**A comprehensive review on Modern Technologies for Climate Resilient Agriculture**

**Abstract**

This review looks at how Indian agriculture and adaption tactics are affected by climate change. Due to human activity, climate change is causing problems including extreme weather occurrences and rising temperatures. Increased temperatures have the potential to cause heat stress in crops, which lowers yields and results in lower-quality produce. Farmers employ climate-resilient crop development and planting date adjustments as adaptation strategies. Variable or irregular rainfall patterns can lead to drought conditions, which can dry out farmlands and result in crop failures. However, floods brought on by too much rain can harm crops and soil and cause disruptions to agricultural activities, particularly during the monsoon season. Initiatives for precision farming, urban food production, and soil conservation all support resource recycling and food security. Efficient water management and better irrigation are necessary to address water scarcity. The number of agricultural pests is impacted by climate change, endangering the world's food supply. Numerous adaptation tactics are being used, such as socioeconomic initiatives, resource-conservation technologies, and traditional behaviors. Precision farming and other climate-smart agricultural technology boost resilience and yields. Regional appropriateness, economic feasibility, and group execution are all necessary for success. A complex socio-ecological system, agriculture is subject to climatic, economic, and policy risks. Climate-smart agriculture methods that are site-specific are essential for the resilience and food security of smallholders. Adoption of these technologies can be aided by publicly offered agricultural extension services, but obstacles like budgetary limitations and cultural considerations need to be taken into account. This assessment highlights the necessity of comprehensive, context-specific strategies to address climate change vulnerabilities in Indian agriculture and guarantee a sustainable future for smallholder livelihoods and food production.

**Keywords**

Rising temperatures, Climate change, socio-ecological system, climate-resilient crops

**Introduction**

The globe is currently facing a major challenge from global climate change. Land and ocean temperatures have been rising at an average pace of 0.06 °C every decade since 1850, more than three times faster than the rate of warming since 1982, which was around 0.20 °C per decade [1]. The main causes of global warming over the past century have been determined to be the burning of fossil fuels, significant greenhouse gas emissions, and fast population expansion. Experts have noted that human activity is the primary cause of the increase in the Earth's average surface temperature in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Between 1850 and 2019, the global surface temperature increased by 0.8 to 1.3 degrees Celsius, mostly due to the release of greenhouse gases, which is the main cause of global warming [2]. Furthermore, the world's climate is changing quickly due to modern society's long-standing reliance on fossil fuels. This tendency has already caused record-breaking floods, wildfires, and droughts, progressively affecting populations all over the world. Earth's future is primarily dependent on the decisions made by today's population, and the situation will worsen if greenhouse gas emissions continue [3, 76].

As the basis for human existence and growth, agricultural productivity is significantly impacted by the swift changes in the global climate [4, 5, 6, 12]. In addition to decreasing crop yields through increased frequency of extreme weather events, unequal precipitation, droughts, and floods, global warming also upsets ecological balance and has an impact on crop pest and disease prevention and management [7, 8, 11]. Furthermore, soil degradation and land resource scarcity brought on by climate change have an effect on the sustainable growth of agricultural production [9, 15]. Innovative solutions and robust international cooperation are desperately needed to meet this problem. Countries can work together to promote sustainable technology development and achieve significant reductions in greenhouse gas emissions [10, 13, 14].

**Direct Effects of Climate Change on Farming Production**

Climate change's direct effects on crop cycles, yield, and quality are among the most urgent and immediate issues facing agricultural output. Farmers' livelihoods, sustainability, and stability are seriously threatened by these problems.

**Crop Cycles Affected by Climate Change**

Crops' growing seasons have generally shortened due to climate change [16,17], and greater temperature swings may cause crops to accumulate nutrients insufficiently. Changes in sunshine hours also impact crop growth cycles, and crop growth will be constrained by less sunlight [18]. Climate change can also impact crop flowering and grain-filling periods, leading to different levels of drought and frost damage. From a worldwide standpoint [19] examined how crop growth cycles are impacted by climate change and the significance of adaptive management techniques by modifying planting dates and cultivars. In order to evaluate the adaptation of crop cycles for maize, rice, sorghum, soybeans, and wheat as well as the effect of climate change on crop production, this study integrated biophysical crop models with farmer decision models. According to the research, the flexibility of planting dates and types affects not only the beginning and end of growth periods but also intermediate developmental stages, especially flowering and other stages that are sensitive to high temperatures. According to this study, temperature is the main factor influencing the crop growth period at latitudes of about 30 °S and above.

Planting dates for spring crop varieties are usually based on when the warm season begins, whereas the cold season begins for winter crop varieties. A study by [20] examined how the water cycle and crop growth are affected by global climate change, with a particular emphasis on the growth of winter wheat and summer maize in the North China Plain under demanding irrigation management conditions. The effects of future climate change on agricultural output and hydrology were measured in this study using an updated SWAT model and forecasts from several global climate models (GCMs) in CMIP5 and CMIP6 [21, 75].

**Climate Change's Effect on Crop Production**

Crop productivity is impacted in a variety of intricate ways by the changing global environment. An increase in evapotranspiration rates, which worsens water evaporation and causes soil dryness and water scarcity, has a negative impact on crop productivity. A global analysis of the yields of the four main cereal crops wheat, rice, soybeans, and maize is presented in the following articles. In their study, [22] examined how temperature increases affect the yields of important cereal crops worldwide and the significance of temperature–humidity coupling in controlling crop responses to heat globally. They discovered that there is a compound heat-drought effect on crops in some areas where higher temperatures and less precipitation and evapotranspiration cause a more noticeable drop in crop yields, including maize and soybeans. The study's findings imply that in addition to warming crops, climate change has changed the elements that contribute to compound heat-humidity stress, which in turn has an impact on crop sensitivity to heat. [23, 24, 25] forecasted changes in the yields of the four major grain crops indicated above using the most recent crop and climate models. This study took into account a number of climate change causes, such as rising temperatures, altered precipitation and drought patterns, and elevated atmospheric carbon dioxide (CO2) concentrations. The findings suggest that the effects of climate change on agricultural output might become apparent sooner rather than later, with some high-latitude regions seeing increases in yields and low-latitude tropical regions potentially seeing decreases.

**Climate Change Impact on Crop Quality**

Additionally, the nutritional value and flavor of crops are significantly impacted by global climate change. Staple crops may lose quality and protein content as a result of rising temperatures and CO2 concentrations [26, 27]. Consumer demand for some agricultural products may therefore decline, which would have some impact on agricultural output and farmers' earnings. In a research on how climate change affects crop quality [28] specifically examined the nutritional value of rice in China and Japan. This study discovered that the protein, iron, and zinc content of rice, together with the B1, B2, B5, and B9 content, with the exception of vitamin E, showed a declining tendency as the atmospheric CO2 concentration increased steadily. The impact of climate change on vitamin content is directly linked to molecular nitrogen content, according to this study, which implies that an influence of this kind might potentially endanger the health of almost 600 million people globally. In conclusion, this study has added significant knowledge on how climate change affects crop nutritional values and will undoubtedly direct relevant future actions. From a geographical standpoint. [29] investigated the effects of future climate change on northern China's wheat yield and protein, coming to the conclusion that these effects will be detrimental.

**Techniques for Reducing the Effects of Global Climate Change on Agriculture**

A wide range of actions must be taken by agricultural production to address the issues brought about by global climate change. There are three types of methods for these measures: short-, mid-, and long-term [30, 31, 32, 33]. Adopting climate-smart agricultural technology, water-efficient irrigation systems, and climate-resilient crop types are all part of this. Additionally, improving soil conservation and improvement techniques and encouraging carbon-neutral agricultural methods are also important. In order to further improve agriculture's sustainability and adaptability, new agricultural technologies including hydroponics, soilless growing, vertical farming, and semi-enclosed greenhouses are required. The productivity and efficiency of resource use can be greatly increased by these cutting-edge technologies [34]. Furthermore, practical approaches to recycling and reusing water are essential for addressing water scarcity, and environmentally friendly fertilizer production methods can lessen pollution. In conclusion, comprehensive sustainable agricultural growth can be achieved by integrating resource recycling, waste treatment, and agricultural production to create a sustainable closed-loop system [35, 36]. Additionally, enhancing international cooperation and creating adaptive management strategies are crucial. Better resilience to the problems presented by climate change will be made possible by these activities, which will enhance agricultural production's stability, sustainability, and adaptability [37, 38, 39].

**Technologies for Intelligent Agriculture Management and Water-Saving Irrigation Systems**

In reaction to climate change, water-efficient irrigation systems and intelligent farm management technology can increase agricultural flexibility and production. By improving crop growth and irrigation management, advanced agricultural technologies including precision agriculture, remote sensing, and unmanned aerial vehicle monitoring can boost crop output and quality. Based on deep neural networks and satellite observations, deep drainage estimating model for irrigated farmland [40, 41] can help promote water-saving agricultural practices and evaluate the efficacy of different water-saving irrigation technologies. Water-saving irrigation methods, like drip irrigation and micro-sprinkler irrigation, assist conserve water while ensuring crop development in hot and dry climates. A study by [42, 43, 74] used a plastic film drip irrigation system, a water-saving irrigation technology that addresses the unequal distribution and shortage of water resources by optimizing irrigation management and increasing irrigation water usage efficiency.

**Crop Varieties that Resist Weather**

One important strategy to combat climate change is to promote resilient agricultural varieties. By switching to crop varieties that can withstand flooding and adjusting planting schedules, [43] showed that yield loss may be decreased by 18%. By maintaining strong growth and yield in the face of unfavorable weather, resilient crop varieties can lessen the negative effects of climate change on agricultural output. Consequently, the development of more hardy crop types using technologies like gene editing will become a research focus. [44, 45] pointed out that by accurately altering crop genomes, gene editing technologies may help increase food security in low- and middle-income nations. Small farmers may now acquire enhanced varieties, lower the cost of producing seeds, and increase the drought and disease resistance of their crops thanks to these technologies.

**Enhancement and Preservation of Soil**

Improving soil conservation and enhancement can lower soil carbon emissions, which in turn lowers greenhouse gas emissions. Ecosystem stability can be strengthened by, for instance, increasing soil organic carbon storage and improving soil health through the use of various planting methods and appropriate crop rotation [46]. The goals of promoting carbon-neutral farming methods, such sustainable and organic farming, are to lower greenhouse gas emissions, encourage soil carbon absorption, and improve the health of ecosystems. Utilizing the NCAR Community Earth System Model, [47, 48] projected how China's carbon neutrality would mitigate global warming. China's ultimate goal is to reduce global warming, and it has pledged to reaching its peak carbon emissions by 2030 and becoming carbon neutral by 2060.

**Novel Approaches in Agriculture**

The uncertainty of climate change on crops is significantly reduced by innovative agricultural solutions including soilless cultivation, hydroponics, vertical farming, and semi-closed greenhouses, which regulate climatic conditions, conserve resources, and lengthen growing seasons.
In order to create optimal growing circumstances, semi-closed greenhouses maximize environmental parameters including temperature, humidity, and CO2 concentration. This increases crop yields and reduces the effect of outside climate variations on crops, guaranteeing the stability of agricultural production [49]. For the management of semi-closed greenhouses powered by renewable energy, [50] suggested a data-driven robust model predictive control system. The sustainability of agricultural production is improved by this control system, which also lowers energy consumption, perhaps increasing energy efficiency and lowering the need for renewable energy.

With its precise control over growth elements in multi-tier indoor environments, vertical farming is a revolutionary plant production technology that conserves water and nutrients, makes optimal use of land, and produces high-yield fresh produce all year round. Along with tackling the issues of climate change, it provides sustainable options for cutting back on the use of pesticides [51, 52]. The use of fluorescent coatings to increase crop productivity in vertical farms was investigated by [53] using simulations based on numerical analysis. They created a solar lighting design that enhances photosynthetic radiation on vertical farm racks by incorporating fluorescent reflectors into the lighting system. In order to improve spatial light distribution and modify solar spectra, these reflectors which are composed of optical glass impregnated with fluorescent pigments are incorporated into the lighting distribution system, which raises crop yields. In order to ensure healthy crop growth, soilless cultivation techniques reduce soil degradation, increase the efficiency of water resource consumption, and accurately regulate nutrient supplies. Hydroponic systems reduce the need for pesticides and promote quick growth by utilizing effective nutrient absorption processes and optimal space. The reviews of [54] and [55] together discuss the possibilities and difficulties of soilless cultivation technology in improving agricultural production efficiency and attaining environmental sustainability. As an alternative to conventional soil cultivation, researchers stress that soilless cultivation techniques have several benefits, including water saving, lower chemical fertilizer use, higher crop production and quality, and less environmental effect. High initial investment prices, energy requirements, system management complexity, and guaranteeing crop health and nutrient availability are some of the obstacles to the practical implementation of soilless farming technology. In addition to promoting sustainable development and lessening the adverse environmental effects of agricultural production, these cutting-edge technologies also improve food security by increasing productivity and resource usage efficiency, which helps to mitigate the food shortages brought on by climate change. By establishing more regulated and consistent production conditions, these technologies improve agricultural flexibility, propel technological progress, and enable industrial improvements in associated domains, resulting in increased economic

**Practical Ways to Produce Fertilizer in a Sustainable Way**

Significant greenhouse gas emissions and environmental damage are frequently associated with the manufacturing and use of traditional fertilizers. On the other hand, by the optimization of manufacturing procedures and material selection, sustainable fertilizer production technologies successfully lower carbon footprints. By recycling organic matter and agricultural waste, for example, the use of bio-fertilizers and organic fertilizers improves soil fertility, reduces greenhouse gas emissions and fossil fuel consumption, and increases resource efficiency and material recyclability [56, 57]. By reducing dependency on fossil fuels for chemical and fuel generation, green chemical processes minimize the environmental effect of chemical synthesis and manufacturing [58]. Intelligent fertilization systems reduce the amount of excess fertilizer used by precisely controlling fertilization and release, maximizing fertilizer efficiency and minimizing environmental impacts [59, 60]. By minimizing greenhouse gas emissions and dependence on chemical fertilizers, these creative solutions not only boost crop yields and quality but also strengthen agricultural systems' resilience and promote agricultural sustainability and climate change mitigation. Ensuring food security, safeguarding the environment, and advancing agricultural sustainability are all made possible by sustainable fertilizer production technology.

**Potential Water Recycling and Reuse Solutions**

Reusable and recyclable water solutions are important and far-reaching ways to lessen the effects of climate change on agricultural output. These strategies significantly lower agricultural water demand by optimizing water resource management, thereby mitigating the effects of climate change-induced water scarcity. Technologies such as drip irrigation and rainwater collecting systems, for example, can greatly increase the efficiency of water consumption, reduce waste, and guarantee that crops receive enough water even under drought circumstances [61, 62]. Technologies for wastewater regeneration and treatment can turn household and commercial wastewater into irrigation water, lowering the need for freshwater resources and minimizing contamination from wastewater discharge [63, 64]. In addition to supplying nutrients for crops to support development, maintaining soil moisture, and increasing soil fertility, water reuse techniques also improve the stability and health of agricultural ecosystems by reducing pollution and recycling [65, 66]. In general, programs for water reuse and recycling not only improve agricultural production's sustainability and efficiency but also significantly contribute to environmental preservation, climate change mitigation, and food security. As a result, the adoption and promotion of these water resource management technologies offer practical means of accomplishing sustainable agricultural growth and addressing climate change issues.

**Implementing Closed-Loop Sustainable Systems**

Reducing waste production and pollution in the environment while maximizing resource recycling is the goal of developing sustainable closed-loop systems. Microbial fertilizers and advanced synthetic biology techniques greatly improve soil quality, decrease fertilizer runoff and water contamination, and increase nutrient use efficiency, all of which increase crop yields [67, 68, 69]. Intelligent fertilization technology and green chemical processes are also part of sustainable fertilizer manufacturing. Through the integration of waste management, energy production, and agricultural production, closed-loop systems can decrease greenhouse gas emissions, lessen dependency on fossil fuels and chemical fertilizers, and transform agricultural waste into valuable resources. Furthermore, irrigation water in closed-loop systems can be efficiently collected and recycled, giving crops sufficient protection from the elements. Herbicides, fertilizers, and pesticides are not necessary for plants to flourish in regulated conditions, which improves food safety and lessens the environmental impact of chemicals [70]. Global research on closed-loop ecosystems shows that this all-encompassing management strategy increases agriculture production sustainability and resource efficiency while supporting future space exploration with crucial data and technology [71]. In conclusion, developing sustainable closed-loop systems has important ecological and financial ramifications and provides creative ways to combat climate change and advance agricultural sustainability.

**Management Strategies that are Adaptive**

Addressing the risks and dangers posed by climate change requires the development of adaptive management solutions that incorporate insurance systems, disaster risk management, and climate information services [72]. The adaptation and transformation of global agricultural systems is accelerated by bolstering international collaboration to exchange best practices and experiences in climate change and agricultural adaptation. Other nations and areas dealing with comparable issues can benefit greatly from the thorough assessment methodology and evaluation techniques discussed by [73] in the study. The methodology and techniques outlined above allow for a systematic evaluation of the effects of climate change on agricultural output, and the findings of this assessment are important for developing adaptation and mitigation strategies to fight climate change globally. Policymakers can better address the constantly shifting climate environment, protect food security, preserve farmers' livelihoods, and advance the sustainable development of agriculture by having a better understanding of how climate change actually affects agricultural production.

**Conclusion**

Both direct and indirect effects of global climate change on agricultural production are extensive and significant. Direct effects include changes in crop growth cycles, yields, and quality; indirect effects include increased frequency and severity of extreme weather events; changes in soil fertility; changes in precipitation patterns; and changes in the patterns of pest and disease occurrence. Furthermore, through mechanisms including greenhouse gas emissions, deforestation, changes in land use, and supply chains, agricultural operations themselves contribute to climate change, generating feedback loops. The issues presented by climate change need the adoption of comprehensive measures in light of these multifaceted relationships. However, a number of constraints remain in contemporary research, including a lack of innovation in study methodologies and technologies, as well as a restricted number of research topics and geographies. Furthermore, governments, research institutions, farmers, and other stakeholders will need to work together in order to effectively execute the aforementioned initiatives. The precise mechanisms by which climate change affects agricultural production should thus be further investigated in future studies, and more focused technical tools and reaction plans should be suggested. Furthermore, it is impossible to overlook how climate change is affecting agricultural ecosystems and the services they provide in order to ensure the long-term growth of global agricultural output.

**References**

1. NOAA National Centers for Environmental Information. Monthly Global Climate Report for Annual 2023.
2. IPCC. Climate Change 2023 Synthesis Report; IPCC: Geneva, Switzerland, 2023.
3. Tollefson, J. Earth is warmer than it’s been in 125,000 years, says landmark climate report. Nature 2021, 596, 171–172.
4. Sikha Karki, P.B.; Mackey, B. The Experiences and Perceptions of Farmers about the Impacts of Climate Change and Variability on Crop Production: A Review. Clim. Dev. 2020, 12, 80–95.
5. Annie, M.; Pal, R.K.; Gawai, A.S.; Sharma, A. Assessing the Impact of Climate Change on Agricultural Production Using Crop Simulation Model. Int. J. Environ. Clim. Change 2023, 13, 538–550.
6. Ayushi Trivedi, S.K. Pyasi and Galkate, R.V. 2018. Estimation of Evapotranspiration using CROPWAT 8.0 Model for Shipra River Basin in Madhya Pradesh, India. Int.J.Curr.Microbiol.App.Sci. 7(05): 1248-1259.
7. Wu, Y.; Meng, S.; Liu, C.; Gao, W.; Liang, X.-Z. A Bibliometric Analysis of Research for Climate Impact on Agriculture. Front. Sustain. Food Syst. 2023, 7, 1191305.
8. Monteleone, B.; Borzì, I.; Bonaccorso, B.; Martina, M. Quantifying Crop Vulnerability to Weather-Related Extreme Events and Climate Change through Vulnerability Curves. Nat. Hazards 2022, 116, 2761–2796.
9. Ayushi Trivedi, S.K. Pyasi and Galkate, R.V. 2018. A review on modelling of rainfall – runoff process. The Pharma Innovation Journal 7(4): 1161-1164.
10. Yang, Q.-L.; Du, T.; Li, N.; Liang, J.; Javed, T.; Wang, H.; Guo, J.; Liu, Y. Bibliometric Analysis on the Impact of Climate Change on Crop Pest and Disease. *Agronomy* **2023**, *13*, 920.
11. Ayushi Trivedi, Avinash Kumar Gautam and Harshita Vyas. 2017. Comparative analysis of dripper. Agriculture Update TECHSEAR 12(4): 990-994.
12. Eekhout, J.P.C.; De Vente, J. Global Impact of Climate Change on Soil Erosion and Potential for Adaptation through Soil Conservation. Earth-Sci. Rev. 2022, 226, 103921.
13. Fuentes, M.; Cárdenas, J.P.; Olivares, G.; Rasmussen, E.; Salazar, S.; Urbina, C.; Vidal, G.; Lawler, D. Global Digital Analysis for Science Diplomacy on Climate Change and Sustainable Development. Sustainability 2023, 15, 15747.
14. Ayushi Trivedi and Avinash Kumar Gautam. 2017. Hydraulic characteristics of micro-tube dripper. LIFE SCIENCE BULLETIN 14 (2): 213-216.
15. Bibi, F.; Rahman, A. An Overview of Climate Change Impacts on Agriculture and Their Mitigation Strategies. Agriculture 2023, 13, 1508.
16. Vatistas, C.; Avgoustaki, D.D.; Bartzanas, T. A Systematic Literature Review on Controlled-Environment Agriculture: How Vertical Farms and Greenhouses Can Influence the Sustainability and Footprint of Urban Microclimate with Local Food Production. Atmosphere 2022, 13, 1258.
17. Avinash Kumar Gautam, Atul Kumar Shrivastava and Ayushi Trivedi. 2017. Effect of raised bed, zero and conventional till system on performance of soybean crop in vertisol. Agriculture Update 12 (4): 923-927.
18. Ayushi Trivedi and Avinash Kumar Gautam. 2019. Temporal Effects on the Performance of Emitters. Bulletin of Environment, Pharmacology and Life Sciences 8 (2): 37-42.
19. Benitez-Alfonso, Y.; Soanes, B.K.; Zimba, S.; Sinanaj, B.; German, L.; Sharma, V.; Bohra, A.; Kolesnikova, A.; Dunn, J.A.; Martin, A.C.; et al. Enhancing Climate Change Resilience in Agricultural Crops. *Curr. Biol.* **2023**, *33*, R1246–R1261.
20. Surbhi Suman, Ankita Sharma and Ayushi Trivedi. 2020. Bioactive Phytochemicals in Rice Bran: Processing and Functional Properties: A Review. Int.J.Curr.Microbiol.App.Sci Special Issue-11: 2954-2960.
21. Alam, A.; Rukhsana (Eds.) Climate Change Impact, Agriculture, and Society: An Overview. In *Climate Change, Agriculture and Society*; Springer International Publishing: Cham, Switzerland, 2023; pp. 3–13.
22. Ayushi Trivedi, S. K. Pyasi, R.V. Galkate and Vinay Kumar Gautam. 2020. A Case Study of Rainfall Runoff Modelling for Shipra River Basin. nt.J.Curr.Microbiol.App.Sci Special Issue-11: 3027-3043.
23. Bhanu Pratap Singh, Pradeep Srivastava, Ayushi Trivedi, Deepesh Singh. 2021. Application of Geospatial Techniques for Hydrological Modelling. International Journal of Multidisciplinary Research and Analysis : 181-192.
24. Prajapati, H.A.; Yadav, K.; Hanamasagar, Y.; Kumar, M.B.; Khan, T.; Belagalla, N.; Thomas, V.; Jabeen, A.; Gomadhi, G.; Malathi, G. Impact of Climate Change on Global Agriculture: Challenges and Adaptation. *Int. J. Environ. Clim. Change* **2024**, *14*, 372–379.
25. Ayushi Trivedi and Manoj Kumar Awasthi. 2020. A Review on River Revival. International Journal of Environment and Climate Change 10(12): 202-210.
26. Xiao, D.; Zhang, Y.; Huizi, B.; Tang, J. Trends and Climate Response in the Phenology of Crops in Northeast China. *Front. Earth Sci.* **2021**, *9*, 811621.
27. Vinay Kumar Gautam, M. K. Awasthi and Ayushi Trivedi. 2020. Optimum Allocation of Water and Land Resource for Maximizing Farm Income of Jabalpur District, Madhya Pradesh. International Journal of Environment and Climate Change 10(12): 224-232.
28. Tan, Q.; Liu, Y.; Dai, L.; Pan, T. Shortened Key Growth Periods of Soybean Observed in China under Climate Change. *Sci. Rep.* **2021**, *11*, 8197.
29. Ayushi Trivedi, Bhanu Pratap Singh and Nirjharnee Nandeha. 2020. Flood Forecasting using the Avenue of Models. JISET - International Journal of Innovative Science, Engineering & Technology 7(12) : 299-311.
30. Malay Singh, Y. K. Tiwari, M. K. Awasthi and Ayushi Trivedi. 2020. Analysis of Geospatial Causes for Lowering Discharge in Kanari River. Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-11: 2840-2853.
31. Ozkaynak, E. Effects of Air Temperature and Hours of Sunlight on the Length of the Vegetation Period and the Yield of Some Field Crops. *Ekoloji* **2013**, *22*, 58–63.
32. Ayushi Trivedi, S. K. Pyasi and R. V. Galkate. 2019. Impact of Climate Change Using Trend Analysis of Rainfall, RRL AWBM Toolkit, Synthetic and Arbitrary Scenarios. Current Journal of Applied Science and Technology 38(6): 1-18
33. Minoli, S.; Jägermeyr, J.; Asseng, S.; Urfels, A.; Müller, C. Global Crop Yields Can Be Lifted by Timely Adaptation of Growing Periods to Climate Change. *Nat. Commun.* **2022**, *13*, 7079.
34. Ayushi Trivedi. 2019. Reckoning of Impact of Climate Change using RRL AWBM Toolkit. Trends in Biosciences 12(20) : 1336-1337.
35. Ayushi Trivedi and Manoj Kumar Awasthi. 2021. Runoff Estimation by Integration of GIS and SCS-CN Method for Kanari River Watershed. Indian Journal of Ecology 48(6): 1635-1640.
36. Li, X.; Tan, L.; Li, Y.; Qi, J.; Feng, P.; Li, B.; Li Liu, D.; Zhang, X.; Marek, G.W.; Zhang, Y.; et al. Effects of Global Climate Change on the Hydrological Cycle and Crop Growth under Heavily Irrigated Management—A Comparison between CMIP5 and CMIP6. *Comput. Electron. Agric.* **2022**, *202*, 107408.
37. Ayushi Trivedi, Vinay Kumar Gautam, S.K.Pyasi and Galkate R.V. 2020. Development of RRL AWBM model and investigation of its performance, efficiency and suitability in Shipra River Basin. Journal of Soil and Water Conservation 20(2) : 1-8.
38. Ahmad, Q.-A.; Moors, E.; Biemans, H.; Shaheen, N.; Masih, I.; Ur Rahman Hashmi, M.Z. Climate-Induced Shifts in Irrigation Water Demand and Supply during Sensitive Crop Growth Phases in South Asia. *Clim. Change* **2023**, *176*, 150.
39. Deepak Katkani, Anita Babbar, Vipin Kumar Mishra, Ayushi Trivedi, Shweta Tiwari and Rohit Kumar Kumawat. 2021. A Review on Applications and Utility of Remote Sensing and Geographic Information Systems in Agriculture and Natural Resource Management. International Journal of Environment and Climate Change 12 (4): 1-18.
40. Lesk, C.; Coffel, E.; Winter, J.; Ray, D.; Zscheischler, J.; Seneviratne, S.I.; Horton, R. Stronger Temperature–Moisture Couplings Exacerbate the Impact of Climate Warming on Global Crop Yields. *Nat. Food* **2021**, *2*, 683–691.
41. Ayushi Trivedi, K.V.R. Rao, Yogesh Rajwade, Deepika Yadav and Neelendra Singh Verma. 2022. Remote Sensing and Geographic Information System Applications for Precision Farming and Natural Resource Management. Indian Journal of Ecology 49(5): 1624-1633.
42. Ayushi Trivedi and Vinay Kumar Gautam. 2022. Decadal analysis of water level fluctuation using GIS in Jabalpur district of Madhya Pradesh. Journal of Soil and Water Conservation 21(3) : 250-259.
43. Jägermeyr, J.; Müller, C.; Ruane, A.C.; Elliott, J.; Balkovic, J.; Castillo, O.; Faye, B.; Foster, I.; Folberth, C.; Franke, J.A.; et al. Climate Impacts on Global Agriculture Emerge Earlier in New Generation of Climate and Crop Models. *Nat. Food* **2021**, *2*, 873–885.
44. Neelendra Singh Verma, KV Ramana Rao, Yogesh Rajwade, Deepika Yadav and Ayushi Trivedi. 2023. Growth and yield of strawberry (Fragaria x ananassa Duch) under different mulches in vertisols of Madhya Pradesh. The Pharma Innovation Journal 12(11): 1324-1327.
45. Nirjharnee Nandeha, Ayushi Trivedi, Neelendra Singh Verma, Neha Kushwaha and Satish Kumar Singh. 2023. Benefits and Challenges of Indian Organic Farming: A Comprehensive Review. International Journal of Environment and Climate Change 13(9): 2142-2151.
46. Zhu, P.; Burney, J.; Chang, J.; Jin, Z.; Mueller, N.D.; Xin, Q.; Xu, J.; Yu, L.; Makowski, D.; Ciais, P. Warming Reduces Global Agricultural Production by Decreasing Cropping Frequency and Yields. *Nat. Clim. Change* **2022**, *12*, 1016–1023.
47. Deepika Yadav, Yogesh Rajwade, K.V. Ramana Rao, Ayushi Trivedi and Neelendra Singh Verma. 2023. Adoption of Plastic Mulching Techniques for Enhancing African Marigold ( L.) Production. Indian Journal of Ecology 50(3): 685-689.
48. Vinay Kumar Gautam , Ayushi Trivedi and M.K. Awasthi. 2023. Optimal water resources allocation and crop planning for Mandla district of Madhya Pradesh. Indian Journal of Soil Conservation 51(1): 68-75.
49. Rezaei, E.E.; Webber, H.; Asseng, S.; Boote, K.; Durand, J.L.; Ewert, F.; Martre, P.; MacCarthy, D.S. Climate change impacts on crop yields. *Nat. Rev. Earth Environ.* **2023**, *4*, 831–846.
50. Ayushi Trivedi, M. K. Awasthi, Vinay Kumar Gautam, Chaitanya B. Pande and Norashidah Md Din. 2023. Evaluating the groundwater recharge requirement and restoration in the Kanari river, India, using SWAT model. Environment, Development and Sustainability. Doi: https://doi.org/10.1007/s10668-023-03235-8
51. Deepika Yadav, K V Ramana Rao, Ayushi Trivedi, Yogesh Rajwade and Neelendra Verma. 2023. Reflective mulch films a boon for enhancing crop production: A review. Environment Conservation Journal 24 (1):281-287.
52. Nirjharnee Nandeha, Ayushi Trivedi, M L Kewat, S.K Chavda, Debesh Singh, Deepak Chouhan, Ajay Singh, Akshay Kumar Kurdekar and Anand Dinesh Jejal. 2024. Optimizing bio-organic preparations and Sharbati wheat varieties for higher organic wheat productivity and profitability. AMA 55(1): 16739- 16760.
53. Asseng, S.; Martre, P.; Maiorano, A.; Rötter, R.P.; O’Leary, G.J.; Fitzgerald, G.J.; Girousse, C.; Motzo, R.; Giunta, F.; Babar, M.A.; et al. Climate Change Impact and Adaptation for Wheat Protein. *Glob. Change Biol.* **2019**, *25*, 155–173.
54. Ashwini Kumar, Ayushi Trivedi, Nirjharnee Nandeha, Girish Patidar, Rishika Choudhary and Debesh Singh. 2024. A Comprehensive Analysis of Technology in Aeroponics: Presenting the Adoption and Integration of Technology in Sustainable Agriculture Practices. International Journal of Environment and Climate Change 14(2): 872-882.
55. Smita Agrawal, Amit Kumar, Yash Gupta and Ayushi Trivedi. 2024. Potato Biofortification: A Systematic Literature Review on Biotechnological Innovations of Potato for Enhanced Nutrition. Horticulturae 2024, 10, 292. https://doi.org/10.3390/horticulturae10030292. 1-17.
56. Ashwini Kumar, Ayushi Trivedi, Nirjharnee Nandeha and Niveditha MP. 2024. Sustainable Agriculture Development and Optimim Utilization of Natural resources: Striking a Balance. Journal of Scientific Research and Reports. 30(5): 477-486.
57. Janmohammadi, M.; Sabaghnia, N. Strategies to Alleviate the Unusual Effects of Climate Change on Crop Production: A Thirsty and Warm Future, Low Crop Quality. A Review. Biologija 2023, 69, 121–133.
58. Zhu, C.; Kobayashi, K.; Loladze, I.; Zhu, J.; Jiang, Q.; Xu, X.; Liu, G.; Seneweera, S.; Ebi, K.L.; Drewnowski, A.; et al. Carbon Dioxide (CO2) Levels This Century Will Alter the Protein, Micronutrients, and Vitamin Content of Rice Grains with Potential Health Consequences for the Poorest Rice-Dependent Countries. Sci. Adv. 2018, 4, eaaq1012.
59. Zhang, D.; Liu, J.; Li, D.; Batchelor, W.D.; Wu, D.; Zhen, X.; Ju, H. Future Climate Change Impacts on Wheat Grain Yield and Protein in the North China Region. Sci. Total Environ. 2023, 902, 166147.
60. Shamim, S.; Abdullah, M.; Shair, H.; Ahmad, J.; Farooq, M.; Ajmal, S. Evaluation for impact of climate change on wheat (Triticum aestivum L.) grain quality and yield traits. Biol. Clin. Sci. Res. J. 2024, 1, 842.
61. Malik, A.; Li, M.; Lenzen, M.; Fry, J.; Liyanapathirana, N.; Beyer, K.; Boylan, S.; Lee, A.; Raubenheimer, D.; Geschke, A.; et al. Impacts of Climate Change and Extreme Weather on Food Supply Chains Cascade across Sectors and Regions in Australia. *Nat. Food* **2022**, *3*, 631–643.
62. Vikas Gupta, Ayushi Trived, Nirjharnee Nandeha, Duyu Monya, K. Dujeshwer, Amit Kumar Pandey and Ashutosh Singh. 2024. Micro Plastic Pollution in Soil Environment: A Comprehensive Review. Journal of Scientific Research and Reports. 30(6): 412-419.
63. Ashwini Kumar, Dibyajyoti Mahanta, Mohini M. Dange, Ayushi Trivedi, and Nirjharnee Nandeha. 2024. “Global Challenges Facing Plant Pathology: A Review on Multidisciplinary Approaches to Meet the Food Security”. Journal of Scientific Research and Reports 30 (6):884-92. https://doi.org/10.9734/jsrr/2024/v30i62106.
64. Prabha Haldkar, Mohini M. Dange, Ayushi Trivedi, Nirjharnee Nandeha, and Suneel Kumar Rathour. 2024. “A Review on Nanotechnology in Food Science: Functionality, Applicability and Safety Assessment”. Journal of Scientific Research and Reports 30 (6):876-83. <https://doi.org/10.9734/jsrr/2024/v30i62105>
65. Sünnemann, M.; Beugnon, R.; Breitkreuz, C.; Buscot, F.; Cesarz, S.; Jones, A.; Lehmann, A.; Lochner, A.; Orgiazzi, A.; Reitz, T.; et al. Climate Change and Cropland Management Compromise Soil Integrity and Multifunctionality. *Commun. Earth Environ.* **2023**, *4*, 394.
66. Ayushi Trivedi, M. K. Awasthi, Nirjharnee Nandeha, Vinay Kumar Gautam and Mukesh Kumar Mehla. 2024. Addressing water security challenges through groundwater recharge for revival of Kanari River using AHP and geospatial techniques. Discover Water. Springer Nature. 4:59. https://doi.org/10.1007/s43832-024-00124-7
67. Dai, A.; Zhao, T.; Chen, J. Climate Change and Drought: A Precipitation and Evaporation Perspective. *Curr. Clim. Change Rep.* **2018**, *4*, 301–312.
68. Nandeha N and Kewat ML. 2018. Evaluation of bio-organic preparations on yield of Sharbati wheat varieties under Kymore plateau and Satpura hill zone of Madhya Pradesh. International Journal of Current Microbiology and Applied Sciences 7(6):619-626
69. Nandeha N, Dewangan, YK and Sahu PL. 2016. Effect of crop geometry and nutrient management on yield performance of sweet corn (Zea mays l. Saccharata) under Chhattisgarh plain ecosystem. The Bioscan,11(4): 2293-2295.
70. Nandeha N, Dewangan, YK and Sahu PL. 2016. Response of sweet corn (Zea mays l. saccharata) under vayring crop geometry and nutrient management on nutrient uptake and economics under Chhattisgarh plain ecosystem. Progressive Research– An International Journal 11: 3738-3740.
71. Kyei-Mensah, C.; Kyerematen, R.; Adu-Acheampong, S. Impact of Rainfall Variability on Crop Production within the Worobong Ecological Area of Fanteakwa District, Ghana. Adv. Agric. 2019, 2019, 7930127.
72. Nugroho, S.; Febriamansyah, R.; Nurhamidah, N.; Gunawan, D. Assessment of Extreme Precipitation for Developing Agricultural Adaptation Strategy in the Selo Watershed Area. Int. J. Adv. Sci. Eng. Inf. Technol. 2023, 13, 1889–1897.
73. Nandeha N, Sahu J and Sahu PL. 2017. Panchgavya: gift from the Indian breed cow. Progressive Research – An International Journal. Volume 12 (Special-I): 1070-1075.
74. Sahu H, GS Tomar and Nandeha N.2017. Effect of planting density and levels of nitrogen on yield and yield attributes of sweet sorghum (Sorghum bicolor L. Monech) varieties. International journal ofchemical studies. 6(1):2098-2101
75. Sahu PL, Chitale S, Nandeha N, Kurrey D and Kanwar PC.2015.Effect of different combination of organic materials and biofertilizers on growth and economics on scented rice (Oryza sativa L.) varieties.
76. Kumar R, Shrivastava S.K., Sahu P.L and Nandeha N., 2017. Efficacy of adjuvants on npv persistency against helicoverpa armigera (hubner) on tomato crop. Progressive Research – An International Journal. Volume 12 (Special-I) : 878-880