International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

# Scenario of Climate Change and its Impacts

**Ankit Balvanshi, H. L. Tiwari**

***Abstract:*** ***This paper gives an extensive review of previous research work conducted to identify the impacts of climate change on water availability, crop yield and food quality. The research investigations conducted suggests that climate models with higher resolution can be more helpful in generation of future climatic projections. Stochastic projections of more than one model are vital for finding vulnerabilities and also to form management policies. Climate change has its impacts primarily on temperature, precipitation, surface water and ground water so the agricultural practices need to be improved simultaneously. Models which simulate the yield are useful tools for assessing the yield response to change in climatic constraints. Multiple climate models integrated with weather generators and yield simulating models (like DSSAT, AquaCrop, InfoCrop, CropSyst) are very useful in improving the strategies to adapt with the changing climate and food quality. The evapo-transpiration will get changed due to increase in temperature; crop yield will also get reduced. Hence the agricultural lands needs to be expanded, studies with multiple climate models are to be integrated with population, crop yields so as to tackle the problem of water availability, crop production, food quality & security.***

***Index Terms: AquaCrop, Climate change, Crop yield, DSSAT, Food security, Water availability.***

## I. INTRODUCTION

Worldwide food-security debilitated by changing climate is a standout amongst the main critical difficulties in the 21st century. The problem to supply adequate nourishment for the expanding population of the world while dealing with the already stressed environment is an important challenge [1]. Climate change has caused critical effects on water assets, food security, hydropower, human wellbeing particularly for African nations, and in addition to the entire world [2]. The studies focussing on climate change and its effects are progressively becoming significant areas of concern for example, maize, wheat and rice yields [3– 9], water resources in the stream or catchments [10– 13], woodlands or forests [14], industries [15] and the local landscape [16, 17]. Variable nature of climate is one of the most significant factors influencing annual crop yields [18]. Availability of water is one of the restrictive constraints for production of crop and food-security. Fujihara et al.[19] concluded that scarcity of water will not occur if demand of water is hiked; but, if the irrigated area is expanded under present irrigation efficiency rates, water insufficiency will occur. This paper is projected to supply useful information to scientists as well as policy-makers who are concerned in understanding the impacts of changing climate on water availability, crop yield and food-security so as to formulate appropriate strategies.

## II. SCENARIOS OF CLIMATE CHANGE

A Climate-scenario is a sensible representation of the upcoming climate based on a variety of climatological interactions and supposition of radioactive forcing [20]. It can be envisaged by global climate models (GCMs) and regional climate models (RCMs), which are complex 3d numerical illustration to show the processes between the atmosphere, land surface, oceans and sea [21]. Climatic projections are to be considered as competent technique to put up the possible future situations under specified emission scenarios [22, 23]. Table 1 shows a synopsis of Global Circulation Models used for future scenario projection.

Higher spatial determination GCMs as a rule performs proficiently for climate recreations and as a result they give climate researchers with the capacity to procure better understanding into the effect of climate change on agriculture yields [21]. Blenkinsop [24] proposed that RCMs have a few issues when they are utilized to mimic the observed durations affectability month to month precipitation sums. Climate models needs to be incorporated with different different approaches to predict the parameters such as precipitation, minimum-maximum temperature, radiation. Metzger et al. [25] introduced an A-T-E-A-M (Advanced-Terrestrial-Ecosystem-Analysis-and-Modelling) model structure to quantify the susceptibility of climate-change using the GCMs, HadCM3 to predict climate-change in year 2080. Suppiah et al. [22] employed the statistical techniques to pick 15 best suitable models to obtain the yearly and seasonal average climatic forecasts of precipitation and temperature in Australia. Kang [26] conducted a review study to find the factors contributing to climate change and consequently to crop yields and food security. It was concluded that the climate change studies are the trending topics for the climate scientists and policy makers. Groves [27] invented a fresh logical scheme based on Robust-Decision-Making to compute the SRES scenarios developed by the scenario axes technique.

Valipour et al. [28] conducted a study including the regions arid, semi-arid, Medi-terranean, and very humid. The objective of the research was to select the best model to calculate the potential evapo-transpiration due to climate change. It was concluded that the Blaney Criddle and Abtew models were the most efficient models for arid and semi-arid-areas.

**Revised Manuscript Received on 30 May 2019.**
***** Correspondence Author
**Ankit Balvanshi***, Research Scholar, Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal, India.
**H.L. Tiwari**, Associate Professor, Department of Civil Engineering, Maulana Azad National Institute of Technology, Bhopal, India.

**Table 1 Global circulation models (GCMs) employed for projections under different scenarios [22]**

| Model | Horizontal-Resolution | Modeled data availability |
|---|---|---|
| BCC CM1 | 1.9 X 1.9 | 1871 to 2100 |
| BCCR BCM2.0 | 1.9 X 1.9 | 1850 to 2099 |
| CCSM3 | 1.4 X 1.4 | 1870 to 2099 |
| CCCM3.1-(T 47) | 2.8 X 2.8 | 1850 to 2100 |
| CCCM3.1-(T 63) | 1.9 X 1.9 | 1850 to 2100 |
| CNRM-CM3 | 1.9 X 1.9 | 1860 to 2090 |
| CSIRO Mk-3.0 | 1.9 X 1.9 | 1871 to 2100 |
| MPI OM | 1.9 X 1.9 | 1860 to 2100 |
| ECHO G | 3.9 X 3.9 | 1860 to 2100 |
| FGOALS g1.0 | 2.8 X 2.8 | 1850 to 2099 |
| GFDL CM2.0 | 2.0 X 2.5 | 1861 to 2100 |
| GFDL CM2.1 | 2.0 X2.5 | 1861 to 2100 |
| GISS AOM | 3.0 X 4.0 | 1850 to 2100 |
| GISS EH | 4.0 X 5.0 | 1880 to 2099 |
| GISS ER | 4.0 X 5.0 | 1880 to 2100 |
| INM CM3.0 | 4.0 X 5.0 | 1871 to 2100 |
| IPSL CM4 | 2.5X 3.75 | 1860 to 2100 |
| MIROC3.2 | 1.12X1.12 | 1900 to 2100 |
| MIROC3.2 | 2.8X 2.8 | 1850 to 2100 |
| MRI CGCM-2.3.2 | 2.8 X 2.8 | 1851 to 2100 |
| PCM | 2.8 X 2.8 | 1890 to 2099 |
| UKMO- HadCM3 | 2.5 X 3.75 | 1860 to 2099 |
| UKMO-HadGEM1 | 1.25X 1.9 | 1860 to 2098 |

Xu et al. [29] employed the P.R.E.C.I.S. model to forecast average rainfall and temperature in China for year 2080 for B2 climate scenarios. It was concluded that the average precipitation and temperature would hike. GCMs have been used to forecast climatic scenarios and assess climate change effects by employing downscaling techniques [30]. GCM data on average have a low resolution of several degrees thus lacks in the spatial and temporal accuracy required for thorough small scale researches [31-33].

## III. CLIMATE CHANGE EFFECT ON AVAILABILITY OF WATER

Water-resources assume an imperative part in human flourishing and yield efficiency [34]. The water accessibility problems incorporate, to what extent water can be occupied from the accessible water to what extent water be able to put away in surface stores. Environmental variation is one of the peak weights in water cycle alongside populace development, contamination [35, 36]. Guo et al.[37] considered the impact of climate change on the overflow and water assets with the geographic data framework & G.C.M.s in China and proposed that overland flow is less sensitive to temperature increment in comparison to rainfall increase. Ma et al. [38] investigated about atmosphere changeability effects on yearly stream-flow by the k-test and p-test in the Shiyang River, China, the outcomes show that environmental variation can lessen 64 % of mean yearly stream-flow inferable from diminished precipitation. Wurbs et al.[39] built up Water Accessibility Displaying (WAM) framework to survey the water supply capacities and investigate atmosphere effects on water accessibility for water clients who rely upon water of the Brazos River Basin, Texas, and the key outcome is that future atmosphere may diminish the mean stream-flow, and its consequences for water accessibility are different in various districts of the waterway bowl. Quinn et al. [40] researched on an incorporated framework to examine the effects of atmosphere inconstancy on water resources in the San Joaquin Basin of California, it was presumed that the strategy can give suggestions to successful administration systems to evaluate atmosphere uncertainties. Qin et al. [41] clarified the multi-criteria choice master framework to break down water accessibility under climatic change conditions in the Georgia Basin in Canada. The outcome demonstrates that it is vital to survey environmental variation impact on financial and natural perspectives.

## IV. CLIMATE CHANGE IMPACTS ON CROP YIELD AND FOOD SECURITY

The effects of climatic change on yield can be estimated by models which simulate the yield of agriculture crops. Various harvest models example CERES Maize & Wheat (Crop Environment Resource Synthesis), InFoCrop, AquaCrop-FAO and SWAP (Soil– Water– Atmosphere– Plant) [6], have been utilized across the globe in simulation of yield of crops and estimating the fluctuations in agricultural outputs.

Table 2 demonstrates list of various models employed to showcase the yields and change in agricultural outputs due to climate variability.

**Table 2 Various Crop Yield and Climate Impact Assessment Models**

| Model Employed | Objective crop(s) | Projected impacts |
|---|---|---|
| InFoCrop [26] | Rice | Elevated $CO_2$ and temperature |
| GLAM [9] | Peanut | Climate uncertainty |
| GLYCIM [18] | Soybean | Temperature rainfall and $CO_2$ concentration |
| CERES [33] | Maize | Dry matter |
| CERES [26] | Maize | Sustainable yield |
| CERES [26] | Maize | Planting date and variable weather |
| CERES [26] | Maize | Precis'e and deficit irrigation |
| CropSyst [26] | Wheat | Rainfall and warming temperature |
| CERES [26] | Wheat | $CO_2$ levels |
| SWAP [26] | Rice | $CO_2$ levels |
| IBSNAT-ICASA [26] | Cereal/soybean | Climate change |
| SWAT [26] | Maize | Climate vulnerability |

Eitzinger et al. [42] employed the C-E-R-E-S Wheat Model to evaluate the impact of environmental variation on wheat yield. Multiple climate scenarios were considered in this research study. It was concluded that that the increase in CO2 increases the yield of crop. Luo et al. [43] employed the D.S.S.A.T. 3.5 (Decision Support System for Agro-innovation Transfer) CERES-Wheat models to assess the climatic change consequences on wheat yields Southern Australian region was taken as research area considering all CO2 levels. It was concluded that wheat yield will increment till 2080's under all CO2 levels. Foster et al. [44] presented an open-source software FAO AquaCrop model. It was concluded that Aquacrop model is effective in simulating the water limited crop yield growing in dissimilar environmental and agronomic conditions.

## V. CONCLUSIONS

This paper gives an exhaustive review on the various climate models, multiple climatic scenarios and crop yield simulating models. The major impacts of climate change were found primarily pointing towards water availability, crop yield and food security. For the prediction of climate change impacts, various climate models were developed by the researchers, research organisations and climate scientists all over the world. But the models which integrate with higher spatial resolution were found quite helpful in estimating and prediction of future climate scenarios. The projections of future climate illustrates that temperature will be hiked but the precipitation may hike or drop depending on the location of the study-area. Further, it was observed that Global warming will create hike in temperature and extreme rainfall events to occur frequently. Thus, Crop yield will be affected directly due to this climate change. However, the impacts on crop production can be reduced if proper studies including multiple climate models and multiple weather generators are employed to get more accurate forecasts for the future projections. Models which simulate the yield are useful tools for assessing the yield response to change in climatic constraints. Multiple climate models integrated with weather generators and yield simulating models like DSSAT, InfoCrop, AquaCrop, CropSyst are very useful tools. The adaptive measures for climate change can be formed by conduct of studies which ensembles multiple climate models integrated with constraints like population, yield and hence the ill effects of climate change may be encountered.

## REFERENCES


1. Lal R. 2005.Climate change, Soil Carbon Dynamics, And Global Food Security. In: Lal R, Stewart B, Uphoff N, et al., editors. Climate change and global food security. Boca Raton (FL): CRC Press; pp. 113to43.
2. Magadza C.H.D. 2000.Climate Change Impacts And Human Settlements In Africa: Prospects For Adaptation. Environ Monit Assess;61: pp.193to205.
3. Howden S.M., O'Leary GJ. 1997. Evaluating Options To Reduce Greenhouse Gas Emissions From An Australian Temperate Wheat Cropping System. Environ Modell Software;12: pp.169to76.
4. Hoogenboom G. 2000. Contribution Of Agrometeorology To The Simulation Of Crop Production And Its Applications. Agric Forest Meteorol;103: pp.137to57.
5. Gbetibouo G, Hassan R. 2005. Economic Impact Of Climate Change On Major South African Field Crops: A Ricardian Approach. Glob Planet Change;47: pp.143to52.
6. Aggarwal P.K, Kalra N, Chander S, et al. 2006.InfoCrop: A Dynamic Simulation Model For The Assessment Of Crop Yields, Losses Due To Pests, And Environmental Impact Of Agro-Ecosystems In Tropical Environments. I. Model Description. Agric Syst;89: pp.1to25.
7. Aggarwal P.K, Banerjee B, Daryaei M.G, et al. 2006. InfoCrop: A Dynamic Simulation Model For The Assessment Of Crop Yields, Losses Due To Pests, And Environmental Impact Of Agro-Ecosystems In Tropical Environments II. Performance Of The Model. Agric Syst;89: pp.47to67.
8. Dhungana P., Eskridge K.M., Weiss A., et al. 2006. Designing Crop Technology For A Future Climate: An Example Using Response Surface Methodology And The CERES-Wheat Model. Agric Syst;87: pp.63to79.
9. Challinor A.J., Wheeler T.R. 2008. Crop Yield Reduction In The Tropics Under Climate Change: Processes And Uncertainties. Agric Forest Meteorol;148: pp.343to56.
10. Chang H., Knight C.G., Staneva M.P., et al. 2002.Water Resource Impacts Of Climate Change In Southwestern Bulgaria. Geol J;57: pp.159to68.
11. Wilby R.L. 2005. Uncertainty In Water Resource Model Parameters Used For Climate Change Impact Assessment. Hydrol Process;19:3 pp.201to19.
12. Wilby R.L., Whitehead PG, Wade AJ, et al.2006. Integrated Modelling Of Climate Change Impacts On Water Resources And Quality In A Lowland Catchment: River Kennet, UK. J Hydrol;330: pp.204to20.
13. Herrera-Pantoja M, Hiscock K.M.2008. The Effects Of Climate Change On Potential Groundwater Recharge In Great Britain. Hydrol Process;22: pp.73to86.
14. Lexer M.J., Honninger K., Scheifinger H., et al.2002. The Sensitivity Of Austrian Forests To Scenarios Of Climatic Change: A Large-Scale Risk Assessment Based On A Modified Gap Model And Forest Inventory Data. Ecol Manag;162: pp.53to72.
15. Harle K.J., Howden S.M., Hunt L.P.2007. The Potential Impact Of Climate Change On The Australian Wool Industry By 2030.Agric Syst;93: pp.61–89.
16. Dockerty T., Lovett A., Sunnenberg G. 2005.Visualising The Potential Impacts Of Climate Change On Rural Landscapes. Comput Environ Urban Syst;29: pp.297–320.
17. Dockerty T., Lovett A., Appleton K., et al. 2006.Developing Scenarios And Visualisations To Illustrate Potential Policy And Climatic Influences On Future Agricultural Landscapes. Agric Ecosyst Environ;114: pp.103–20.
18. Reddy V.R., Pachepsky Y.A. 2000.Predicting Crop Yields Under Climate Change Conditions From Monthly GCM Weather Projections. Environ Modell Software;15: pp.79–86.
19. Fujihara Y., Tanaka K., Watanabe T. 2008. Assessing The Impacts Of Climate Change On The Water Resources Of The Seyhan River Basin In Turkey: Use Of Dynamically Downscaled Data For Hydrologic Simulations. J Hydrol;353: pp.33–48.
20. IPCC. Appendix I: glossary. In: Parry ML, Canziani OF, Palutikof JP, et al., editors. Climate Change 2007: Impacts, Adaptation And Vulnerability. Contribution Of Working Group II To The Fourth Assessment Report Of The Intergovernmental Panel On Climate Change. Cambridge: Cambridge University Press; 2007. pp.79–131.
21. Jaiwal R.K., Tiwari H.L., Lohani A.K. 2017. Assessment of climate change impact on rainfall for studying water availability in upper Mahanadi catchment, India. J.Water Clim Change 8(3), DOI: 10.2166/wcc.2017.097.
22. Suppiah R., Hennessy K.J., Whetton P.H., et al. 2007. Australian Climate Change Projections Derived From Simulations Performed For The IPCC 4th Assessment Report. Aust Meteorol Mag;56: pp.131–52.
23. IPCC. Summary for policymakers. In: Solomon S, Qin D, Manning M, et al., editors. Climate change 2007: the physical science basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge: Cam-bridge University Press; 2007. pp. 1–18.
24. Blenkinsop S., Fowler H.J. 2007. Changes In European Drought Characteristics Projected By The PRUDENCE Regional Climate Models. Int J Climatol; 27: pp.1595–610.
25. Metzger M.J., Leemans R., Schroter D. 2005. A Multidisciplinary Multi-Scale Framework For Assessing Vulnerabilities To Global Change. Int J Appl Earth Obsery Geoinform;7: pp.253–67.

25. Metzger M.J., Leemans R., Schroter D. 2005. A Multidisciplinary Multi-Scale Framework For Assessing Vulnerabilities To Global Change. Int J Appl Earth Obsery Geoinform;7: pp.253–67.
26. Kang Y., Khan S., Xiaoyi M. 2009. Climate Change Impacts On Crop Yield, Crop Water Productivity And Food Security – A Review. Progress in Natural Science;19(12): pp.1665-1674.
27. Groves D, Lempert R. 2007. A New Analytic Method For Finding Policy-Relevant Scenarios. Global Environ Change;17: pp.73–85.
28. Valipour M, Sefidkouhi M.A.G., Raeini M. 2017. Selecting The Best Model To Estimate Potential Evapotranspirationwith Respect To Climate Change And Magnitudes Of Extreme Events. Agricultural Water Management; 180: pp.50-60.
29. Xu Y., Zhang Y., Lin E., et al. 2006. Analysis On The Climate Change Responses Over China Under SRES B2 Scenario Using PRECIS. Chin Sci Bull;51(18):pp.260–7.
30. Thomas A. 2008.Agricultural Irrigation Demand Under Present And Future Climate Scenarios In China. Glob Planet Change;60: pp.306–26.
31. Bonan G.B., Oleson K.W., Vertenstein M., et al. 2002. The Land Surface Climatology Of The Community Land Model Coupled To The NCAR Community Climate Model. J Clim;15: pp.3123–49.
32. Salinger M.J., Stigter C.J., Das H.P. 2000.Agrometeorological Adaptation Strategies To Increasing Climate Variability And Climate Change. Agric Forest Meteorol;103: pp.167–84.
33. Cuculeanu V., Tuinea P., Balteanu D. 2002. Climate Change Impacts In Romania: Vulnerability And Adaptation Options. Geol J;57: pp.203–9.
34. ACE (Atmosphere, Climate and Environment). Climate Change Fact Sheet Series For Key Stage 4 And A-Level, Buchdahl; 2002. pp.1–171.
35. Aerts J, Droogers P. 2004. Climate Change In Contrasting River Basins: Adaptation Strategies For Water, Food, And Environment. The Neth-erlands: CABI Publishing; pp. 1–264.
36. Dracup J.A., Vicuna S. 2005. An Overview Of Hydrology And Water Resources Studies On Climate Change: The California Experience. Copyright ASCE; pp.1–12.
37. Guo S., Wang J., Xiong L., et al. 2002. A Macro-Scale And Semi-Distributed Monthly Water Balance Model To Predict Climate Change Impacts In China. J Hydrol;268: pp.1–15.
38. Ma Z., Kang S., Zhang L., et al. 2008. Analysis Of Impacts Of Climate Variability And Human Activity On Streamflow For A River Basin In Arid Region Of Northwest China. J Hydrol;352: pp.239–49.
39. Wurbs R.A., Asce M, Muttiah R.S., et al. 2005. Incorporation Of Climate Change In Water Availability Modeling. J Hydrol Engg;5: pp.375–85.
40. Quinn N.W.T., Miller N.L., Dracup J.A., et al. 2001. An Integrated Modeling System For Environmental Impact Analysis Of Climate Variability And Extreme Weather Events In The San Joaquin Basin, California. Adv Environ Res;5: pp.309–17.
41. Qin X.S., Huang G.H., Chakma A., et al. 2008. A MCDM-Based Expert System For Climate-Change Impact Assessment And Adaptation Planning – A Case Study For The Georgia Basin, Canada. Expert Syst Appl;34: pp.2164–79.
42. Eitzinger J., Stastna M., Zahid Z., et al. 2003. A Simulation Study Of The Effect Of Soil Water Balance And Water Stress On Winter Wheat Production Under Different Climate Change Scenarios. Agric Water Manage;61: pp.195–217.
43. Luo Q., Williams M, Bellotti W., et al. 2003. Quantitative And Visual Assessments Of Climate Change Impacts On South Australian Wheat Production. Agric Syst;77: pp.173–86.
44. Foster T., Brozovic N., Butler A.P. et al. 2017. Aquacrop-OS: An Open Source Version Of FAO's Crop Water Productivity Model. Agricultural Water Management;181: pp.18-22.