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Climate Change Impact on Agriculture

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ABSTRACT:

Climate change is one of the biggest challenges to the world in present times. It is defined as significant changes in the average values of meteorological elements, such as precipitation and temperature, for which averages have been computed over a long period . The past few decades indicate that significant changes in climate at a global level were the result of enhanced human activities that altered the composition of the global atmosphere. The concentration of greenhouses gases such as methane , carbon dioxide , and nitrous oxide have been increased This research were undertaken on the determinants of farmer's adaptation to climate change in case of jimma rare woreda, Horro guduru wollega, Oromia, Ethiopia, This study analyze factors affecting farm level adaptation methods adopted by farm households in the study area. Climate change is expected to have a significant negative impact on agricultural productivity and food security in Sub-Saharan Africa. In Ethiopia, approximately 85%ofthe total agricultural output relies on rain-fed smallholder farming systems, which are particularly sensitive to climate change. Results of the logistic regression model showed that education, household size, annual household income, access to information, credit and membership of farmer-based organization are the most important factors that influence farmers' adaptation to climate change. The main constraints on adaptation include unpredictability of weather, high farm input cost, lack of access to timely weather information and water resources. The policy implication of this study is that governments should mainstream barriers to, and choice factors of, adaptation practices to climate change related projects and programs.

INTRODUCTION:

Objectives of the Study

General Objective

The general objective is to study major determinants of Climate change adaptation of rural households in Jimma rare woreda, Horro guduru wollega Zone.

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Specific Objective of the Study

The specific objectives of the study are:

1. To assess how they adapt their farming in response to perceived changes in climate?
2. To analyze the perception of smallholder crop-livestock farmers on climate change
3. To assess the major determinants to farmers' choices of climate change adaptation in the study area

Sources and Types of Data

Both primary and secondary data were used for this study. The primary data needed for the study was obtained from randomly selected Woreda's. The types of data which was generated through the various data collection instruments from these sources are quantitative and qualitative data. Secondary sources of data are government policy documents and reports, poverty research reports from the research journals, books and magazine, policy documents and working and discussion papers of various institutions and from the zonal and woreda administration offices, and woreda microfinance.

Then after, a structured household questionnaire was administered to 326 sample households of participant and non-participant in the selected kebeles. In doing so, training was given to enumerators about the questionnaire and follow up was made to ensure that the process of data collection was smooth. The survey questionnaire was pre-tested before full scale data collection in order to clarify issues in the questionnaire.

Method of Data Analysis

Both descriptive and statistics and econometric models were used for analysis. Econometric models used to analyze the empirical data collected from the sample population for this study. Descriptive statistics such as mean, standard deviation, percentages, pie charts, graphs and cross tabulations was used in analyzing the data.

Econometric Analysis

Data analysis followed upon completion of data coding and organizing. The STATA 14 version is the statistical software which was used for analyzing the data.

MODEL SPECIFICATION:

A Stata will be willbe used to analyze the data. Percentages, frequencies and means were used to represent farmers' perceived long-term changes in temperature and rainfall and barriers to the use of adaptation practices by farmers. A weighted average index (WAI) analysis has previously been applied to assess farmer-perceived important adaptation strategies in

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Bangladesh and barriers of adap-tation to climate change in Nepal (Uddin et al., 2014; Devkota et al., 2014). In this study, the WAI was used to rank the effects of climate change on crop performance, environment, households' socio-economy and psychological threats. Similarly, the WAI was applied to rank farmer-perceived rate of occurrence of weather extremes (i.e. dry spell, drought and flood). Respon- dents were asked to score the weather extremes based on a 0-2 Likert scale (i.e in terms of 'high', 'moderate' and 'low'). The WAI was then estimated using the for- mula below.

$$WAI=\frac{F2W2 + F1W1 + F0W0}{F2 + F1 + F0}$$

$$WAI=\frac{\sum FiWi}{\sum Fi}$$

Where: F = frequency; W = weight of each scale; i = weight (2 = high occurrence; 1 = moderate occurrence and 0 = low occurrence)

The dependent variable in this study is whether a household has 'adapted' or 'not adapted' any adaptation practices to climate change. Based on discussions with MOFA staff, review of the literature and field observations, the adaptation practices identified included improved crop varieties (drought-tolerant and early maturing crops), crop diversification (mixed cropping and crop rotation), farm diversification (mulching, composting, ridging and terracing), change in planting date, income generating activities, irrigation practice (dry season gar-dening) and agro forestry. Adaptation is the dependent dummy variable.

Definition of Variables

Dependent variable

Climate change adaptation is dependent variable for the logit analysis which has dichotomous nature representing rural household farmer's adaptation decision to climate change. This is to distinguish or discriminate between those adaptors or non-adaptors of climate change in the study area. It takes value of "1" for adaptors and "0" for non-adaptors to climate change.

Independent variables

The following are the independent variables that will considered for the analysis of adaptation determinants:

Age of the household head: Age refers to the length of time one has been alive. It is a continuous variable, defined as the farm household heads age at the time of interview measured in years.

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Gender of household head: This is a dummy variable that assumes a value of "1" if the head of the household is male and "0" otherwise. With this background including the existing gender differences; male headed households have mobility, participate in different meetings and have more exposure to information; therefore it is hypothesized that male headed households have more access to use formal credit.

Marital status: This is dummy variablewhich takes value of 1 if household is married and 0 otherwise.

Educational status of a household head: this is continues variable which takes time spend in school in year. Farmers who can read and write are expected to have more exposure to the external environment and accumulate knowledge. They have the ability to analyze costs and benefits. The more educated the household head the more credit he will use for consumption purposes.

Non-farm participation: Non-farm activities are the activities which are not related to farming or agricultural activities. Non-farm employment is any form of other than farm in the type wages. In rural area, majority of households are involved in farm activities but many of them get their income from non-farm activities**.**

Family size: Refers to the total number of family in the household.

Cultivated land (farm) size: is the farm size in hectares measured by the total land area under crop production.

Extension Contact: It refers the number of times the household received extension service within a year and will measure in number of frequency which the household receive the service in year. The main objective of the extension service was to increase the crop production by using modern agricultural technologies like chemical fertilizer, irrigation etc and had more participated in agriculture intensification activities than the counterparts as a result farmers who have a frequent contact with extension agents are expected to have more information that will influence farm household's demand for credit from the formal sources (Ambachew&Ermiyas, 2016; Titay, 2013). On the other hand, the propensity of households to participate in farm activities is positively influenced by their extent of contact with that since they are better in farm income relatively and it leads them to participate in farm activities (Yishak, 2017). Therefore, it was hypothesized that this variable positively influences farmer's access to use formal credit.

Distance from Market: It refers to the proximity or farness of the household's residence from the "nearest" market place and will measure by walking hour which the household waste to arrive the nearest market. In other researches like Bassie (2014) and Ayantoye (2017) it measured by km, but since this study area is rural it is difficult to get the real distance in km and the estimated hour which will get by asking the household is better relatively. Access to market and other public infrastructure create opportunities of more

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income by providing in diversifying livelihood strategies through non and off- farm employment, easy access to input and transport facilities; household nearer to market center have better chance to microfinance participation (Yishak, 2017).

Attitudes towards risk: The other factor, which influences the household's to adaptation climate change, is their attitude towards risk.

SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS:

Results of the study showed that 82 % of respondents perceived an increase while 6 % perceived a decrease in temperature trend over the past 10 years (Table 2). Also, 9 % of farmers perceived no change in temperature while 3 % could not indicate if there was a long-term temperature change or not. As regards rainfall, an overwhelming majority of farmers (87 %) perceived a decrease in the precipitation trend over the past 10 years (Table 2), whereas 5 % of respondents perceived an increase and 6 % perceived no change in precipitation. The results also showed that 2 % of farmers did not know if there was a change in precipitation or not. that farmers attributed the perceived trend of increasing temperature to decreasing precipitation. Farmers also attributed the perceived trend of decreasing rainfall to factors such as deforestation, bushfires and ancestral curses. The results are in line with findings of previous studies reported in Southern Ghana, Nigeria, Senegal and Southern Africa which showed that the majority of farmers have perceived long-term changes in climate variables (Fosuh-Mensah et al., 2012; Apata, 2011).

Perceived occurrence of weather extremes

The results of farmers' perceptions regarding occurrences of weather extremes are presented in Table 3. Farmers generally perceive weather extremes in terms of dry spells, drought and floods. The rate of occurrence of dry spells was ranked highest by respondents (WAI = 1.88). Drought and flood occurrences were ranked 2nd and 3rd respectively (WAI = 0.53 and WAI = 0.34). Same results were obtained during the focus group discussions. Farmers revealed that unlike floods, dry spells occur every year during the crop production season. The respondents claimed that the frequency and severity of floods is decreasing due to decreasing rainfall trend. On the other hand, farmers indicated that the frequency and severity of drought is beginning to increase in recent times. Similar findings were reported in the Wa West District of Ghana where farmers perceived higher frequency and severity of drought than floods (Kusakari et al., 2014). In Uganda however, farmers were reported to have perceived a higher rate of occurrence of flood than drought (Okonya et al., 2013).

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Table 4.1 − Farmers' perception of long-term changes in climate variables

Variables	Frequency % of Respondent
Temperature	
Don't know	19
Decreasing	16
Stable	10
Increasing	156
Precipitation	13
Don't know	22
Increasing	34
Stable	87
Decreasing	145

Farmer-perceived effects of climatic change on agriculture

Generally, rural farmers perceive effects of climate change on agriculture in terms of poor crop performance, environmental degradation, socio-economic challenges and psychological threats. With a WAI value of 2, poor crop performance was perceived to be the highest effect of climate change on rural agriculture (Table 4). Socio-economic threats and environmental degradation were ranked 2nd and 3rd with WAI values of 1.45 and 1.39, respectively. The respondents also perceived and ranked psychological threats as effects of climate change (WAI = 1.30).

Results of the focus group discussions showed that dry spells and droughts generally cause wilting and drying up of crop plants. These culminate into poor crop development and low yields. The farmers claimed that socio-economic effects of climatic change included out-migration, indebtedness, food shortage and low household incomes. The climatic change related psychological effects identified by farmers included stress, depression and suicides. This is likely the case because farmers' inability to pay back farm resources borrowed from colleague farmers and relatives in the event of a climate-related crop failure can cause psychological trauma. Low incomes and food shortages can also lead to depression, sicknesses and deaths in farm households. The revelation in this study that farmers link psychological threats to climate change is intriguing since it appears no studies as yet have reported similar findings.

Farmers' adaptation practices and reasons for adoption

About 67 % of farmers who perceived climate change have used adaptation practices. The results of the adaptation measures being used by farmers are shown in Table 5. A slim

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majority of respondents (51 %) use crop diversification strategies in response to climatic variability. Changing the planting date was chosen by 22 % while improving crop varieties were chosen by 12 %. Farmers also use farm diversification measures (6 %), income generating activities (6 %) and irrigation (2 %) to mitigate the effects of climate change on their farming activities. About 1 % of the respondents also undertake agroforestry.

As regards reasons for adaptation, an overwhelming majority (95 %) of respondents use adaptation measures to cope with dry spell effects on crop plants (Table 6). Also, 94 % and 75 % of farm households adapted to cope with drought effects and improve crop production, respectively. The results also showed that adaptation practices were adopted by 74 % of respondents to improve soil fertility and 34 % to cope with the effects of floods. Results of the FGDs showed that farmers use drought-tolerant and early maturing varieties and change of planting date to adapt to dry spells, droughts and floods. Farmers also use crop rotation and mixed cropping strategies to reduce effects of dry spell on crop plants. Some of the farmers claimed that they used composting and mulching to conserve soil moisture and improve soil fertility so as to increase their crop production. The FGDs also revealed that farmers adopted terracing and ridging methods to reduce the effects of floods.

Table 4 .2− Farmer-perceived effects of climate change on agriculture

Effect variable	Ranking of extremes High moderate low				WAI	Rank
Poor crop performance	100	0	0		2.00	1
Socio-economic challenges	54	37	9		1.45	2
Environmental degradation	45	49	6		1.39	3
Psychological threats	50	30	12		1.30	4

Table 4.3 − Adaptation practices being used by farmers

Adaptation practices	% Of respondents	Actual adaptation measures
Crop diversification	51	Crop rotation and mixed cropping
Change planting date	22	
Improved crop varieties	12	Drought-tolerant and early maturing varieties
Farm diversification	6	Reduce farm size and composting/ mulching
Income generating activities	6	Petty trading and ‘pito’ brewing
Irrigation	2	Dry season gardening
Agroforestry	1	Tree planting

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Table 4.4. − Reasons for adaptation to climatic change

Reasons for adaptation	% of respondents	Mean	Std. Deviation
Cope with flood	34	0.59	0.494
Improve soil fertility	74	0.84	0.367
Improve crop production	75	0.64	0.483
Cope with drought	94	0.99	0.103
Cope with dry spell	95	0.96	0.202

Determinants of farmers' choices of adaptation strategies to climate change

Of the demographic, socio-economic and institutional variables tested, education status and knowledge on CCASs were found to have influence on the choice of farmers' decision to take all livestock-based adaptation options studied. Access to veterinary service and extension was found to be a determinant factor on farmers' decision to implement animal destocking, shifting and diversification of livestock spp., animal feed development related strategies and animal health care and management. In addition, to education status and knowledge of farmer on CCASs, livelihood diversification strategy was influenced by the household annual income and presence of non-farming income. Unlike other strategies, animal destocking was influenced by access to market (Table 4.1).

The marginal effects of the logit model on determinant factors are described in Table 4.2.Considering the decision-makers characteristics, farmers with better education levels were7.5%, 4.9%, 2.8%, 2.1% and 1.7% more likely to take animal health care and management, livelihood diversification, animal destocking, shifting and diversification of livestock spp. and animal feed development strategies, respectively, compared to illiterate farmers. Female headed households are 7.3% more likely to take the livelihood diversification adaptation strategy compared to male headed households. Besides, the likelihood of taking livelihood diversification, animal health care and management, animal feed development, animal destocking and shifting and diversification of livestock spp. options increased by 16.4%,15.7%, 5.6%, 3.0% and 2.3%, respectively, for farmers who are aware of the different CCASs.

The household level factors and household size had a positive effect on animal feed development related adaptation strategy where for every unit increase in household size the likelihood of taking this adaption measure has increased by 2%. Besides, for every unit increase in TLU of the household, the likelihood of taking shifting and diversification of livestock species, and animal feed development related strategies have increased by 4.8%and

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3.3%, respectively. Household income has positive effect on farmers' decision to take animal health care and management and livelihood diversification strategies.

Table 4.5.Parameter estimates of logit model for climate change adaptation decision

Explanatory variables	Animal destocking	Shifting and diversification of livestock spp.	Animal feed development	Animal Health and Mgt	Livelihood diversification
Sex	1.191 (0.542))	_0.133 (0.937)	1.470 (0.447)	0.389 (0.818)	_0.661 (0.694)
Age	_0.182 (0.127)	_0.157 (0.180)	_0.183 (0.122)	_0.152(0.192)	_0.139 (0.236)
Education	4.172** (0.033)	3.773** (0.050)	3.891**(0.045)	3.298* (0.086)	4.252** (0.032)
Household size	0.206 (0.642)	0.179 (0.673)	0.363 (0.402)	0.080 (0.850)	0.032 (0.940)
Household annual income	0.003 (0.367)	0.003 (0.313)	0.0053 (0.13)	0.005 (0.147)	0.006* (0.094)
Non-farm income	_0.157 (0.933)	_1.069 (0.557)	_0.945 (0.607)	_1.560 (0.393)	3.525* (0.055)
Livestock size (TLU)	0.580 (0.306)	0.594 (0.274)	00.724 (0.190)	0.228 (0.674)	_0.439 (0.439)
Land ownership	15.286 (0.982)	0.952 (0.531)	1.099 (0.490)	0.223 (0.875)	-0.742 (0.621)
Market access	4.186** (0.020)	1.532 (0.353)	2.070 (0.216)	1.690 (0.305)	1.212 (0.469)
Access to vet service and extension	4.017** (0.015)	3.999** (0.010)	3.121**(0.046)	5.631*** (0.001)	1.925 (0.219)
Knowledge on CCA	10.211***(0.001)	9.795***(0.001)	9.135***(0.002)	9.348*** (0.001)	11.654*** (0.000)
Constant	_24.271 (0.971)	_6.460 (0.221)	_8.280 (0.128)	_6.974 (0.185)	_6.819 (0.208)

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Table 4.6. Marginal effects of independent variables on climate change adaptation strategies

Explanatory variables	Animal destocking	Shifting and diversification of livestock spp.	Animal feed development	Animal Health and Mgt	Livelihood diversification
Sex	0.050 (0.444)	_0.097 (0.149)	0.104 (0.242)	0.017 (0.814)	_0.073* (0.088)
Age	_0.001 (0.426)	0.001 (0.964)	_0.002 (0.284)	0.001 (0.758)	0.001 (0.623)
Education	0.028* (0.033)	0.021* (0.066)	0.017** (0.048)	00.075 (0.165)	0.049** (0.020)
Household size	0.206 (0.642)	0.179 (0.673)	0.363 (0.402)	0.080 (0.850)	0.032 (0.940)
Household annual income	_0.000 (0.158)	_0.0001* (0.070)	_0.0001 (0.308)	0.002** (0.030)	0.0001** (0.033)
Non-farm income	0.024 (0.326)	0_0.092 (0.021)	_0.039 (0.208)	_0.192 (0.000)	0.300*** (0.000)
Livestock size (TLU)	0.012 (0.259)	0.048** (0.015)	0.033** (0.027	0.031* (0.106	0.059*** (0.000)
Land ownership	0.884 (0.982)	_0.182(0.988)	_0.171 (0.987)	_0.316 (0.978)	_0.209 (0.969)
Market access	0.151*** (0.002)	_0.066 (0.201)	0.005 (0.908)	0_0.026 (0.608)	_0.047 (0.160)
Access to vet service and extension	0.140*** (0.009)	0.036** (0.063)	0.093** (0.021)	0.315*** (0.003	0.150*** (0.000)
Knowledge on CCA	0.030*** (0.064)	0.023 (0.038)	0.056** (0.011)	0.157 (0.059)	0.164* (0.053)
Notes: ***, ** and * significant at 1%, 5% and 10% probability level, respectively					

Farmers who have non-farm income sources are 10% more likely to implement livelihood diversification strategy. The likelihood of taking animal health care and management and shifting and diversification of livestock species strategies had reduced by 19.2% and 9.2%, respectively, for farmers who have non-farm income.

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Access to veterinary services and market are statistically significant determinants where farmers who have better access to veterinary service facilities such as clinics and extension service are 31.5%, 14.0%, 9.3% and 3.6% more likely to take animal health care andmanagement, animal destocking, animal feed development and shifting and diversification of livestock spp. strategies, respectively. However, access to veterinary service and extension has anegative effect on farmers' choice of taking livelihood diversification strategy, where there was a15% reduction. The likelihood of implementing animal destocking adaptation measure hasincreased by 15.1%for farmers who have a better access to market.

SIGNIFICANCE OF THE STUDY:

The research will serve policy makers, program managers, donor field staff and NGO personnel, researchers and practitioners of Climate to acquire the understanding about the process of intervention, level of the contribution of farmers to reducing climate problem and take other necessary supportive measures to minimize climate change. In addition, the research may serve as an eye-opener and a pointer towards further study in the area, as it is among the first of its type in Jimma rare Woreda.

SCOPE AND LIMITATION OF THE STUDY:

The study will be conducted in Jimma rareof Horro guduru Wollega zone, Oromia Regional State.This study will emphasized mostly on adaptation of climate change and analyses at the level of households by taking 'snap-shot' at a particular period of time based on cross sectional design, collects data at one time, and hence, one can generalize the findings from such one-shot studies to the population only at the time of the survey.

CONCLUSION:

- In light of the above, this study concludes that governments and development partners should mainstream the determining factors of adaptation and barriers to adaptation into climate change related policies, projects and programs.
- Accessibility to timely weather information and formation of famer-based organizations (FBOs) should be prioritized to help farmers improve their information sharing and decision-making processes. There is also the need for construction of dams and dug-outs so that farmers can undertake dry season gardening and irrigation farming.
- Awareness creation trainings, provision of appropriate herd management and marketing strategies, institutional, political and economic support systems should be taken into account to ensure the sustainability of climate change adaptation by local communities and enhance their adaptive capacity.

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- The federal and local governments in should design policy frameworks to enhance the adaptive capacity of mixed crop-livestock farming communities and similarly guide other stakeholders working to improve the livelihoods of crop-livestock farmers
- The Ethiopia Meteorological Agency should be adequately trained and resourced to collect and disseminate accurate and timely weather information. Additionally, government should ensure that flexible terms of agricultural credits are made accessible to farmers so that they can meet the financial demands of adaptation.
- Furthermore, this study revealed that the rate of occurrence of dry spells and drought is higher than flood. Government should, therefore, boost the capacity of research scientists and agricultural staff to develop and promote appropriate and effective technologies (e.g. drought-tolerant and early maturing crop varieties) to help farmers adapt to these extreme weather events.

REFERENCES:

1. World Meteorological Organization. *International Meteorological Vocabulary*, 2nd ed.; WMO: Geneva, Switzerland, 1992. [**Google Scholar**]
2. IPCC. Climate change 2007: Impacts, adaptation and vulnerability. In *Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*; Cambridge University Press: Cambridge, UK, 2007. [**Google Scholar**]
3. IPCC. *Climate Change 2014: Synthesis Report*; Pachauri, R.K., Meyer, L.A., Eds.; Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change; IPCC: Geneva, Switzerland, 2014; 151p. [**Google Scholar**]
4. Sathaye, J.; Shukla, P.R.; Ravindranath, N.H. Climate change, sustainable development and India: Global and national concerns. *Curr. Sci.* **2006**, *90*, 314–325. [**Google Scholar**]
5. Abeydeera, L.H.U.W.; Mesthrige, J.W.; Samarasinghalage, T.I. Global research on carbon emissions: A scientometric review. *Sustainability* **2019**, *11*, 3972. [**Google Scholar**] [**CrossRef**][**Green Version**]
6. NASA Earth Observatory. Goddard Space Flight Centre United States. Available online: **www.earthobservatory.nasa.gov** (accessed on 15 May 2020).
7. Arora, M.; Goel, N.K.; Singh, P. Evaluation of temperature trends over India/ Evaluation de tendances de temperature en Inde. *Hydrol. Sci. J.* **2005**, *50*, 81–93. [**Google Scholar**] [**CrossRef**]
8. NOAA. Earth System Research Laboratory (NOAA). 2020. Available online: **www.esrl.noaa.gov** (accessed on 15 December 2020).

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group –I) Journal Volume 11, Issue 11, 2022

9. CDIAC. Carbon Dioxide Information Analysis Center. 2020. Available online: **www.cdiac.ess-dive.lbl.gov** (accessed on 13 November 2020).
10. Tol, R.S.J. The economic impact of climate change in the 20th and 21st centuries. *Clim. Chang.* **2013**, *117*, 795–808. [**Google Scholar**] [**CrossRef**][**Green Version**]
11. Our World in Data. Available online: **www.ourworldindata.org** (accessed on 4 December 2020).
12. Richie, H.; Roser, M. Our World in Data. CO2 and Greenhouse Emissions. 2017. Available online: **https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions** (accessed on 12 November 2020).
13. Wei, T.; Yang, S.; Moore, J.C.; Shi, P.; Cui, X.; Duan, Q.; Xu, B.; Dai, Y.; Yuan, W.; Wei, X.; et al. Developed and developing world responsibilities for historical climate change and CO_2 mitigation. *Proc. Natl. Acad. Sci. USA* **2012**, *109*, 12911–12915. [**Google Scholar**] [**CrossRef**][**Green Version**]
14. Hare, B.; Meinshausen, M. How much warming are we committed to and how much can be avoided? *Clim. Chang.* **2006**, *75*, 111–149. [**Google Scholar**] [**CrossRef**]
15. NCDC. National Climatic Data Center-National Center for Environmental Information (NOAA). 2020. Available online: **www.ncdc.noaa.gov** (accessed on 11 December 2020).
16. Bokhari, S.A.A.; Rasul, G.; Ruane, A.C.; Hoogenboom, G.; Ahmad, A. The past and future changes in climate of the rice-wheat cropping zone in Punjab, Pakistan. *Pak. J. Meteorol.* **2017**, *13*, 9–23. [**Google Scholar**]
17. Kaur, N.; Kaur, P. Projected climate change under different scenarios in central region of Punjab, India. *J. Agrometeorol.* **2016**, *18*, 88–92. [**Google Scholar**]
18. Chen, H.; Sun, J. Projected changes in climate extremes in China in a 1.5C warmer world. *Int. J. Climatol.* **2018**, *38*, 3607–3617. [**Google Scholar**] [**CrossRef**]
19. Rajbhandari, R.; Shrestha, A.B.; Kulkarni, A.; Patwardhan, S.K.; Bajracharya, S.R. Projected changes in climate over the Indus river basin using a high resolution regional climate model (PRECIS). *Clim. Dyn.* **2015**, *44*, 339–357. [**Google Scholar**] [**CrossRef**][**Green Version**]
20. Ning, L.; Riddle, E.E.; Bradley, R.S. Projected changes in climate extremes over the Northeastern United States. *J. Climate* **2015**, *28*, 3289–3310. [**Google Scholar**] [**CrossRef**][**Green Version**]
21. Zhang, Y.G.; Nearing, M.A.; Zhang, X.C.; Xie, Y.; Wei, H. Projected rainfall erosivity changes under climate change from multimodel and multiscenario projections in Northeast China. *J. Hydrol.* **2010**, *384*, 97–106. [**Google Scholar**] [**CrossRef**]

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group –I) Journal Volume 11, Issue 11, 2022

22. Zaveri, E.; Russ, J.; Damania, R. Rainfall anomalies are a significant driver of cropland expansion. *Proc. Natl. Acad. Sci. USA* **2020**, *117*, 10225–10233. [**Google Scholar**] [**CrossRef**]
23. Betts, R.A.; Alfieri, L.; Bradshaw, C.; Caeser, J.; Feyen, L.; Friedlingstein, P.; Gohar, L.; Koutroulis, A.; Lewis, K.; Morfopoulos, C.; et al. Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5 °C and 2 °C global warming with a higher-resolution global climate model. *Phil. Trans. R. Soc. A* **2018**, *376*, 20160452. [**Google Scholar**] [**CrossRef**] [**PubMed**]
24. World Population Review. Walnut, United States. Available online: **www.worldpopulationreview.com** (accessed on 12 May 2020).
25. Alexandratos, N.; Bruinsma, J. *World Agriculture: Towards 2030/2050*; ESA Working Paper No. 12–03; FAO: Rome, Italy, 2012. [**Google Scholar**]
26. Lobell, D.B.; Schlenker, W.; Costa-Roberts, J. Climate trends and global crop production since 1980. *Science* **2011**, *333*, 616–620. [**Google Scholar**] [**CrossRef**][**Green Version**]
27. Malhi, G.S.; Kaur, M.; Kaushik, P.; Alyemeni, M.N.; Alsahli, A.; Ahmad, P. Arbuscular mycorrhiza in combating abiotic stresses in vegetables: An eco-friendly approach. *Saudi J. Biol. Sci.* **2020**. [**Google Scholar**] [**CrossRef**]
28. Baul, T.K.; McDonald, M. Integration of Indigenous knowledge in addressing climate change. *Indian J. Tradit. Knowl.* **2015**, *1*, 20–27. [**Google Scholar**]
29. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G. The prisma group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Int. J. Surg.* **2010**, *8*, 336–341. [**Google Scholar**]
30. Fargnoli, M.; Lombardi, M. Safety vision of Agricultural tractors: An engineering perspective based on recent studies (2009–2019). *Safety* **2020**, *6*, 1. [**Google Scholar**] [**CrossRef**][**Green Version**]
31. Stern, D.I.; Kaufmann, R.K. Anthropogenic and natural causes of climate change. *Clim. Chang.* **2014**, *122*, 257–269. [**Google Scholar**] [**CrossRef**]
32. Montzka, S.A.; Dlugokencky, E.J.; Butler, J.H. Non-CO_2 greenhouse gases and climate change. *Nature* **2011**, *476*, 43–50. [**Google Scholar**] [**CrossRef**] [**PubMed**]
33. Groenigen, K.J.V.; Osenberg, C.W.; Hungate, B.A. Increased soil emissions of potent greenhouse gases under increased atmospheric CO_2. *Nature* **2011**, *475*, 214–216. [**Google Scholar**] [**CrossRef**] [**PubMed**]
34. Popp, A.; Lotze-Campen, H.; Bodirsky, B. Food consumption, diet shifts and associated non-CO_2 greenhouse gases from agricultural production. *Glob. Environ. Chang.* **2010**, *20*, 451–462. [**Google Scholar**] [**CrossRef**]

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group –I) Journal Volume 11, Issue 11, 2022

35. O'Mara, F.P. The significance of livestock as a contributor to global greenhouse gas emissions today and in the near future. *Anim. Feed Sci. Technol.* **2011**, *166–167*, 7–15. [**Google Scholar**] [**CrossRef**][**Green Version**]

36. Lesschen, J.P.; Berg, M.V.D.; Westhoek, H.J.; Oenema, O. Greenhouse gas emission profiles of European livestock sectors. *Anim. Feed Sci. Technol.* **2011**, *166–167*, 16–28. [**Google Scholar**] [**CrossRef**]

37. Kahrl, F.; Li, Y.; Su, Y.; Tennigkeit, T.; Wilkes, A.; Xu, J. Greenhouse gas emissions from nitrogen fertilizer use in China. *Environ. Sci. Policy* **2010**, *13*, 688–694. [**Google Scholar**] [**CrossRef**]

38. Soltani, A.; Rajabi, M.H.; Zeinali, E.; Soltani, E. Energy inputs and greenhouse gases emissions in wheat production in Gorgan, Iran. *Energy* **2013**, *50*, 54–61. [**Google Scholar**] [**CrossRef**]

39. Mendelsohn, R. The impact of climate change on agriculture in developing countries. *J. Nat. Res. Policy Res.* **2009**, *1*, 5–19. [**Google Scholar**] [**CrossRef**][**Green Version**]

40. Adams, R.M.; Hurd, B.H.; Lenhart, S.; Leary, N. Effects of global climate change on agriculture: An interpretative review. *Clim. Res.* **1998**, *11*, 19–30. [**Google Scholar**] [**CrossRef**][**Green Version**]

41. Karimi, V.; Karimi, E.; Keshavarz, M. Climate change and agriculture: Impacts and adaptive responses in Iran. *J. Integr. Agric.* **2018**, *17*, 1–15. [**Google Scholar**] [**CrossRef**][**Green Version**]

42. Molua, E.L.; Lambi, C.M. *The Economic Impact of Climate Change on Agriculture in*

43. Gregorio, G.B.; Islam, M.R.; Vergara, G.V.; Thirumeni, S. Recent advances in rice science to design salinity and other abiotic stress tolerant rice varieties. *SABRAO J. Breed. Genet.* **2013**, *45*, 31–41. [**Google Scholar**]

44. Lipper, L.; Thornton, P.; Campbell, B.M.; Baedeker, T.; Brainmoh, A.; Bwalya, M.; Caron, P.; Cattaneo, A.; Garrity, D.; Henry, K.; et al. Climate-smart agriculture for food security. *Nat. Clim. Chang.* **2014**, *4*, 1068–1072. [**Google Scholar**] [**CrossRef**]

45. Zougmore, R.; Jalloh, A.; Tioro, A. Climate-smart soil water and nutrient management options in semiarid West Africa: A review of evidence and analysis of stone bunds and *zai* techniques. *Agric. Food Sec.* **2014**, *3*, 1–8. [**Google Scholar**] [**CrossRef**][**Green Version**]

46. Imran, M.A.; Ali, A.; Ashfaq, M.; Hassan, S.; Culas, R.; Ma, C. Impact of climate smart agriculture (CSA) practices on cotton production and livelihood of farmers in Punjab, Pakistan. *Sustainability* **2018**, *10*, 2101. [**Google Scholar**] [**CrossRef**][**Green Version**]

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group –I) Journal Volume 11, Issue 11, 2022

47. Taneja, G.; Pal, B.D.; Joshi, P.K.; Aggarwal, P.K.; Tyagi, N.K. Farmers' preferences for climate-smart agriculture-an assessment in the Indo-Gangetic plain. In *Climate Smart Agriculture in South Asia*; Pal, B., Kishore, A., Joshi, P., Tyagi, N., Eds.; Springer: Singapore, 2019. [**Google Scholar**] [**CrossRef**][**Green Version**]

48. Tol, R.S.J. On the uncertainty about the total economic impact of climate change. *Environ. Res. Econ.* **2012**, *53*, 97–116. [**Google Scholar**] [**CrossRef**][**Green Version**]

49. Costinot, A.; Donaldson, D.; Smith, C. Evolving comparative advantage and the impact of climate change in agricultural markets: Evidence from 1.7 million fields around the world. *J. Pol. Econ.* **2016**, *124*, 20–25. [**Google Scholar**] [**CrossRef**][**Green Version**]

50. Ciscar, J.C.; Iglesias, A.; Feyen, L.; Szabo, L.; Regemorter, D.V.; Amelung, B.; Nicholls, R.; Watkiss, P.; Christensen, O.B.; Dankers, R.; et al. Physical and economic consequences of climate change in Europe. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 2678–2683. [**Google Scholar**] [**CrossRef**][**Green Version**]

51. Hsiang, S.; Kopp, R.; Jina, A.; Rising, J.; Delgado, M.; Mohan, S.; Rasmussen, D.J.; Muir-Wood, R.; Wilson, P.; Oppenheimer, M.; et al. Estimating economic damage from climate change in the United States. *Science* **2017**, *356*, 1362–1369. [**Google Scholar**] [**CrossRef**][**Green Version**]

52. Burke, M.; Hsiang, S.M.; Miguel, E. Global non-linear effect of temperature on economic production. *Nature* **2015**, *527*, 235–239. [**Google Scholar**] [**CrossRef**] [**PubMed**]

53. Carleton, T.A.; Hsiang, S.M. Social and economic impacts of climate. *Science* **2016**, *353*, 9837. [**Google Scholar**] [**CrossRef**] [**PubMed**][**Green Version**]

54. Pampolino, M.F.; Manguiat, I.J.; Ramanathan, S.; Gines, H.C.; Tan, P.S.; Chi, T.T.N.; Rajendran, R.; Buresh, R.J. Environmental impact and economic benfits of site-specific nutrient management (SSNM) in irrigated rice systems. *Agric. Syst.* **2007**, *93*, 1–24. [**Google Scholar**] [**CrossRef**]

55. Wagan, S.A.; Memon, Q.U.A.; Wagan, T.A.; Memon, I.H.; Wagan, A. Economic analysis of laser land leveling technology water use efficiency and crop productivity of wheat crop in Sindh, Pakistan. *J. Environ. Earth Sci.* **2015**, *5*, 21–25. [**Google Scholar**]

56. Latif, A.; Shakir, A.S.; Rashid, M.U. Appraisal of economic impact of zero tillage, laser land levelling and bed-furrow intervention in Punjab, Pakistan. *Pak. J. Eng. Appl. Sci.* **2013**, *13*, 65–81. [**Google Scholar**]

57. Ogada, M.J.; Rao, E.J.O.; Radeny, M.; Recha, J.W.; Solomon, D. Cllimate-smart agriculture, household income and asset accumulation among smallholder farmers in Nyando basin of Kenya. *World Dev. Perspect.* **2020**. [**Google Scholar**] [**CrossRef**]

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group –I) Journal Volume 11, Issue 11, 2022

58. Birthal, P.S.; Nigam, A.N.; Narayanan, A.V.; Kareem, K.A. Potential economic benefits from adoption of improved drought-tolerant groundnut in India. *Agric. Econ. Res. Rev.* **2012**, *25*, 1–14. [**Google Scholar**]

59. Tripathi, R.S.; Raju, R.; Thimmappa, K. Impacts of zero tillage on economics of wheat production in Haryana. *Agric. Econ. Res. Rev.* **2013**, *26*, 101–108. [**Google Scholar**]

60. Aryal, J.P.; Mehrotra, M.B.; Jat, M.L.; Sidhu, H.S. Impacts of laser land leveling in rice-wheat systems of the north-western indo-gangetic plains of India. *Food Sec.* **2015**. [**Google Scholar**] [**CrossRef**]

61. Aryal, J.P.; Sapkota, T.B.; Jat, M.L.; Bishnoi, J.K. On-farm economic and environmental impact of zero-tillage wheat: A case of north-west India. *Expl. Agric.* **2015**, *51*, 1–16. [**Google Scholar**] [**CrossRef**][**Green Version**]

62. Singh, V.K.; Shukla, A.K.; Singh, M.P.; Majumdar, K.; Mishra, R.P.; Rani, M.; Singh, S.K. Effect of site-specific nutrient management on yield, profit and apparent nutrient balance under pre-dominant cropping systems of Upper Gangetic Plains. *Indian J. Agric. Sci.* **2015**, *85*, 335–343. [**Google Scholar**]

63. Khatri-Chhetri, A.; Aryal, J.P.; Sapkota, T.B.; Khurana, R. Economic benefits of climate-smart agricultural practices to smallholder farmers in the Indo-Gangetic Plains of India. *Curr. Sci.* **2016**, *110*, 1251–1256. [**Google Scholar**]

64. Mishra, A.K.; Khanal, A.R.; Pede, V. Economic and resource conservation perspectives of direct seeded rice planting methods: Evidence from India. In Proceedings of the Agricultural and Applied Economics Association's 2017 AAEA Annual Meeting, Chicago, IL, USA, 30 July–2 August 2016. [**Google Scholar**]

65. Narayanamoorthy, A.; Devika, N. Economic and resource impacts of drip method of irrigation on okra cultivation: An analysis of field survey data. *J. Land Rural Stud.* **2017**, *6*, 15–33. [**Google Scholar**] [**CrossRef**]

66. Bhullar, M.S.; Singh, S.; Kumar, S.; Gill, G. Agronomic and economic impacts of direct seeded rice in Punjab. *Agric. Res. J.* **2018**, *55*, 236–242. [**Google Scholar**] [**CrossRef**]

67. Narayanamoorthy, A.; Bhattarai, M.; Joshi, P. An assessment of the economic impact of drip irrigation in vegetable production in India. *Agric. Econ. Res. Rev.* **2018**, *31*, 105–112. [**Google Scholar**] [**CrossRef**][**Green Version**]