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Climate change and women employment in agriculture in the Sahel region: An empirical insight

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Abstract

In recent times, the Sahel region has been particularly identified as the flash point of climate change crisis in Africa, due to the persistent reliance on both biophysical factors and natural resources, especially agriculture for economic livelihood. Against this scenario, this study provides an empirical evidence to establish the nexus between climate change and women employment in agriculture within the Sahel region. The study employed panel data from 1990 to 2020 of 9 countries within the Sahel region. Consequently, a panel Fully Modified Ordinary Least Squares (FMOLS) was used to estimate the relationship between the variables of interest. Thus, the results showed that about 60% of women in the Sahel region are actively employed in agriculture. However, change in rainfall pattern has a significant adverse effect on women employment in agriculture. In view of these findings, we conclude that a rise in women's employment in agriculture would be mitigated if adverse effects of changes in rainfall pattern are controlled. Additionally, policymakers should be proactive in policy formulation that increases the region's resilience and adaptation to the future adverse effects of agriculturally induced climate change. *(Afr J Reprod Health 2023; 27 [10]: 111-120).*

Keywords: Agriculture, climate change, greenhouse gas, rainfall, women employment

Résumé

Ces derniers temps, la région du Sahel a été particulièrement identifiée comme le foyer de la crise du changement climatique en Afrique, en raison de sa dépendance persistante à l'égard des facteurs biophysiques et des ressources naturelles, en particulier l'agriculture, pour ses moyens de subsistance. Face à ce scénario, cette étude fournit une preuve empirique permettant d'établir le lien entre le changement climatique et l'emploi des femmes dans l'agriculture dans la région du Sahel. L'étude a utilisé des données de panel de 1990 à 2020 provenant de 9 pays de la région du Sahel. Par conséquent, un panel de moindres carrés ordinaires entièrement modifiés (FMOLS) a été utilisé pour estimer la relation entre les variables d'intérêt. Ainsi, les résultats ont montré qu'environ 60 % des femmes de la région du Sahel sont activement employées dans l'agriculture. Cependant, le changement du régime des précipitations a un effet négatif important sur l'emploi des femmes dans l'agriculture. Au vu de ces résultats, nous concluons qu'une augmentation de l'emploi des femmes dans l'agriculture serait atténuée si les effets négatifs des changements dans le régime des précipitations étaient contrôlés. En outre, les décideurs politiques doivent être proactifs dans la formulation de politiques qui augmentent la résilience et l'adaptation de la région aux futurs effets néfastes du changement climatique induit par l'agriculture. *(Afr J Reprod Health 2023; 27 [10]: 111-120).*

Mots-clés: Agriculture, changement climatique, gaz à effet de serre, précipitations, emploi des femmes

Introduction

Climate change represents one of the most critical global issues recognized by the Intergovernmental Panel on Climate Change (IPCC)[1]. The impact of this phenomenon are felt in different ways across different sectors of the economy and regions across the world in recent times, the fifth assessment report of the United Nations' IPCC enunciated the disastrous impact of climate change on agricultural sector[2,3]. Many sub regions of the world currently face the challenge of climate change ranging from disequilibrium in food systems, loss of livelihoods, health hazards, political instability but to mention a few. In regions where, adaptive capacity or mitigating measures are not implemented, climate

change constitutes a severe risk in weakening the systems of such regions[4].

The Sahel region has been particularly identified as the flash point of climate change crisis in Africa due to various factors[5]. The Sahel region is currently in a dire state of vulnerability to the influence of climate change due to the persistent reliance on both biophysical factors and natural resources especially agriculture for economic livelihood. According to Sartori and Fattibene[6] the structure of agriculture is extremely underdeveloped as well. In recent time, in countries like Nigeria, Burkina Faso, Mali, Niger, Mauritania and Chad, perpetual shortage of water resources due to severe drought has persistently fueled conflicts among farmers, fishermen and herders, and this has consequently metamorphosed into unimaginable levels of insecurity of lives, food, and properties[7-10].

Consequently, one of the major livelihood support systems for the residents of the Sahel region is agriculture[11]. This is because the majority of the people in this sub-region of Africa depend heavily on agricultural activities, to ensure the creation of job opportunities, generation of income, and other socio-economic needs. More importantly, food economy has contributed approximately 80% of total employment in the Sahel region over the time[12,13]. The female population in this region overwhelmingly depend on agricultural and food economies, having 40% contribution to agricultural production, 80% contribution to agricultural processing, and 70% contribution to the region's agricultural labour[14,12]. This shows that the participation of women in agricultural activities in the Sahel region cannot be undermined. Therefore, climate change and its spillovers on female employment in agriculture have become the priorities of both researchers and policymakers in countries in the Sahel region. Against this backdrop, an empirical investigation of the nexus between climate change and female employment in agriculture needs to be investigated.

This study is very germane in the Sahel region because a large number of female farmers are vulnerable to climate change, as majority of them over rely on rain as a means of sustaining their agricultural actvities[15] in which the inconsistence of the patterns of rainfalls have continually reduced agricultural outputs in the region [16, 17] Another major factor that increases the vulnerability of female

farmers to climate change in the Sahel region is inadequate funding for agricultural extension services in the region.[18, 19]. Against this background, this study investigated the nexus between climate change and women employment in agriculture within the Sahel region. The study provides an empirical answer to the question of how the climate change variables influence female employment in the agricultural sector within the Sahel region.

Therefore, the study`s hypothesis is stated as follows;

H_0: there is no significant relationship between climate change and women employment in agriculture in the Sahel region.

H_1: there is a significant relationship between climate change and women employment in agriculture in the Sahel region

We believe that the results of the study will inform the design of policies and programmes for increasing women's participation in agriculture in the Sahel despite the harsh consequences of climate change in the region.

Literature review

Anugwa *et al.*[20] looked into how gender interacts with the effects of climate change vulnerability on Nigerian agriculture and food security. The findings showed of the study stipulated that women are more susceptible than men to the negative implications of climate change on agricultural and food security. Duru[21] assessed how climate change affects rural women's livelihoods in Nigeria. The outcomes of the study showed that there lack of fundamental infrastructure, a small capital base and the adoption of primitive farming practices made women to be vulnerable to the effects of climate change.

Ngum and Bastiaensen[22] examined how the intersectionality of the numerous normative regimes governing accessibility to land and the multiple gendered identities of female farmers affect their tactics for adapting to climate change in Cameroon's five unique agroecological zones. The findings demonstrated that women's levels of vulnerability and coping mechanisms to climate change vary by environment and by gender across the zone Praag *et al.*[23] studied how environmental changes are perceived and how these relate to migration in

Senegal, the DR Congo, and Morocco. The findings of the researchers showed that individuals' livelihoods influence their ability to react to climate adjustments, while their degree of educational attainment makes them more conversant with the current environmental debate and regulations.

Ifeanyi-Obi and Ugorji[24] looked at how social exclusion affected how well female farmers of arable crops adapted to climatic change in Nigeria. It was discovered that poor availability of credit facilities to support adaptation activities made it difficult for female arable crop farmers to adapt to climate change in the country. Akinbami *et al.*[25] explored women's perceptions of the awareness of and effects of climatic change in South West Nigeria's various vegetation zones. The authors argued that the majority of women engaged in crop farming in vegetation zones demonstrated superior comprehension than women engaged in other forms of employment.

Azong *et al.*[26] investigated the specifics of the vulnerability felt by rural women in Cameroon utilizing a life history methodology. The study confirmed diversifying sources of income and altering farming methods were the reliable adaption techniques used. Grey and Wise[27] investigated the impact of climatic variability on migration in Africa. It was evident in the study that migration is affected by climate variability differently depending on the country: in Uganda, migration appears to rise with temperature anomalies, while in Kenya, Burkina Faso, and Nigeria, there is no significant association between migration and temperature.

Hummel[28] investigated the relationships among climate change, land degradation, and migratory movements in rural Sahel region. Migration, environment and climate were conceptualized to be the major social-ecological problem in the region. Van der Land and Hummel[29] focused on the function of educational institutions in environmentally induced migration the Sahel. It was submitted in the study that formal education is crucial in lowering exposure to environmental stress. Yila and Bernadette[30] investigated the variables influencing smallholder farmers' adaptation methods to climate change in the semi-arid region of Nigeria.

Agricultural labour force, the household head's education level, the land tenure arrangements, the household head's gender, and the years of farming experience were the crucial factors influencing smallholder farmers. Goh[31] evaluated how climate change affects men and women's assets and well-being differently in emerging economies. The research's results demonstrated the complexity of the relationship between gender and climate change in low-income communities. Molua[32] examined the impact of climate threats on the productive activities and management choices of male and female farmers. The study enunciated that the profitability of farms is explicitly impacted by rising climate variability and the unpredictability of climatic circumstances.

Mertz *et al.*[33] used focus group interviews and a household survey to analyse sedentary farmers' views on climate change and their coping and adaption techniques in the central Senegal savanna region. It was determined that although the populations under study are mindful of climate challenges, climatic narratives are likely to sway reactions when the topic of climate is brought up. Molua[34] investigated the impact of alterations in climatic averages on Cameroon's overall agricultural output. The evidence gathered demonstrated without irrigation infrastructure, Cameroon's agriculture would suffer from a 3.5% rise in temperature and a 4.5% rise in precipitation, which would result in a loss of around 46.7% in output value. In conclusion, it is evident that studies regarding climate change and women employment in agriculture are very scarce within the Sahel region. Therefore, this study`s relevance cannot be undermined.

Methods

Research design

In considering the right research design for this study, an expo-facto research design was used due to the kind of technicality involved in addressing the objective of this study. The study utilizes secondary data which provided information about how climate change variables explain variation in sustainable agricultural growth within the context of the Sahel region.

Theoretical framework

This research anchors on cascading climate risks theoretical framework initiated by the CASCADES research team. The framework enunciated factors that triggered climate change from the perspectives

Table 1: A priori expectations and meaning of model`s abbreviations

Abbreviation	Variables	Parameters	Expected Value
CIR	Change in Rainfall	β_1	Positive (+)
GHG	Greenhouse Gas	β_2	Negative (-)
INO	Innovation	β_3	Positive (+)
IFA	Infrastructural Development	β_4	Positive (+)
GER	Government Expenditure on R&D	β_5	Positive (+)
WEA	Women employment in agricultural sector		Dependent variable

Source: Authors` computation

Table 2: Measurement and operation definitions of variables

Abbreviations	Description of Variables
WEA	Women employment in agricultural sector. Female employment in agriculture as % of female employment
CIR	Change in Rainfall Pattern. This is measured by average precipitation in depth in MM per year
GHG	Greenhouse Gas. This is measured by total greenhouse gas emission
INO	Innovation. The number of individuals who have access to internet as percentage of total population is used to proxy it, as percentage is its measurement
IFA	Infrastructural Development. The number of individuals who have access to electricity as percentage of total population. Percentage is the unit of its measurement
GER	Government Expenditures on Research and Development. This is measured by the government`s capital and recurrent spending on education as percentage of government expenditure. Its unit is in percentage.

Note: CIR means Change in Rainfall, GHG means Greenhouse Gas, INO stands for Innovation, IFA is Infrastructural Development, GER is Government Expenditure on R&D and WEA means Women employment in agricultural sector.
Source: Authors' computation

of biophysical phenomenon, meteorological variables and hydrological factors. Consequently, the framework provides a channel through which climate change trigger factors and transmit their disastrous spillovers effects on the aggregate agricultural products, livelihoods and social networks in ecosystem in one hand, and impacts transmission systems which have the tendency of escalating risks that could disperse beyond sectors and borders over the time[8].

Model specification

Specifying the model for this study for the investigation of the impact of climate change female employment in agriculture in the Sahel region utilizes the idea enunciated in similar studies[35, 36, 37, 38]. Consequently, total emissions of greenhouse gas alongside change in rainfall and change in temperature was employed as a proxy in climate change variables. In addition, innovation and

infrastructural development were used as control variables whereas government expenditure in research development was employed as a policy variable with a view to improving the robustness of the model. In that order, the equation specified as shown in equation (1)

$$WEA = f\ (CIR, INO, GHG, IFA, GER) \qquad (1)$$

Conversion of equation (1) into a linear panel model leads to equation (2)

$$WEA_{it} = \alpha_0 + \beta_1 CIR_{it} + \beta_2 INO_{it} + \beta_3 GHG_{it} + \beta_4 IFA_{it} + \beta_5 GER_{it} + \mu_{it} \qquad (2)$$

Table 1 shows the full meanings of all the abbreviations used to proxy the study`s variables. Also, in providing detailed information about how the variables of the study were defined operationally, efforts have been made to summarize how these variables have been proxied in Table 2.

Source of data and scope of the study

In investigating the relationship between climate change and sustainable agricultural growth in Sahel region using secondary data, this study used annual time series data within the periods of 1990 and 2020. Data from 9 countries out of 13 countries within the Sahel region were collected from the World Development Indicators published by the World Bank[39]. Consequently, it is important to stress that the inclusion of these countries in the study was based on data available on the variables of interest. The countries selected were: Burkina Faso, Chad, Eritrea, Mali, Mauritania, Niger, Nigeria, Senegal and Sudan. The observed missing data of some variables were addressed by following the technique of Benchani and Swiss[40] in filling missing data in panel study. To this end, the study employed the average of the last four most recent years in the dataset to replace the missing points. This technique makes the panel dataset to be strongly balanced, and eventually contributed to the possibility of the balanced panel analysis in this study.

Results

This section provides detailed analysis and discussion of the results, alongside the policy recommendation of the study.

Table 3 gives the detailed description of all the relevant variables in this study. Starting from WEA – women employment in agriculture, it could be inferred that from both maximum and minimum capacities, agricultural employment accounts for 65.6% and 51.6% of women who are engaged in productive employment respectively in the Sahel region. Whereas, within the periods of 1990 and 2020, agriculture employment has a mean value of 59.9%. Subsequently, the minimum total greenhouse gas emitted in the region is 38,581.11Kt, whereas, the maximum value emitted is 75,714.78Kt. But, the total greenhouse gas emission in the Sahel region has an average value of 54,624.35Kt.

Furthermore, the change in rainfall pattern has an average value of 450.6452 MM per year. It is important to stress that the change in rainfall pattern ranges between 451.6667 MM and 441.3333 MM per year in the last three decades in the Sahel region. In the same vein, on average basis, 3.2% of the Sahel`s government budgets were spent on research

and development. Also, 4.3% and 2.1% are the maximum and minimum percentage of the Sahel`s government budgets on research and development simultaneously. In addition, the level of infrastructural development in the Sahel region as depicted by the number of individuals who have access to electricity and internet. It evident from Table 1 that 26% of the Sahel`s residents have access to electricity on average basis. However, 5.1% of the Sahel`s residents have access to internet.

In Table 4, the degree of how the explanatory variables is related is shown as follows; the principal explanatory variables used to proxy climate change in this study are total greenhouse gas emission, GHG and change in rainfall pattern,CIR. It is needful to state that correlation between these variables is very low. This signifies that these two variables cannot cause multicollinearity in this study. Hence, further empirical analysis could be pursed. The study that involves data from secondary sources over a long period of time like three decades usually face the problem of unit root because these data are trended in nature. The negative side of this phenomenon is that, the usage of such data in an empirical study without a caution could instigate spurious outcomes in which their implications on policy recommendations could be disastrous. In order to avert this problem, this study subjects the data to unit root test by estimating the Levin, Lin & Chu and Im Pesaran in which the aftermath results are displayed in Table 4. The findings establish that it is only Innovation, INO that is not stationary at level while the rest of the variables are stationary at level. Therefore, the study investigates the long run relationship among these variables via cointegration in the subsequent table.

The contents of Table 5 show the estimated results of the cointegration test conducted in establishing if the long run relationship exists or not among the variables used in this article. The findings in the table confirm that climate change variables, women employment in agriculture and other control variables possess a long run equilibrium relationship in the Sahel region.

Table 6 contains the FMOLS outputs of the relationship between climate change and women employment in agriculture in the Sahel region from 1990 to 2020. Firstly, R-Squared which is 0.987490 establishes that climate change variables alongside control variables explain about 98% of the variation

Table 3: Descriptive statistics of the study's variables

	WEA (%)	GHG (Kt)	INO (%)	GER (%)	IFA (%)	CIR(MM)
Mean	59.95277	54624.35	5.099741	3.289199	26.08182	450.6452
Median	60.06674	53051.11	1.382306	3.339699	24.34351	450.8889
Maximum	65.60629	75714.78	24.58867	4.269487	42.28098	451.6667
Minimum	51.56922	38581.11	0.000255	2.160331	12.67111	441.3333
Std. Dev.	4.360345	10176.30	7.210268	0.572747	8.919501	1.766646
Skewness	0.434268	0.556723	1.485667	-0.219207	0.241754	-4.713592
Kurtosis	2.062434	2.206248	3.968181	2.110580	1.815635	25.10024
Jarque-Bera	18.98812	21.73645	113.5321	11.43057	19.02433	6711.023
Probability	0.000075	0.000019	0.000000	0.003295	0.000074	0.000000
Sum	16726.82	15240193	1422.828	917.6865	7276.829	125730.0
Sum Sq. Dev.	5285.505	2.88E+10	14452.65	91.19473	22116.98	867.6487
Observations	279	279	279	279	279	279

Note: CIR means Change in Rainfall, GHG means Greenhouse Gas, INO stands for Innovation, IFA is Infrastructural Development, GER is Government Expenditure on R&D and WEA means Women employment in agricultural sector.
Source: Authors` Computation

Table 4: Correlation matrix

	IFA	CIR	GHG	INO	RES
IFA	1.000000	-0.054150	0.983515	0.883321	0.913211
CIR	-0.054150	1.000000	-0.016672	0.029295	-0.065543
GHG	0.983515	-0.016672	1.000000	0.931206	0.863353
INO	0.883321	0.029295	0.931206	1.000000	0.683152
GER	0.913211	-0.065543	0.863353	0.683152	1.000000

Source: Authors` Computation.
Note: CIR means Change in Rainfall, GHG means Greenhouse Gas, INO stands for Innovation, IFA is Infrastructural Development, GER is Government Expenditure on R&D and WEA means Women employment in agricultural sector.

Table 4: Panel unit root test

LLC Results			
VARIABLES	t-statistic	Probability	Order
WEA	-5.22594	0.0000	I(0)
GHG	-10.4731	0.0000	I(0)
IFA	-10.8710	0.0000	I(0)
CIR	-11.4079	0.0000	I(0)
INO	1.47135	0.9294	I(1)
GER	-12.5625	0.0000	I(0)
Im Pesaran Results			
VARIABLES	t-statistic	Probability	Order
WEA	-7.58184	0.0000	I(0)
GHG	-9.15381	0.0000	I(0)
IFA	-12.2150	0.0000	I(0)
CIR	-9.24815	0.0000	I(0)
INO	2.71626	0.9967	I(1)
GER	-11.8331	0.0000	I(0)

Note: CIR means Change in Rainfall, GHG means Greenhouse Gas, INO stands for Innovation, IFA is Infrastructural Development, GER is Government Expenditure on R&D and WEA means Women employment in agricultural sector.
Authors` Computation (2023)

in women employment in agriculture. This suggests that the model the study uses is relatively robust. Also, none of the regressors follows the '*a prori*' expectation. Consequently, GH - total greenhouse gas emission has a positive but insignificant relationship with women employment in agriculture

Table 5: Johansen Fisher panel cointegration test

Hypothesized Number of CEs	FisherStat.* (from trace test)	Prob.	FisherStat.* (from Max-eigen test)	Prob.
None	195.6	0.0000	72.04	0.0000
At most 1	129.9	0.0000	47.10	0.0002
At most 2	90.93	0.0000	53.40	0.0000
At most 3	49.87	0.0001	62.91	0.0000
At most 4	7.421	0.9861	9.800	0.9382
At most 5	2.315	1.0000	2.315	1.0000

Authors` Computation (2023)   *Probabilities are computed using asymptotic Chi-square distribution
Note: CIR means Change in Rainfall, GHG means Greenhouse Gas, INO stands for Innovation, IFA is Infrastructural Development, GER is Government Expenditure on R&D and WEA means Women employment in agricultural sector.

Table 6: Climate change and women employment in agriculture in the Sahel Region

Dependent Variable: WEA				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
GHG	3.27E-05	3.04E-05	12.26321	0.0000
IFA	-0.372953*	0.030412	6.531007	0.0000
CIR	-0.127869*	0.019579		
INO	-0.139035*	0.019570	7.104595	0.0000
GER	-0.804143*	0.191999	4.188266	0.0000
R-squared	0.987490			
Adjusted R-Squared	0.986855			

Source: Authors` compilation. *(*) indicates significance at a 1% probability level*
Note: CIR means Change in Rainfall, GHG means Greenhouse Gas, INO stands for Innovation, IFA is Infrastructural Development, GER is Government Expenditure on R&D and WEA means Women employment in agricultural sector.

in the Sahel region. However, CIR - change in rainfall pattern and women employment in agriculture have a significant negative relationship. Furthermore, IFA- infrastructures have a negative but significant effect on women employment in agriculture in the Sahel region. In the same page, innovation and women employment in agriculture have a significant inverse relationship. Government expenditures on research and development have a significant negative relationship with women employment in agriculture in the Sahel region.

Discussion

Discussing these findings within the context of the research question and objective of this study, the average mean value of women employment in agriculture within the periods of 1990 and 2020 is 59.9%. This shows that agricultural sector accounts for 59.9% of women who are engaged in productive employment in the Sahel as against current 52% recorded in SSA, 59% in South Asia, 20% in East Asia and Pacific region, 16% in the Middle East and North Africa, 8% in Latin America and Caribbean and 3% in Europe.

It implies that the Sahel region has the highest percentage of women employment in agriculture among all the other regions of the world. However, the total greenhouse gas emission in the Sahel region has an average value of 54, 624.35Kt which is far lower than 823,787Kt emitted in SSA, 1,627,955Kt emitted in Latin America and Carribean, 2,544,021Kt emitted in the Middle East and North Africa, 3, 383, 432Kt emitted in Europe, 4, 156,424Kt emitted in South Asia, and 14, 658, 934Kt emitted in East Asia and Pacific region. This is an indication that the Sahel region is less vulnerable to climate change induced by greenhouse gas emissions comparing to other regions of the world. In the same vein, on average basis, 3.2% of the Sahel`s government budgets were spent on research and development. This is far below the 26% of the national budget of developing countries on education as recommended by the UNESCO.

In addition, the level of infrastructural development in the Sahel region as depicted by the number of individuals who have access to electricity. It evident that 26% of the Sahel`s residents have access to electricity on average basis and 5.1% of the Sahel`s residents have access to internet respectively. This is an indication of infrastructure and innovation deficit in the region.

Moreover, total greenhouse gas emission has a positive but insignificant impact on women employment in agriculture in the Sahel region. Nevertheless, change in rainfall pattern causes a significant adverse effect on women employment in agriculture. As such, a unit change in rainfall pattern brings about a reduction in women employment in agriculture by 0.12% in the Sahel region. That means rainfall pattern is not favourable to the expansion of employment of women in agriculture in the Sahel. This finding is consistent with submission of Akinseye et al[16] and Recha et al[17] in related studies. Furthermore, infrastructures have a negative but significant effect on women employment in agriculture.

Based on this finding, a unit change in infrastructures, holding all other factors constant, will reduce employment in agriculture by 0.37% in the region. In the same page, innovation and women employment in agriculture have a significant inverse relationship. Government expenditures on research and development have a significant negative relationship with women employment in agriculture in the Sahel region. Therefore, it could be submitted that deficiencies in infrastructures, innovation, research and development are significant factors reducing women employment in agriculture in the Sahel region. This finding corroborates the argument of Adeoti et al[18] Ugwu[19] and Osabohien et al.[41]

In summary, climate change variables - total greenhouse gas emission and change in rainfall pattern have a contradictory relationship with women employment in agriculture in the Sahel region. It is instructive to note that greenhouse gas emission does not have an adverse effect on women employment in agriculture in the Sahel region. The reason for this might be attributed to the less presence or inadequate concentration of industries that are powered by fossil fuels. Whereas, change in rainfall pattern has a significant adverse effect on women employment in agriculture in the Sahel region. The reason for this finding might be the aftermath effect of incessant flood and deforestation in the region, which both could stimulate local farmers, especially women to be jobless. In addition, innovation, infrastructures and government expenditures on research and development possess a significant adverse effect on women employment in agriculture in the Sahel region.

The reason for this outcome might be related to inadequate funding or unavailability of critical infrastructures such as education, electricity, internet facilities in the rural areas of the Sahel region.In the light of the above findings, it is instructive to state that if the Sahel region would experience a rise in women employment in agriculture, policy and programme that would mitigate the adverse effect of change in rainfall pattern should be embarked upon, one of such policies is the use of sustainable irrigation which has non-negative spillovers on the ecosystem. The policymakers should be proactive in policy formulation by engaging in programs that would make region to be resilient and adapted to the future adverse effects of agriculturally induced climate change. And the policymakers should embark on massive investment in critical infrastructures such as education, electricity and internet facilities especially in the rural area.

Strengths

The strength of this study lies in its high level of novelty in terms of its contribution to the body of knowledge. Another strength of this paper is its clearly stated research question, rigorous empirical analysis, and consideration of panel FMOLS. This study is limited and serves as a future direction for other researchers. The study focused on only 9 countries out of 13 countries within the Sahel region. Further studies could be carried out on other African sub regions. In addition, future studies could apply different methods of estimations.

Limitations

The interpretations of this study are based on the specific regression analysis performed and should be considered in light of any limitations or assumptions made during the analysis.

Conclusion

This study therefore concludes that climate change variables; greenhouse gas emission does not have

adverse effect on women employment in agriculture in the Sahel. Whereas, change in rainfall pattern exerts an adverse effect on women employment in agriculture in the region.

Acknowledgement

Authors' contribution

Bai Liu conceived and designed the study
Xiujian Liao collected and analysed the data
Fanyan Liu reviewed empirical studies
Qihang Chen designed the methodology
Haowei Lei wrote the introduction and edited the paper.

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