

RESEARCH TOPIC: THE INFLUENCE OF CLIMATE CHANGE, LAND USE CHANGE ON AGRICULTURAL PRODUCTIVITY AMONG OKLAHOMA RURAL FARMERS

Statement of the Problem

Today, Climate change has become a global challenge, posing a lot of challenges for humanity, society and the agricultural ecosystems as this has altered the land use pattern such as deforestation, urbanization and agricultural expansion. Therefore, it's imperative to investigate how this emerging construct affects agricultural productivity and food security so as to suggest specific strategies to mitigate its negative effects on agricultural productivity.

One of the predictor variables in the study is climate change which refers to significant changes in global temperature, precipitation, wind patterns and other measures of climate that occur over several decades or longer (University of California Davis, 2023)

Whereas the second predictor variable is land use change which is a process by which human activities transform the natural landscape, referring to how land has been used, usually emphasizing the functional role of land for economic activities (Sustainability of Bioenergy,2019).

To what extent will climate change influence agricultural productivity among rural farmers in Oklahoma?

To what extent will land use change influence agricultural productivity among rural farmers in Oklahoma?

In what manner can climate Change and land use change interact to influence agricultural productivity among Oklahoma rural farmers?

Purpose of the Study

The purpose of this quantitative study is to investigate the effects of climate change and land use change on agricultural productivity among Oklahoma rural farmers. Specifically, This study sought to investigate the following:

1. To examine if climate change has an influence on agricultural productivity among Oklahoma rural farmers
2. To examine if land use change influences agricultural productivity among Oklahoma rural farmers.

3. To show if the predictor variable (climate change and land use change) will interact to influence agricultural productivity among Oklahoma rural farmers.

Importance of the Study

This study is important for several reasons. This study will help to address the problem of rising food insecurity and reveal how climate change and land use change are implicated on agricultural productivity among Oklahoma rural farmers and to find out if there is any significant interaction between climate change and land use change on agricultural productivity.

This study will serve as a contribution to knowledge in the agricultural sector with respect to agricultural productivity and food security and it would be useful to other researchers, government agencies and policy makers in the agriculture industry.

Again, this study would proffer a workable manual on how individuals and communities respond to climate change and land use change which would in turn give a valuable insights into the effectiveness of current policies and interventions by relevant agencies.

LITERATURE IN REVIEW

This section reviewed seven relevant literature related to agricultural productivity with respect to climate change and land use change exploring keywords: **Agricultural productivity, climate change and land use change.**

The two categories are presented as follows:

Climate change and Agricultural Productivity

In a study of the historical warnings of future food insecurity with unprecedented seasonal heat (Battisti D. S., Naylor R. L (2009) examined the influenced of climate change and its impact on agricultural productivity.

According to (Battisti & Naylor, 2009), higher growing season temperatures can significantly impact agricultural productivity, farm incomes and food security.

Higher growing season temperatures can have dramatic impacts on agricultural productivity, farm incomes, and food security. They used observational data and output from 23 global climate models to show a high probability (>90%) that growing season temperatures in the tropics and subtropics by the end of the 21st century will exceed the most extreme seasonal temperatures recorded from 1900 to 2006. In temperate regions, the hottest seasons on record will represent the future norm in many locations. We used historical examples to illustrate the magnitude of damage to food systems caused by extreme seasonal heat and show that these short-run events could become long-term trends without sufficient investments in adaptation.

In another study of the potential distribution of bioenergy crops in Europe under present and future climate by Tuck G., Glendinning M. J., Smith P., House J. I., Wattenbach M.(2006).

(Tuck et al. (2006)examined agricultural productivity and climate change.

In this study, Crops suitable for temperate and Mediterranean climates were selected from four groups: oilseeds (e.g. oilseed rape, sunflower), starch crops (e.g. potatoes), cereals (e.g. barley) and solid biofuel crops (e.g. sorghum, Miscanthus). The impact of climate change under different scenarios and GCMs on the potential future distribution of these crops was determined, based on predicted future climatic conditions.

In a related study by Olesen J. E., et al. (2007) on the Uncertainties in projected impacts of climate change on European agriculture and terrestrial ecosystems based on scenarios from regional climate models, The uncertainties and sources of variation

in projected impacts of climate change on agriculture and terrestrial ecosystems depend not only on the emission scenarios and climate models used for projecting future climates, but also on the impact models used, and the local soil and climatic conditions of the managed or unmanaged ecosystems under study.

In a related study of Potential impact of climate change on selected agricultural crops in north-eastern Austria (Alexandrov et al. 2002) investigated The vulnerability and adaptation of major agricultural crops to various soils in north-eastern Austria under a changing climate and the CERES crop model for winter wheat and the CROPGRO model for soybean were validated for the agrometeorological conditions in the selected region. The simulated winter wheat and soybean yields in most cases agreed with the measured data. Several incremental and transient global circulation model (GCM) climate change scenarios were created and used in the study. In these scenarios, annual temperatures in the selected region are expected to rise between 0.9 and 4.8 °C from the 2020s to the 2080s. The results show that warming will decrease the crop-growing duration of the selected crops. For winter wheat, a gradual increase in air temperature resulted in a yield decrease. Incremental warming, especially in combination with an increase in precipitation, leads to higher soybean yield. A drier climate will reduce soybean yield, especially on soils with low water storage capacity. All transient GCM climate change scenarios for the 21st century, including the adjustment for only air temperature, precipitation and solar radiation, projected reductions of winter wheat yield. However, when the direct effect of increased levels of CO₂ concentration was assumed, all GCM climate change scenarios projected an increase in winter wheat yield in the region. The increase in simulated soybean yield for the 21st century was primarily because of the positive impact of warming and especially of the beneficial influence of the direct CO₂ effect. Changes in climate variability were found to affect winter wheat and soybean yield in various ways. Results from the adaptation assessments suggest that changes in sowing date, winter wheat and soybean cultivar selection could significantly affect crop production in the 21st century.

In another study of the socio-economic and climate change impacts on agriculture:

an integrated assessment by Fischer et al.(2005) a comprehensive assessment of the impacts of climate change on agro-ecosystems

over this century is developed, up to 2080 and at a global level, albeit with significant regional detail. To this end an integrated ecological–economic modelling framework is employed, encompassing climate scenarios, agro-ecological zoning information, socio-economic drivers, as well as world food trade dynamics. Specifically, global simulations are performed using the FAO/IIASA agro-ecological zone model, in conjunction with IIASA's global food system model, using climate variables from five different general circulation models, under four different socio-economic scenarios from the intergovernmental panel on climate change. First, impacts of different scenarios of climate change on bio-physical soil and crop growth determinants of yield are evaluated on a 5'×5' latitude/longitude global grid; second, the extent of potential agricultural land and related potential crop production is computed. The detailed bio-physical results are then fed into an economic analysis, to assess how climate impacts may interact with alternative development pathways, and key trends expected over this century for food demand and production, and trade, as well as key composite indices such as risk of hunger and malnutrition, are computed. This modelling approach connects the relevant bio-physical and socio-economic variables within a unified and coherent framework to produce a global assessment of food production and security under climate change. The results from the study suggest that critical impact asymmetries due to both climate and socio-economic structures may deepen current production and consumption gaps between developed and developing world; it is suggested that adaptation of agricultural techniques will be central to limit potential damages under climate change.

Land Use Change and Agricultural Productivity

In another related study by Audsley et al. (2006) on what can scenario modelling tell us about future European scale agricultural land-use, and what not?

Given scenarios describing future climates and socio-techno-economics, this study estimates the consequences for agricultural land use, combining models of crop growth and farm decision making to predict profitability over Europe, driven solely by soil and climate at each location. Each location is then classified by its profitability as intensive or extensive agriculture or not suitable for agriculture.

The main effects of both climate and socio-economics were in the agriculturally marginal areas of Europe. The results showed the effect of different climates is relatively small, whereas there are large variations when economic scenarios are included. Only Finland's agricultural area significantly responds to climate by increasing at the expense of forests in several scenarios. Several locations show more difference due to climate model (PCM versus HadCM3) than emission scenario, because of large differences in predicted precipitation, notably the Ardennes switching to arable in HadCM3.

Scenario modelling has identified several such regions where there is a need to be watchful, but few where all of the scenario results agree, suggesting great uncertainty in future projections. Thus, it has not been possible to predict any futures, though all results agree that in Central Europe, changes are likely to be relatively small.

In a study of the Future scenarios of European agricultural land use I. Estimating changes in crop productivity by Ewert et al., 2005) The future of agricultural land use in Europe is unknown but is likely to be influenced by the productivity of crops. Changes in crop productivity are difficult to predict but can be explored by scenarios that represent alternative economic and environmental pathways of future development. Ewert et al. 2005) developed a simple static approach to estimate future changes in the productivity of food crops in Europe (EU15 member countries, Norway and Switzerland) as part of a larger approach of land use change assessment for four scenarios of the IPCC Special Report on Emission Scenarios (SRES) representing alternative future developments of the world that may be global or regional, economic or environmental. Estimations were performed for wheat (*Triticum aestivum*) as a reference crop for the time period from 2000 until 2080 with particular emphasis on the time slices 2020, 2050 and 2080. Productivity changes were modelled depending on changes in climatic conditions, atmospheric CO₂ concentration and technology development. Regional yield statistics were related to an environmental stratification (EnS) with 84 environmental strata for Europe to estimate productivity changes depending on climate change as projected by the global climate model HadCM3. A simple empirical relationship was used to estimate crop productivity as affected by increasing CO₂ concentration simulated by the global environment model IMAGE 2.2. Technology was modelled to affect potential yield and the gap between actual and potential yield. We estimated increases in crop productivity that ranged between 25 and 163% depending on the time slice and scenario compared to the baseline year (2000). The increases were the smallest for the regional environmental scenario and the largest for the global economic scenario. Technology development was identified as the most important driver but relationships that determine technology development remain unclear and deserve further attention. Estimated productivity changes beyond 2020 were consistent with changes in the world-wide demand for food crops projected by IMAGE. However, estimated increases in productivity exceeded expected demand changes in Europe for most scenarios, which is consistent with the observed present oversupply in Europe. The developed scenarios enable exploration of future land use changes within the IPCC SRES scenario framework.

Summary of Literature Review

Seven Literatures related to the variables of interest were reviewed in this work and all the the seven literatures indinated a positive relationships between the predictors and criterion variables.

According to (Battisti & Naylor, 2009), Higher growing season temperatures can significantly impact agricultural productivity, farm incomes and food security. In this Battisti & Naylor, 2009 found that temperature (climate change) has a positive influence on agricultural productivity.

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This study estimates the consequences for agricultural land use, combining models of crop growth and farm decision making to predict profitability over the whole of Europe, driven solely by soil and climate at each location. Each location is then classified by its profitability as intensive or extensive agriculture or not suitable for agriculture.

The main effects of both climate and socio-economics were in the agriculturally marginal areas of Europe. The results showed the

effect of different climates is relatively small, whereas there are large variations when economic scenarios are included. Only Finland's agricultural area significantly responds to climate by increasing at the expense of forests in several scenarios. Several locations show more difference due to climate model (PCM versus HadCM3) than emission scenario, because of large differences in predicted precipitation, notably the Ardennes switching to arable in HadCM3. There the independent variable land use was found to have an influence on agricultural productivity.

In a related study by Olesen J. E., et al .(2007) on the Uncertainties in projected impacts of climate change on European agriculture and terrestrial ecosystems based on scenarios from regional climate models, The uncertainties and sources of variation in projected impacts of climate change on agriculture and terrestrial ecosystems depend not only on the emission scenarios and climate models used for projecting future climates, but also on the impact models used, and the local soil and climatic conditions of the managed or unmanaged ecosystems under study. they addressed these uncertainties by applying different impact models at site, regional and continental scales, and by separating the variation in simulated relative changes in ecosystem performance into the different sources of uncertainty and variation using analyses of variance.

The variation in simulated results attributed to differences between the climate models were, in all cases, smaller than the variation attributed to either emission scenarios or local conditions. The methods used for applying the climate model outputs played a larger role than the choice of the GCM or RCM. The thermal suitability for grain maize cultivation in Europe was estimated to expand by 30–50% across all SRES emissions scenarios. Strong increases in net primary productivity (NPP) (35–54%) were projected in northern European ecosystems as a result of a longer growing season and higher CO₂ concentrations. In this study, the agricultural productivity were found to be influenced by Climate change.

In another study of the potential impact of climate change on selected agricultural crops in north-eastern Austria (Alexandrov et al. 2002) investigated The vulnerability and adaptation of major agricultural crops to various soils in north-eastern Austria under a

changing climate and the CERES crop model for winter wheat and the CROPGRO model for soybean were validated for the agrometeorological conditions in the selected region. The simulated winter wheat and soybean yields in most cases agreed with the measured data. Several incremental and transient global circulation model (GCM) climate change scenarios were created and used in the study. In these scenarios, annual temperatures in the selected region are expected to rise between 0.9 and 4.8 °C from the 2020s to the 2080s. The results show that warming will decrease the crop-growing duration of the selected crops. For winter wheat, a gradual increase in air temperature resulted in a yield decrease. Incremental warming, especially in combination with an increase in precipitation, leads to higher soybean yield. A drier climate will reduce soybean yield, especially on soils with low water storage capacity.

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agro-ecosystems over this century is developed, up to 2080 and at a global level, albeit with significant regional detail. To this end an integrated ecological–economic modelling framework is employed, encompassing climate scenarios, agro-ecological zoning information, socio-economic drivers, as well as world food trade dynamics. Specifically, global simulations are performed using the FAO/IIASA agro-ecological zone model, in conjunction with IIASA's global food system model, using climate variables from five different general circulation models, under four different socio-economic scenarios from the intergovernmental panel on climate change. The results from the study suggest that critical impact asymmetries due to both climate and socio-economic structures may deepen current production and consumption gaps between developed and developing world; it is suggested that adaptation of agricultural techniques will be central to limit potential damages under climate change. The study also found that climate change and other factors have an influence on agricultural productivity.

Finally, of the seven literatures reviewed examining the relationship between Climate change and land use change on agricultural productivity, all seven variables reported a positive relationship (eg., (Battisti & Naylor, 2009, Tuck et al., 2006, Audsley et al. 2006, Olesen J. E., et al .2007, Alexandrov et al. 2002, Ewert et al., 2005, Fischer et al., 2005).

Agricultural productivity is central to food security, poverty reduction and ensuring flourishing economy against hunger. Therefore, studying agricultural productivity will help individuals and society to have food security, end hunger, food deserts and poverty.

From the foregone, it is evident that there is a scarcity of research on the influence of climate change and land use change on agricultural productivity among Oklahoma rural farmers.

METHODOLOGY

Design

A cross-sectional survey method utilizing a 2×2 factorial design can be employed in this study. This is there is need to compare two groups of independent variables (climate change and land use

change) before investigating their main and interaction effect on agricultural productivity.

Approach

200 participants will be recruited from household rural farmers of Texas County, Cimarron County Hughes County, Leflore and Delaware County after identifying them through relevant organizations, a rapport will be established with them and their confidentiality assured before the survey instrument will be administered after getting their informed consent.

Instrument

In this study, batteries of questionnaire will be used, divided into three (3) sections, A, B, and C for the collection of data.

Section A will contain demographic information such as age, gender, religion, marital status and educational level. Section B will contain land use change structured survey questionnaire to be developed before the study as the existing instrument are lacking required information, Section C contains Climate Indicators for Agriculture developed by the USDA and University of Colorado (2020), Section C contain

APSIM (Agricultural Production Systems sIMulator) developed by McCown, R.L., G.L. Hammer, J.N.G. Hargreaves, D.P. Holzworth, and D.M. Freebairn. (1996).

Sampling

A purposive sampling method will be employed in this study to gather data.

Statistical Analysis

The 2-Way Analysis of Variance (ANOVA) will be adopted in this study, this is because ANOVA involves a joint study of two independent variable and in this study, we have climate change and land use change as two independent variables. The study data can be coded using descriptive statistic.(mean, standard deviation and frequencies).

Findings

Data Analysis and Interpretations

Discussion

This research was conducted to investigate the influence of climate change and land use change on agricultural productivity among Oklahoma rural farmers.

The first result indicated that climate change exerted significant influence on agricultural.

Implications and Significance of Findings

Findings of this study shows obvious implications on how climate change and land use change play a significant role on agricultural productivity among Oklahoma rural farmers.

Comparison with Existing Literature

The findings in this research is agreement with the findings of Battisti D. S., Naylor R. L (2009) which examined the influenced of climate change and its impact on agricultural productivity and found a significant influence. Another study that supported the findings in this study was that earlier undertaken by Audsley et al. (2006) on what can scenario modelling tell us about future European scale agricultural land-use, and what not? this study estimates the consequences for agricultural land use, this study confirmed main effects of both climate and socioeconomic on agricultural marginal areas of Europe.

Limitations

The data collection will pose a limitation to this study as the number of farmers proposed are smaller. Therefore the findings from this study can not be reliable and generalized to a larger population.

Another limitation to this study is the fact the study will be based on self report. Hence, random bias is inevitable which would invariably affect the quality of data.

The cross-sectional measurement will not also be able to test causal relationship effectively.

Conclusion

This study was conducted to assess the influence of climate change and land use on agricultural productivity among Oklahoma rural farmers in Oklahoma. Two hundred (200) household farmers were purposively recruited from a population of rural farmers from

four counties (Texas, Cimarron, Hughes, Leflore and Delaware) In Oklahoma. In order to measure the variables of interest, a battery of questionnaires were developed and validated by me with high internal consistency in line with existing scales.

The study was a cross-sectional survey utilizing a 2×2 factorial designs and a 2×2 analysis of variance for unequal sample size was adopted for statistical data analysis.

Hypotheses were tested, the first hypothesis which stated that climate change will affect agricultural productivity was accepted. The second hypothesis which stated that land use change will affect agricultural productivity was also confirmed. In addition, the third hypothesis which stated there will be a significant interaction between climate change and land use change on agricultural productivity among Oklahoma rural farmers was also confirmed.

Summary of Key Findings

Climate change influence agricultural productivity

Land use change affect agricultural productivity

Both climate change and land use change interact to affect agricultural productivity among Oklahoma rural farmers.

Contributions to Research

This research will help as contribution to the body of knowledge in the area of Agriculture and food security, It would be useful to researchers that want more information in related field.

Contributions to Practice

The outcome of the study when documented and implemented government, agencies and industries to know how to mitigate the impact of climate change and land use change on agricultural productivity to reduce food insecurity and hunger due.

This study will also help to widen the horizon of our understanding with respect to agricultural productivity while policies can be formulated by United States Department of Agriculture and other agencies of government through this study.

RECOMMENDATIONS FOR FURTHER STUDY

Future research should undertake to recruit more participants, other data collection techniques such as observational interview on the farms should be adopted for future studies. Also, a longitudinal survey method could provide validation of specific relationship between climate change and land use change on agricultural productivity.

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