by farmers for Jubek State in South Sudan. The study adopted a stratified sampling method to identify areas and respondents that questionnaires were administered for data collection and there were 395 farmers who were sampled systematically during the research study. The data collected were entered and coded, then statistically analysed using a logistic regression model to analyse determinants to adopting climate adaptations. The study found that gender, marital status, code of employment, size of the household, and size of the farm were significantly influencing adoption of climate changes adaptations ($p < 0.05$). The farmers practice of farming activities in respect to the adaptation methods used had a probability of increasing the number of climate adoption for higher crop yield. It was concluded that prescribed policies need to incorporate socio-economic factors to provide valuable and efficient climate adaptation methods.

INTRODUCTION

There have been varied atmospheric state that persistently occur in the last couple of decade, more than 30 years, at geo-spatial range at a temporal scale (IPCC, 2014). The change of the atmospheric condition is known as climate variability and its resultant effects are negatively affecting livelihoods. Therefore, the human response to climate variability is characterised by climate adaptation interventions. This is mainly described by variability of parameters like temperature, precipitation, humidity, and sunshine intensity on daily weather anomalies. The change of weather patterns and resulting impacts on the environment has an effect on agricultural yield and livelihoods of the communities especially Jubek Sate of South Sudan. For a period of decades now, these effects have been occurring due to greenhouse gases (GHG) accumulated in the atmosphere leading to increased records of atmospheric air temperature and changes in rainfall patterns (Sapkota & White, 2020).

These effects of climate variability are mostly experienced in economical primary production, that is agriculture which provides 80% of the Sudanese population livelihood dependency (FAO, 2021). The changing climate effects raises food affordability price, reduces accessibility, and significantly degrades environmental resources for livelihoods and human despite of local cereal production. Moreover, climate variability is projected to impact greatly on cereal crop produce by making crops inputs vulnerable to water stress and prevalence to invasive weed, pests, and diseases during the growing period (Schulte et al., 2016). Bhuyan *et al.*, (2018) concluded on a report that due to these vulnerabilities, crop production would

decrease by 90% when it reaches 2100, if the trend persists worldwide.

The only determined success to balance the climate variability and farmers' crop production is adaptation to the effects of climatic vulnerability, which is mostly applied at farm levels. These adaptations strategies are diversified according to the crop type and the area of application including change in time management and work, market responses, government aid and policies; technological advancement, and innovations (Bozzola et al., 2018). These adaptations are still infancy in the developing nations, farm produce is at high risk of droughts and floods. Generally, this is certain that, Africa food production by 2050 will decline by 12–21% due to effects of climate variability (Gebrechorkos et al., 2020). South Sudan has no exception to unprecedented crop yields due to climatic variability, and more 60% of the country's population are severely food insecure as result of low agricultural produce (FAO-WFP, 2021).

In a country like South Sudan, about 83% of the population depends on agricultural direct livelihood that is livestock keeping (pastoral) and cropping which heavily rely on rainfall (World Bank, 2020). This has made South Sudan become more vulnerable to climatic variations, hence economic productivity constrains. Therefore, the need of suitable adaptability to encourage resiliency of climatic (rainfall & temperature) variation is required to improve farm produce in Jubek State and South Sudan as whole, finally food security enhanced (Belay et al., 2017). In spite of measures put by the Non-governmental organisations to encourage food security in South Sudan through climate adaptation methods as a way of coping up

with effects of changing climate (D'Errico et al., 2019), there are still many cases of famine and hunger following the agricultural deterioration by floods and droughts in the country (Maxwell et al., 2020).

Therefore, there is a significant reason to research factors that make farmers adopt new technologies that improve yields from the farm. The contribution of the socio-economic factors and financial constrains provide greater understanding of farm dynamics and mechanisms in the adaptations process. Farmers' social and economic values have been researched by various researchers to provide evidenced policy implication to farmers; (Abera et al., 2020; Belay et al., 2017; Islam et al., 2017; Mabuku et al., 2019; Nyirandorimana et al., 2020; Teshome et al., 2016). The studies provide literature and significant of socio-economic factors in determining the adoption of the climate adaptation strategies that would lead to improvement of yields on the areas of the research studies rather South Sudan.

There are no research studies that have been done in Jubek State South Sudan to determine factors that influence the use of climate adaptation methods.

However, Boansi et al., (2017) did a collaborative study in Sudan Savanna to analyse farmers' adaptation to extreme weather conditions in West African Sudan Savanna. Thus, this study identified the socio-economic factors that leads to adoption of adaptive solutions to cope with erratic climate variability in Jubek State and entire South Sudan. Finally, significant socio-economic factors and household characteristics obtained from the study would improve existing policies to help farmers adapt to erratic climatic conditions through local, national, and non-government organisations in South Sudan.

RESEARCH METHODOLOGY

Area of study

Jubek State is situated in South Sudan to the south. It lies at 4°30′N 31°30′E and covers approximately 336 km². Its average elevation is 500 m above sea level. The state is having fourteen counties: Bungu, Ganzi, Dollo, Rejaf, Lodu, Luri, Gondokoro, Mangalla, Liria, Oponi, Wonduruba, Rokon, Nyarkenyi and Lobonok. The study is going to be done in five counties which are Liria, Gondokoro, Rejaf, Lodu and Luri.
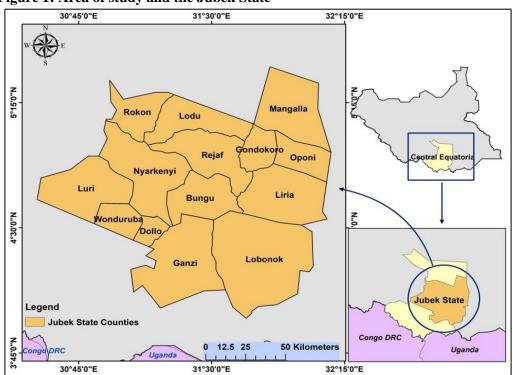
Figure 1: Area of study and the Jubek State

Study Design and Sampling Size

The descriptive research survey was adopted as the research design in this study; in which both qualitative and quantitative data were collected though study majored on qualitative data that considered to describe the perceptions and socio-economic factors affecting adoption of the climate adaptation strategies among the farmers of Jubek State. The targeted population were farmers in Jubek State of South Sudan and farmers had experienced changes in climate hence adopted strategies to improve their yields especially farmers who cropped maise, beans, and millet. According to the report by Farmers Association Ladger Book (2019), there are about 15000 farmers living with their household family in Jubek State. However, the research study selected five counties to focus the study and the selected counties were Rajaf, Liria, Gondokoro, Luri, and Lodu. The selected five counties had a population of 2,488 farmers approximately. Further, the study adopted Yamane, (1967) to calculate the sampling size as shown in the equation below.

$$n = \frac{N}{1+N(e)^2} \qquad = \qquad \eta =$$

$$\frac{2,488}{1+2,488\times(0.05)^2} \qquad = \qquad \eta = 395$$

Where; n = Sample size; N = Farmers Population size; e =level of precision which is 0.05

The total sampling size for the research study become 395 farmers among the 5 counties in Jubek State. These counties were selected due to their seasonal performance in agricultural yield and practicing pastoralism.

Data Collection and Sampling Procedure

The primary data were collected by use of closed questionnaire and field observation and secondary information obtained from literature reviews to supplement primary data. The procedure of selecting sampled respondent was characterised by type of agricultural activity involved, that is crop farming or livestock rearing and sub-location in the entire State of Jubek. Therefore, the study would employ stratified and random sampling methods to collected the data from the framers. Stratified sampling was used to select counties, then random

Payams farmers and their households to the questionnaires administered to them. The respondents were chosen from the location area identified and the type of farming. Then, the farmers' household were selected randomly with equal chance from the calculated sampling population in each area and farm type. During the research study, the researcher ascertained the suitability, accuracy, and relevance of the research instruments. Once the questionnaires were considered valid and reliable, then the researcher administered the questionnaires to the sampled farmers both crops growing and livestock keepers in Jubek state for 14 days. The socio-economic factors were specifically answered by the farmers households in their farm.

Data Analysis

After data collection from the sampled farmers, the descriptive statistic was utilised to analyse the socio-economic data. The descriptive statistics includes frequency, mean, maximum, minimum and standard deviation. However, the information that were observed were qualitatively analysed based on the theoretical and the concept of the study. The computation of the inferential statistic was employed to determine factors that make farmers to adopt climate adaptation methods. Binomial logistic regression model was considered to analyse explanatory variables against the dependent variable however there were mixed data of dummy variable and some data were continuous. After the logistic regression analysis, we carried a marginal effect, regressed to derive a probability of a socio-economic factor to influence farmers' adaptations use. The dependent of variable had to consider response of two values hence data coded as one or zero;

$$Z_i = \left\{ \frac{0-\text{adopting climate adaptation methods}}{1-\text{Not adopting climate adaptation methods}} \right\}$$
[1]

$$Prob\left(\frac{Y_l}{X}\right) = F(Z_i) = \frac{e^{Z_l}}{1+e^{Z_l}} = \frac{1}{1+e^{-Z_l}}$$
[2]

$$Z_i = \beta_0 + \beta_1 X_{1l} + \beta_2 X_{2l} +, , , , , , , , , , , , , + \beta_n X_{nl} + \varepsilon_l$$
[3]

Therefore;

$$log\,(P) = ln\left(\frac{P_l}{1+P_l}\right)$$

[4]

$$ln\left(\frac{P_l}{1+P_l}\right) = \beta_0 + \beta_1 X_{1l} +$$
$$\beta_2 X_{2l} +,,,,,,,,,,,,, + \beta_n X_{nl} + \varepsilon_l$$
[5]

RESULTS AND DISCUSSION

Factors that always influence adaptation methods in small scale agriculture are termed socio-economic factors (Mozzato et al., 2018). The results from the logistic regression model used in this study as method of analysis showed that gender of the farmer, farmers' marital status, code of employment, size of the family (household size), and size of the farm could significantly influence the adoption of climate adaptation methods in Jubek State, South Sudan ($p< 0.05$) as shown ***Error! Reference source not found.***. The socio-economic factors such as age of the farmer, type of farming, main sources of income, and level of education had a probability of influencing adoption of climate adaptation methods though were not significantly influencing the use of adaptations method by Jubek State small scale farmers in South Sudan as shown **Table 3**.

Table 1: Descriptive statistics of socio-economic factors that affects climate adaptation methods

Variables		Obs.	Mean	Std Dev.	Min	Max	Description
Dependent variable	Climate adaptation	391	0.245	0.431	0	1	Dummy
Independent variables	Gender of the farmer	391	0.312	0.463	0	1	Dummy
	Age of the farmer	391	41.08	9.213	23	71	Continuous
	Type of farming	391	1.744	0.795	1	3	Continuous
	Farmers' marital status	391	0.647	0.478	0	1	Dummy
	Code of employment	391	0.425	0.495	0	1	Dummy
	Sources of income	391	0.524	0.500	0	1	Dummy
	Level of education	391	2.168	0.940	1	4	Continuous
	Size of the household	391	4.926	2.501	0	15	Continuous
	Size of the farm	391	2.526	1.771	0	8	Continuous

Table 2: Binary logistic regression coefficients of socio-economic factors that affects the climate adaptation in Jubek State

Socio-economic factors	Coefficients	Std. Error	z -value	p-value
Gender of the farmer	1.658***	0.283	5.87	0.000
Age of the farmer	0.007	0.015	0.49	0.625
Type of farming	-0.034	0.180	-0.19	0.850
Farmers' marital status	0.849**	0.332	2.56	0.011
Code of employment	2.013***	0.684	2.94	0.003
Sources of income	-0.736	0.692	-1.06	0.288
Level of education	-0.150	0.150	-1.00	0.318
Size of the household	0.109**	0.056	2.21	0.028
Size of the farm	-0.161**	0.087	-2.05	0.041
Constant	-3.101***	0.910	-3.41	0.001

*NB: *** $p < 0.01$ and ** $p < 0.05$ shows the level of significance*

Table 3: Marginal effect of socio-economic probability

Explanatory variables	dy/dx	Std. Err	z	p-value
Gender of the farmer	0.225***	0.032	7.09	0.000
Age of the farmer	0.001	0.002	0.49	0.625
Type of farming	-0.005	0.024	-0.19	0.850
Farmers' marital status	0.115***	0.044	2.62	0.009
Code of employment	0.273***	0.090	3.03	0.002
Sources of income	-0.100	0.093	-1.06	0.287
Level of education	-0.020	0.020	-1.00	0.315
Size of the household	0.015**	0.007	1.96	0.028
Size of the farm	-0.023**	0.012	-1.88	0.041

*NB: *** $p<0.01$ and ** $p<0.05$ shows the level of significance*

Gender of the Farmers

Gender is defined as either male or female. This study results showed that there were a positive and significant correlations between the gender of the farmer, and the use of climate adaptation methods, ($p < 0.001$) in curbing the effects of climate change (***Error! Reference source not found.***). The descriptive analysis found that 79% of the male farmers were using climate adaptation methods while only 21% of the female farmers were using the climate adaptation in their farms (***Error! Reference source not found.***). Moreover, the study found that gender disparity had a probability of 22.5% to increase and shift the use of climate adaptation methods by small scale farmers in Jubek States as shown in

Table 3Error! Reference source not found..

The results from this study was supported by Thinda *et al.,* (2020) and Ylipaa *et al.*, (2019), studies which were done in South Africa and Vietnam respectively, they found that gender has greater role in understanding the adoption of climate adaptation methods among small scale framers. However, males had dominated the chance of adopting to climate change effects as compared to counter parts female in the society.

Table 4: Gender response on climate adaptations

Variable Definition		Yes	No
Gender of the farmers	Male	233 (79%)	36 (37.5%)
	Female	62 (21.0%)	60 (62.5%)

Age of the Farmer

Farmer's age in Jubek State was found to be positively and insignificantly influence the adoption of adaptation strategies to combat effects of climate variability ($p > 0.05$; ***Error! Reference source not found.***). The facts remain that the increase of farmer's age could increase the adoption of adaptation methods. However, age had a probability

of 0.1% of making farmers to adopt adaptation methods though was not significant as shown

Table 3Error! Reference source not found.. The same results were reported by Muriu-Ng'ang'a *et al.,* (2017) study which found that farmers' age were directly proportional to water harvesting as an adaptation methods for farming hence increasing the agricultural production.

Type of Farming

The types of farming employed by the community in Jubek State included crop farming (47.6%), pastoral farming (30.4%), and mixed farming (22.0%) as shown in the ***Error! Reference source not found.**.* Thus these results deduced that crop farming was mainly practiced by Jubek community. The binomial logistic results showed type of farming practiced by farmer was negative and

insignificant factor to determine adaptation method used by farmers (p > 0.05, ***Error! Reference source not found.***). However, types of farming had a probability of 0.5% to affect the method of adaptations employed by farmers in their farms (

Table 3). Ylipaa *et al.,* (2019) found that types of farming are main source of livelihood in Vietnam and thus could influence the adaptations method employed by farmer to make better yields.

Table 5: Types of farming engaged by Jubek farmers

Variable	Frequency	Percent	Cumulative %
Crop farming	186	47.6	47.6
Pastoralist	119	30.4	78.0
Mixed farming	86	22.0	100.0
Total	391	100.0	

Farmer's Marital Status

The marital status of a farmer was found to positively correlate and influenced the choice of adaptation employed by farmer, there was a significant determination of marital status to adaptation (p < 0.001, ***Error! Reference source not found.***). Moreover, marital status had a probability of 11.5% to influence the use of adaptation methods in the farm as shown in

Table 3. The farmers sampled who were married (87.7%) reported to use adaptations method more as compared to single (68.8%) farmer. The same results were found by Duong *et al.,* (2020) and Mabuku *et al*., (2019) showed that marital status of a farmer could influence the determination of adaptation methods use in the farm to produce higher yield. Therefore, the results deduced that farmers who are married had much responsibilities

and share of knowledge from the partners (Gram et al., 2018).

Code of Employment

In Jubek State, farmers were employed and unemployed. This study found that 57.5% of the farmers are not employed thus mainly depend on farming as the source of livelihoods and 42.5% of the farmers had some alternative employment sources of livelihoods (***Error! Reference source not found.***6). The results showed that employment code was positively and significantly correlating with adaptation choice of the farmer to adopt climate adaptations (p < 0.001; ***Error! Reference source not found.***). These results deduced that employment could influence the farmers adaptations choice farm since farming could be the main source of livelihoods or otherwise. However, employment codes had 27.5% probability of increasing the rate of adaptation by the farmer in Jubek State as shown in

Table 3. In agreement with other studies; Duong *et al.* (2020) Ochieng *et al.* (2016) and Thinda *et al,* (2020) that found the same results as in this study,

these are confirmation that employment status influence the adoption of adaptation methods by farmers in Jubek State and this would help to curb level of poverty.

Table 6: Employment status of farmers

Variable	Frequency	Percent	Cumulative %
Not Employed	225	57.5	57.5
Employed	166	42.5	100.0
Total	391	100.0	

Sources of Income

As enumerated by other studies around the world, income from the farm plays a critical role in the economy and farmers' livelihoods (Lloyd & Dennison, 2018). The farm income of farmers from Jubek States showed highly negative and insignificant influence to farmers adaptations use in Jubek ($p > 0.05$; **Error! Reference source not found.**). Moreover, the source of income results from this study, was not influencing farmers to use adaptations as found in other studies such as Ojo & Baiyegunhi, (2020) in South-wast of Nigeria and Yomo *et al.,* (2020) in Ghana, which found that farmers' income from agriculture were significantly marking the behaviour of using adaptations method to increase the income. The sources of income would negatively determine farmers' use of adaptations method by 10.0% (

source of the source, a farmer who entirely depend on agricultural production would invest on adaptation strategies to increase yield.

Level of Education

In regards to the farmers' level of education, there was a negative correlation between farmers' level of education and adoption of climate adaptation methods, though was not significant ($p > 0.05$; *Error! Reference source not found.*). Most of the farmers had primary education 35.0%. The farmers with no education were 28.4%, secondary education 27.9%, and tertiary 8.7% (*Error! Reference source not found.*). The disparity in level of education shows that most of the farmers were illiterate and therefore education could not influence their adoption to adaptation methods. However, level of education had 2.0% probability of influencing farmers to adapt to effects of climate change (

Table 3). As diversity of income source increase the adaptations use by the farmers reduce the farm. Belay *et al.,* (2017) stated that more income sources would lead to farmers adopting to climate adaptation methods because income depends on

Table 3). In contrast, other studies such as Kassem *et al.,* (2019) in Egypt and Onyekuru & Marchant, (2016) found that farmers' level of education were statistically associated with farmers' use of adaptation methods.

Table 7: Level of Education of farmers in Jubek State

Education level	Frequency	Percent	Cumulative %
No education	111	28.4	28.4
Primary	137	35.0	63.4
Secondary	109	27.9	91.3
Tertiary	34	8.7	100.0

Size of the Household

Household is the number of individuals in the family that dependently gather from the farming. In this study it was found that household size was significantly and positively correlated to adaptation methods p < 0.05 (***Error! Reference source not found.***). The results showed that as the number of family increase the adaptation adoption increase because the farmer needs more yield for the family. The highest family had 15 people and the lowest number in family was one person. This study deduced that family size had a probability of 1.5% to improve the use of adaptation methods as shown in

Table 3. Belay *et al.,* (2017) and Han *et al.*, (2018) researches studies also found the same results as in this study hence the larger the size of the household, the better the chance of adapting to climate change to increase the household yield.

Size of the Farm

The size of the land cultivated by farmers in Jubek State is negatively and significantly related to the adoption of climate adaptation methods in relevant to climate variability (p < 0.05; ***Error! Reference source not found.***). A unit increase of hectare of land cultivated would decrease the likelihood of using climate adaptation methods by 2.3% as shown in

Table 3. The facts that the farmer with larger size of land to cultivate has less fear of taking risk as the counterparts with smaller sizes. Farmers with the large size of cultivated land have a high probability of having many farm plots with different soil physical and chemical characteristics that have been impacted by climate change differently. This result

affirms with studies done by Kassem *et al.*, (2019) in Delta Nile of Ethipia and Vecchio *et al.,* (2020) in Italian farmers, found that size of the farm cultivated by the farmers would increase as adaption methods risk also increase. Most of the farmers with large number of hectares would increase their adaptation methods to avoid the risk on the farm hence yield increase.

CONCLUSION AND POLICY IMPLICATION

Farmers make choice of climate adaption following climate variability and socio-economic factors of the household. Adopting to climate change adaptations increases the number of yields to farmers thus it is critical that farmers need to apply the strategies. However, the application capacity of a farmer climate to adopt climate change adaptation strategies depends on socio-economic factors. The research study employed quotative survey that descriptively used to collect the data hence used logistic regression to analysis. The results from the logistic regression model used in this study as method of analysis showed that gender of the farmer, farmers' marital status, code of employment, seize of the family (household size), and size of the farm could significantly influence the adoption of climate adaptation methods in Jubek State, South Sudan.

The policy interventions in South Sudan especially Jubek State needs to draft policies that would inform the donors, NGOs, and the local government to understand dynamics dictating farmers' adaptations to climate change in their farms. Therefore, South Sudan government needs to formulate reliable and farmers-based policies that allow easier access to informational services that provide farmers with better adaptation methods based on their socio-economic status.

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