Library Progress International *Print version ISSN 0970 1052*
Vol.43, No.2, Jul-Dec 2023: P.2165-2175 *Online version ISSN 2320 317X*

Original Article *Available online at www.bpasjournals.com*

An Analytical Study on Climate Change, Food Security and Sustainable Agriculture: Indian Perspective

Mr. Taku Maji*, Dr. Rumi Dhar** and **Dr. Gyati Yam*****

*****(Research Scholar), Department of Law, Nagaland University; Email Id-takumaji@gmail.com
******(Assistant Professor) Department of Law, Nagaland University, Lumami; Email Id-rumidhar@nagalanduniversity.ac.in
*******(Assistant Professor) Department of Forestry, Nagaland University, Lumami; Email Id-gyatiyam@nagalanduniversity.ac.in

How to cite this article: Mr. Taku Maji, Dr. Rumi Dhar and Dr. Gyati Yam (2023). An Analytical Study on Climate Change, Food Security and Sustainable Agriculture: Indian Perspective. *Library Progress International,* 43(2), 2165-2175

Abstract: Agricultural practices are responsible for 10 to 12% of the total global anthropogenic emissions of Green Houses Gases (GHGs). Farming techniques are intrinsically linked to Climate Change. In regard to climate Change, agriculture faces a dual challenge such as need to adapt and need to mitigation its impact on the climate change. In view of climate change's effect on agriculture production is crucial due to mounting concerns regarding food security. Climate change negatively affects the nutritional value of plant food, is the direct effect of Climate Change on agriculture and food security. Thus, Food security is severely influenced by climate change. This paper is an attempt to highlight and address the vicious cycle between climate change and agriculture and vice-versa; how climate change does affect agriculture yields? And how does agricultural practice affect climate change? The present study is aimed to examine the effects of climate change on agriculture and food security.

The research methodology, in this paper, is followed on the method of doctrinal and observational, and would not involve any empirical approach. The descriptive information is based on the analysis of secondary source of data. The secondary data is availed from various journals, internet, media report, books etc. In conclusion, climate change may result in detrimental impacts on agriculture and food security particularly in developing countries like India. Sustainable agriculture can mitigate climate change by reducing GHGs emissions and increasing carbon sequestration in soils.

Keywords: Climate Change, Emission, Food Security, Green Houses Gases, India, Mitigation, Sustainable Agriculture.

Introduction

There is a vicious cycle between climate change and agriculture. Climate change negatively affects agricultural yields and farming techniques themselves exacerbate climate change patterns by trying to increase yields. This specific issue should to be tackled to break the vicious cycle, thus limiting the effect of climate change on agriculture and vice-versa.. The changing climate will influence the food grain production in different manners. The concept of "Sustainable Agriculture" endeavors to reduce chemical inputs and energy use in farming systems, in order to minimize environmental damage and to ensure longer-term productivity. Sustainable farming is one application of environmental responsibility. Sustainable agriculture can mitigate climate change by reducing GHGs emissions and increasing carbon sequestration in soils. sustainable agriculture simultaneously enhances agricultural productivity and soil carbon sequestration by restoring soils that have been degraded by excessive disturbance, erosion, organic matter loss, and other processes. Sustainable

agriculture can also play an important role in climate change adaptation. Sustainable farming practices reduce the vulnerability of crops to floods and drought by increasing the organic matter in soils, thereby enhancing the soil's water retention capacity. Finally, sustainable agriculture promotes food security by protecting the livelihoods of small farmers and indigenous communities.

The research methodology in this paper would be followed on the method of doctrinal and observational and would not involve any empirical approach. The information will be based on the analysis of secondary source of data. The secondary data is availed from various journals, internet, governmental publications, earlier study, media report and books. the research would be descriptive and narrative information, using secondary source of data.

Climate Change and Agriculture

An optimistic scenario predicts a global temperature increase of 2 degree by 2100, which would bring about a drastic overhaul of agriculture practice[1]. Thus, agricultural practices are intrinsically linked to climate change. Regardless of farmers' ability to adapt to this phenomenon, the dramatic changes currently occurring will change the farmer to adapt even more their land use and production intensity[2]. Agriculture faces a dual challenge when it comes to climate change: it will need to adapt if it is to feed a population that has just reached the 7 billion mark, but it will also need to mitigation its impact on the climate change if it is to avoid contributing to its own destruction[3]. Agriculture is responsible for approximately 13.5 % of global greenhouse gases emissions, primarily methane and nitrous oxide[4]. Agriculture makes as significant contribution to greenhouse gases emissions, accounting for between 11 and 15% of the total and is caused of between 70 and 90% of deforestation worldwide[5]. It is also worth note that agriculture itself is responsible for 10 to 12% of the total global anthropogenic emissions of GHGs as explained by the OECD in 2012.[6] Thus, Farm management practices directly affect these GHGs and mitigation actions are needed. The OECD highlights the fact that many win-win situations such as fertilizer management and animal breeding are not adopted. On contrary, climate change affects agriculture in three major ways: increases in CO2 will directly affect crop and weed growth rates (the so-called fertilizer effect); temperature, rainfall and sunshine regimes, all crucial to crop growth, will change; and sea level rise could lead to a loss of agriculture land.[7] Changing wind patterns could also introduce new pests and pathogens whilst rising temperatures could assist a plethora of fungi, bacteria, virus, nematodes and insects[8]**.** The projecting climate change effect on specific crops yields or livestock is complex due to intersecting of physical, biological, and agronomic factors[9]. Most research on climate change effect focused on four staples crops- Rice, Wheat, Soy and Maize. Many studies do not account for climate or extreme weather effects on yields or land value. Rising temperature associated with climate change have already affected crops yielding globally[10]. However, it is important to note that effects on agriculture are uneven and depend geographies, crop type, and degree if the temperature increases.[11] It was evaluated that climate change could reduce farm income globally by 15 to 18 % and by 20 to 25 % in unirrigated areas[12].

[1] Climate change: Agriculture at the negotiating table, technical center for agricultural and rural cooperation (cta), spore, no. 156 (December 2011 - January 2012), 4, 4-5 (2012)

[2] Aspen institute, climate change and agriculture: an information asymmetry approach khare parth et. Al (eds, (2019)

[3]Climate change: agriculture at the negotiating table, technical centre for agricultural and rural cooperation (cta), spore, no. 156 (december 2011 - january 2012), 4, 4-5 (2012)

[4] Intergovernmental panel on climate change, climate change: synthesis report (2007)

[5] Climate change: agriculture at the negotiating table, technical centre for agricultural and rural cooperation (cta), spore, no. 156 (december 2011 - january 2012), 4, 4-5 (2012)

[6] Aspen institute, climate change and agriculture: an information asymmetry approach, khare parth et. Al (eds, (2019)

[7] Rupert howes, climate change and agriculture: cause and effect, 215, vol. 4.1 jed, 215, 215-18 (1995)

[8] Rupert howes, climate change and agriculture: cause and effect, 215, vol. 4.1 jed, 215, 215-18 (1995)

[9] International institute for sustainable development, climate change and agriculture, julia laforge et. Al (eds), 22 (2021)

[10]Challinor et al., A meta-analysis of crop yield under climate change and adaptation, Nature Climate Change 4, 287–291 (2014).

[11] International institute for sustainable development, climate change and agriculture, Julia Laforge et. Al (eds), 22 (2021)

[12] Hari,KhareandSubramanianClimatechangeandIndianagriculture.*Available*https://changingclimate.ca/site/assets/upload

There seems to be a vicious cycle between climate change and agriculture: climate change negatively effects agricultural yields and farming techniques themselves exacerbate climate change patterns by trying to increase yields[13]. This specific issue should to be tackled to break the vicious cycle, thus limiting the effect of climate change on agriculture and vice-versa[14].

Climate Change:

Considering climate change's effect on agriculture production is crucial due to mounting concerns regarding food security, especially the background of potential food supply disruptions and the high dependence on imports.[15] Climate trends over the last several decades have already been affecting agriculture[16]. For example, these effects have been negative with respect to wheat and maize production in many regions[17], although warming has benefitted crop production in some high-latitude regions. For the future, climate projections indicate that agricultural production will be affected through multiple pathways: heat stress via temperature increases; more frequent extreme weather events such as droughts and floods; changing rainfall amounts and patterns; shifts in timing and length of growing; and changing prevalence and severity of pests, weeds and crop and livestock diseases, for example. There is a enormous literature on these projected impacts, regularly summarized in the IPCC's series of Assessment Reports and elsewhere. In general, strong negative impacts of climate change are expected for major cereals, especially at low latitudes. Exceeding critical physiological limits in temperature will sharply reduce gain yields. Rainfall effects on agriculture are uncertain,[18] and changes in variability in climate and extreme events may affect food security in ways not yet fully elucidated[19].

Nevertheless, changes in climate over the last 30 years have already reduced global agricultural production in the range of 1-5% per decade globally, compared with what would have been achieved in the their absence, with particularly negative impacts for tropical cereal crops such as maize and rice (Portel et al., 2014). The evidence is mounting that even at (+2 Degree C) levels of warming, agricultural productivity is likely to decline across the world but especially across tropical areas.[20] At + 1.5 Degree Celsius of warming, impacts on human and natural systems will still be considerable.[21] Effects will be felt on all agriculture systems. Temperature shifts are likely to change the distribution and productivity of major cash crops such as coffee and cocoa in some tropical regions[22].

Nevertheless, we do have some evidence that adaptation may not be on track. For example, at global level, crops yield growth rates per year are lagging behind. A recent meta-analysis of integrated assessment model projections to the 2050s indicates that on average, a crop yield growth rate of 1.8% per year will be

s/sites/3/2021/05/National-Issues-Report_Final_EN.pdf. Visited on Mar. 5, 2025 at 9:22 pm

[13] Aspen institute, climate change and agriculture: an information asymmetry approach, Khare Parth et. Al (eds, (2019).

[14] Id.

[15] Laron Alleyne and Julian Jones, The Impact of Climate Change on Select Agricultural Production in a Water Scarce Country, 7(1), Journal of Development Policy and Practice, 112, 112–136, (2021)

[16] Philip Thornton, *Agriculture in a changing climate: Keeping our cool in the face of the hothouse,* 47(4) outlook agr, 284, 283–290(2018).

[17] Porter JR, et al., *Food security and food production systems; Field* CB et al., *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Cambridge, United Kingdom and New York, USA: CUP, 485–533 (2014).

[18] Lobell db and asseng s comparing estimates of climate change impacts from process-based and statistical crop models. Environmental research letters 12: 015001 (2017).

[19] see devries r, trade-offs and synergies among climate resilience, nutrition, and agricultural productivity of cereals – what are the implications for the agricultural research agenda? Background paper for the cgiar ispc science forum 2018, (oct. 10, 2018, 8:13 pm), https://www.scienceforum2018. Org/sites/default/files/2018.

[20] Challinor aj, et al., *a meta-analysis of crop yield under climate change and adaptation,* 4 nature climate change 4: 287–291 (2014).

[21] see ipcc (2018). An ipcc special report on the impacts of global warming of 1.5_c above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Summary for policymakers. Geneva: intergovernmental panel on climate change, (oct. 20, 2018 8:26pm), http://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf.

[22] Schroth g, et al., *vulnerability to climate change of cocoa in west africa: patterns, opportunities and limits to adaptation*. Science of total environment, 236: 231–241 (2016).

needed to feed the global population; the current crop yield growth rate in 1.2% per year[23]. This is clearly of concern for vulnerable lower and middle income countries with high population growth rates and a food self-sufficient agenda. On the other hand, international trade can play an important role in extenuating adverse effects of climate change on food security, as the comparative advantage of different countries and production regions change[24]. Barriers to trade may limit this role in some situations, however, and agricultural trade liberalization may undermine global mitigation gains.[25]

Climate change and Agriculture in India

Climate change, farming, and the environment are interconnected- climate change affects the farming practices, which leads to an increased use of practices that are harmful to the environment.[26] This is particularly visible in developing economies, where a major part of the population depends on agriculture for their livelihoods. The Indian agricultural practices have led to several environmental issues, primarily: degradation of land, deforestation, pest problems, disposal of industrial and agricultural waste, and air pollution.[27] Subsistence farming employs nearly half of the population and vagaries of weather push the farmers into the increased use of pesticides, changing the crop type, or other activities that result in environmental harm. For instance, the Indian State of Punjab has more than 80% of its land under cultivation, which has turned into a rice-wheat monoculture and suffers from a severe paddy stubble burning problem. The population impacts are visible in as far as New Delhi, where stubble burning contribution to 32% of its pollution levels in October 2018[28]**.** The increased particulate matter (or PM 2.5) can lead to a host of respiratory problems when inhaled.

Climate change has imposed a multitude of impacts on the farmers[29]**.** The success of agriculture and thereby livelihood security for a marginal farmer depends on their decision making skills. An accurate decision of when to sow or what type and quantity of fertilizer to apply is affected by climate variables and will affect the climate in return. Climate change has generated a lot of risks which ultimately translate to costs and greatly affect livelihood sustainability. Hence, there is a great need for proper planning and real information is crucial for agriculture, particularly in a drastically changing climate. Need for timed and accurate weather information is crucial for agriculture, especially in a drastically changing climate. This study proposes strategies for information standardization and access focusing in two perspectives[30]- (a) World weather data repositories to exhaustively represent ground stations and (b) interpreting and timed weather forecast made available to farmers. This will require collecting and harmonizing climate and meteorological data, soil data, and water table data by the various agencies. Furthermore, the establishment of a framework and architecture for analyzing the data and making information accessible to the farmer is necessary. This will allow farmers to make informed decisions based on both short-term and long term considerations and to adapt to climate change. Thus, this policy involves the promotion of symmetry of information both at the farming level and at the institutional level.

The Government of India could get funds and implement the policy either by implementing a programme dedicated to the policy itself or by mobilizing its already existing programme[31]. Thus, Digital India could fund technological access to information. Start up India could financially support startups getting involved in the policy implementation. However, these programmes are not specifically dedicated to

[23] Aggarwal p, et al. , how much does climate change add to the challenge of feeding the planet this century? Environmental research letters submitted (2018).

[24] Baldos ulc and hertel tw, *the role of international trade in managing food security risks from climate change.* 7 (2), food security, 275–290 (2015).

[25] Himics m, et al., *does the current trade liberalization agenda contribute to greenhouse gas emission mitigation in agriculture?* 76 food policy, 120–129(2018).

[26] aspen institute, climate change and agriculture: an information asymmetry approach, khare parth et. al (eds, (2019).

[27] id.

[28] Safar, stubble burning from punjab, haryana contributed to 32 % of pollution in delhi on saturday,(April 31, 2025,8:41pm)https://economictimes.indiatimes.com/news/politics-and-nation/stubble-burning-from-punjab-haryana-contributed-to-32-of-pollution-in-delhi-on-saturday-safar/arti

[29] Aspen institute, climate change and agriculture: an information asymmetry approach, khare parth et. al (eds, (2019).

[30] id.

[31] id.

agriculture and other tools will be needed to effectively implement the policy. The Indian Government machinery has extensive programmes to support agriculture[32]. Climate change risks to agriculture will have to be tackled in a holistic way. This will require policy changes in minimum support prices, interest free loans, technical knowledge transfer for climate resilient cropping, capacity building of government machinery, encouragement for farmer collectives, efficient market linkages, and substantive investment in research and development support. To name a few, some of the agriculture interventions by the government are Mahila Kisan Sashakthikaran Paryojana (women farming project), interest subvention Schemes, Priority Lending Policies, Krishi Vigyan Kendras. Input subsidy schemes for fertilizers, National Agriculture Policy, and the state and central government department on Agriculture. While there are many government programme in these areas, there is a need for new outlook and philosophy in dealing with the risk of climate change and making suitable modifications in the existing policies[33].

Climate change and Food Security

The 2008 food price crisis once again made food security a top priority on national and international political agendas [34]. This renewed importance of food security as a public priority had important consequences regarding the international governance of food security, development aid policies and the redeployment of agrarian capitalism. According to the Food and Agriculture Organization (FAO), "Food Security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life"[35]. This definition comprises four key dimensions of food supplies: availability, stability, access, and utilization.[36] Climate change poses significant threats to food production[37]**.** The fact is that there is enough food in the world to feed everyone, but not everyone gets enough food to eat. The links between climate change and food security have, to date, largely been explored in relation to impacts on crop productivity and hence, food production.[38] Climate change imparts all aspects of food security: reducing crops yields, increasing water scarcity, exacerbating unequal access to food, destabilizing food supplies and prices, and hampering individuals' ability to absorb nutrients from food.[39] Climate change amplifies the environmental and socio-economic drivers of food insecurity as its impacts are deeply affected by poverty and inequality.[40] There are three major factors leading to food and nutrition insecurity: poverty prohibits people from buying food to feed themselves and their families, climate change affects food production, especially for small scale farmers; and food waste and losses also contribute greatly to hunger.[41] According to the FAO, 75% of the world's food crop diversity was lost in the twentieth century as farmers abandoned local varieties in favour of genetically uniform high-yielding crops.[42] Although thousands of crops have been cultivated since the drawn of agriculture,[43] twelve crops currently supply 80% of the world's plant-based dietary energy.[44] Just four crops- rice, wheat, potato, and maize- supply nearly 60% of the plant- drived calories and protein.

---

[32] id.

[33] Aspen institute, climate change and agriculture: an information asymmetry approach, khare parth et. al (eds, (2019).

[34] Id

[35]Food and agriculture organization, the state of food insecurity in the world 2001 , food and agriculture organization, rome, (2002).

[36]Josef schmidhuber and francesco n. Tubiello, global food security under climate change, 104(50) national academy of sciences, 19703, 19703-19708 (2007).

[37] Julian cribb, the coming famine: the global food crisis and what we can do to avoid it, 136-37 (2010).

[38] P. J. Gregory, et. Al., climate change and food security, phil. Trans. R. Soc. B, 2139, 2139-2148 (2005).

[39] Care, achieving food and nutrition security & resilience to climate change annual report 11 (2021)

[40] Cecilia tacoli, international institute for environment and development, urban poverty, food security and climate change, 4 (2013).

[41] Care, achieving food and nutrition security & resilience to climate change annual report, 5(2021)

[42]SeeU.N.FOOD&Agric.org.,FirstFruitsofPlantGenePact,May.21,3:42PM2025http://www.fao.Org/news/story/0/item/20162

[43] Cary fowler & pat mooney, shattering: food, politics, and the loss of genetic diversity, 76, 63-76 (1990)

[44]See U.N. food & agric. Org., first fruits of plant gene pact, http://www.fao.org/news/story/0/item/20162.

Food Security, Food System and the Link to Climate:

The direct effect of climate change on agriculture, food systems, and food security, climate change negatively affects the nutritional value of plant foods.[45] Food security is decreased when food system are stressed. This can be caused by a range of factors in addition to climate and other environmental changes (e.g. conflict, changes in International trade agreement and policies, HIV/AIDS) and may be particularly severe when these factors act in combination[46]. Global food security will remain a worldwide concern for the next 50 years and beyond.[47] There has been no significant jump in crop yield in many areas stressing the requirement for higher investments in research and infrastructure, as well as addressing the issue of water scarcity.

Food systems may be simple, as in the case of a substance farmer who produces, processes and consumes food on farm.[48] In many areas, the food system has changed drastically in the last century and continues to become increasingly complex.[49] Food security around the globe is changing very rapidly as urbanization and globalization proceeds a pace. The urbanization of many predominantly rural nations in the last three decades has been accompanied by the rapid growth of supermarkets many, often accompanied by foreign investment global chain.[50]

The marked changes in access and utilization of food around the world provide a context in which to evaluate the likely effects of climate and other ecological changes on crops production and food security. Not all food systems or parts of food systems are equally vulnerable to environmental changes because the capacity to cope with existing variability in bio-physical and socio-economic systems, and the ability of humans to perceive ecological changes and to adapt food system, varies.

Climate change and Food Security: Indian Perspective

Climate change is a vital factor affecting food security in many areas including India.[51] The most significant thing one has to keep in view is that certain of the technologies relating to crop production which were found to be innovative and quite pertinent in the past years might need refinement in the current context as far as food security is concerned. For instance, increase utility of chemical fertilizer and pesticides was suggested earlier to obtain the higher food grain production. After realizing the potential environmental hazards caused by them, however, we gradually initiate supporting controlled use of pesticides and fertilizers.[52]

Food security is severely influenced by climate change. The changing climate will influence the food grain production in different manners. For instance, the spatial and temporal variations in precipitation including rainfall may cause in deficit moisture stress, i.e., drought or excess moisture stress condition, i.e., flooding. Likewise, extreme high or low temperatures result in changes in the length of cropping growing season.[53] These factors would too affect the crop productivity and farm net income and therefore climate resilient agricultural practices have to be promoted. This is applicable to all the nations, including India. Appreciating the effect of climate change on India culture is quite complex as several factors involved in this phenomenon.[54]

---

[45] M. C. Tirado, et., al., *climate change and nutrition: creating a climate for nutrition security, 34(4) food and nutrition bullet, nsinf 537, 533-47 (2013)*

[46] P. J. Gregory, et. Al., *climate change and food security*, phil. Trans. R. Soc. B, 2141, 2139-2148 (2005).

[47] P. S. Brahmanand, et. Al., *challenges to food security in india,* vol. 104 (7) , current science association, 841, 841-846, (2013).

[48] P. J. Gregory, et. Al., *climate change and food security*, phil. Trans. R. Soc. B, 2141, 2139-2148 (2005).

[49] Millstone, e. & lang, t., *the atlas of food.* London: earthscan publications ltd. (2003); see barling, d. *Food systems: food policy and governance perspectives*. Gecafs food systems workshop, oct., 21-22 (2004)

[50] Reardon, et. Al., *the rise of supermarkets in africa, asia and latin america*. Am. J. Agric. Econ. 85, 1140-1146 (2003). (doi:10.1111/j.0092- 5853.2003.00520.x.)

[51] P. S. Brahmanand, et. al., *Challenges to food security in India,* Vol. 104 (7) , Current Science Association, 841, 841-846, (2013).

[52] P. S. Brahmanand, et. al., *Challenges to food security in India,* Vol. 104 (7) , Current Science Association, 841, 841-846, (2013).

[53] Id ar 842.

[54] Id.

Stability of Food System

The stability of the whole food system may be at risk under the climate change, as climate change can be significant determinant for prospective future trends,[55] as well as short-term variability of prices. Food and nutrition security can only be achieves when all people have, when needed social, economic and physical access to safe (free of contaminants), adequate and nutritious food to satisfy their dietary needs and choices for an active and healthy life.[56] Since 2007, the global food equation has been at a precariously low level and, consequently, even small shocks on the supply or demand side the equation will have large effects on prices, experienced in 2008.[57] Food security of the poor is strongly affected by staple food prices, as a large part of an improvised family's income has to be spent on staple foods. Climate change is likely to increase food market volatility for both production and supply.[58] In 2009, the UN Food and Agriculture Organisation (FAO) characterized climate change and food security in terms that ought to satisfy both the productionist and distribtutionist camps: "Climate change negatively affects the basic elements of food production, such as water, soil and biodiversity.[59] More broadly it affects all four dimensions of food security: food availability, food accessibility, the stability of the food supply and the ability of consumers to use food, including food safety and nutritional value".[60]

Several studies have attempted to bridge this analytical gap in global-scale models. One approach is to develop statistical links between projected changes in consumption or production to food security indicators.[61] For instance, utilized the correction between the share of undernourished in the population- as defined by the Food and Agriculture Organisation (FAO)- and the ratio of average national food supply (including imports), relative to aggregate national food requirements, to assess the impact of climate change on food security.[62] Based on this relationship, and using a set of socio-economic scenarios, projected an increase in the number of people "at risk of hunger," with their study projecting that an additional 175 million people could be undernourished in 2080 because of climate change. It is a projected 2.6% of overall population of food insecure countries in 2080.[63] The impacts of climate change are expected to be more adverse in low- and middle-income countries.[64]

Food system stability can also be endangered by demand shocks, for example, when aggressive bio-energy and quota policies were applied by the political economy.[65] These sorts of policy shifts, made in the past decade by the United States and European Union, have been motivated in part by energy security concerns

[55] G. C. Nelson, et., al*., food security, farming, and climate change to 2050: scenarios, results and policy options, ifpri, washington dc (2010).*

[56] Kwanele, et., al., *food and nutrition security theory,* 41(3) food and nutrition bulletin, 368, 367-379 (2020).

[57] J. Von braun, *food security,* 1, 9-15 (2009).

[58] l.o. mearns et., at., *climate change,* 32, 257-292 (1996).

[59] William sweet, *food and climate*, foreign policy association, ,66, 63-72 (2014)

[60] id.

[61]John m. Antle, *climate change, vulnerability and food insecurity*, 30 (2) agricultural & applied economics association, 1-7,(2015).

[62] id.

[63] Id.

[64] Fao.The future of food and agriculture—trends and challenges. Food and agriculture organization of the united nations (2017).

[65] J. Beckman, et., al., eur, rev. Agric. Econ. 39, 137-156 (2012).

and partly by climate mitigation objectives.[66] The resulting destabilization of food markets, which contributed to major food problem, was therefore partly related to climate change policy.[67]

Food Security, Sustainable Agriculture and Climate Change

The concept of "Sustainble Agriculture" endeavours to reduce chemical inputs and energy use in farming systems, in order to minimize environmental damage and to ensure longer-term productivity.[68] Sustainable farming is one application of environmental responsibility.[69] Most agricultural assessment of world ecological change made to date have not focused explicitly on sustainability issues, and have neglected the considerable effects of shifting agriculture zones, alterations in commercial fertilizer and pesticide use, and changes in the demand for water resources.[70] Climate change can impact agricultural sustainability in two interrelated ways.[71] Firstly, by diminishing long-term ability of agro-ecosystems to provide food and fiber for the world's population; and secondly, by inducing shifts in agricultural regions that may encroach upon natural habitats, at the expense of floral and faunal diversity.

Many previous studies suggest that agriculture has significant potential to mitigate climate change, which transform the role of agriculture from a major emitter to a much smaller emitter or even a net sink.[72] While industrial agriculture is one of the largest sources of greenhouse gases, small-scale sustainable agriculture can play key role in climate change mitigation and adaptation while conserving agro biodiversity and promoting food security.[73]

Sustainable agricultural production is a goal rather than a rigid of practices. [74] Normally, sustainable agriculture seeks to integrate natural pest, water, and soil management technologies the production process while reducing the use of synthetic pesticides and fertilizers[75]. It combines the knowledge and skill of farmers with the latest scientific innovations to support farmer self-reliance and to minimize dependence on costly external inputs.[76] Sustainable agriculture also strives to enhance and conserve agro biodiversity, including plant resources, livestock, insects and organisms. [77]

Sustainable agriculture can mitigate climate change by reducing GHGs emissions and increasing carbon sequestration in soils.[78] Sustainable farming practices reduce fossil fuel-based carbon dioxide emissions

---

[66] European commission, directive 2003/30/ec of the european parliament and of the council of 8 may 2003 on the promotion of the use of biofuels or other renewable fue|s for transport (published 17 5 2003 official journal the european union, l123/42-46) '(2003); u s congress, energy independence and security act of2007 public law n0.140 (42 u5c 17001 note) 110th congress, 19 december (2007).

[67]Tim wheeler and joachim von braun, *climate change impacts on global food security*, 341 (6145) american association for the advancement of science, 508- 513 (2013).

[68] Tamas toth, et., al., *global environment change and food security:: a socio-economic perspective, cereal research communications ,* 36 akadémiai kiadó, 1773, 1771-1774 (2008).

[69] Bhupal bhattacharya and manik chakraborty, , climate change sustainable and human rights: issues and challenges in india, 113 (susmita dhar and subir kumar roy eds., 1st ed. 2023).

[70] Tamas toth, et., al., *global environment change and food security:: a socio-economic perspective, cereal research communications ,* 36 akadémiai kiadó, 1773, 1771-1774 (2008)

[71] Id.

[72] See the intergovernmental panel on climate change, climate change 2007: synthesis report (May 3, 2025, 5:23 pm). Https://www.ipcc.ch/site/assets/uploads/2018/02/ar4_syr_full_report.pdf

[73] Working group on climate change and development, other worlds are possible: human progress in an age of climate change 40-42 (aug. 3, 2024, 5:23 pm) http://www.iied.org/pubs/pdfs.

[74]Carmen g. Gonzalez, *climate change, food security, and agrobiodiversity: toward a just, resilient, and sustainable food system,*22 (3) fordham environmental law review, 513, 493-522 (2011).

[75] Jules n. Pretty, regenerating agriculture: policies and practices for sustainability and self-reliance, 58-80 (1995)

[76] Jules n. Pretty, agri-culture: reconnecting people, land and nature 56 (2002).

[77] Carmen g. Gonzalez, *climate change, food security, and agrobiodiversity: toward a just, resilient, and sustainable food system,*22 (3) fordham environmental law review, 513, 493-522 (2011).

[78] See generally international trade centre (unct ad/wto) & research institute of organic agriculture (fibl), organic farming and climate change (aug. 3, 2024, 5:23 pm). Http://www.ifoam.org/growing_organic/ 1arguments_for_oa/environmental_benefits/pdfs/

because they consume less fossil fuel per hectare than industrial agriculture.[79] By relying on legumes, manure, and crop residues to fertilize the soil, sustainable agriculture minimizes the use of fossil-fuel based nitrogen fertilizers and also reduces nitrous oxide emissions.[80] Furthermore, sustainable farming usually involves practices such as the use of green and animal manure, crop rotation, intercropping, and composting that reduce soil erosion and enhance the ability of soil to sequester carbon. Agro forestry promotes the sequestration of carbon in above-ground vegetation as well as soil[81]**.** Finally, sustainable agriculture simultaneously enhances agricultural productivity and soil carbon sequestration by restoring soils that have been degraded by excessive disturbance, erosion, organic matter loss, and other processes.[82]

The mitigation potential of agriculture is enormous. Sustainable agriculture could sequester nearly 40% of annual carbon dioxide emissions.[83] According to the IPCC, soil carbon sequestration alone is responsible for 89% of agriculture's mitigation potential.[84] The majority of this carbon sequestration potential (about 70%) is concentrated in developing countries.[85] Moreover, agricultural mitigation strategies can be implemented at an extremely low cost, as compared to mitigation option in non-agricultural sectors, such as energy, transportation and forestry.[86] Sustainable agriculture can also play an important role in climate change adaptation. Sustainable farming practices reduce the vulnerability of crops to floods and drought by increasing the organic matter in soils, thereby enhancing the soil's water retention capacity.[87] Farmers practicing sustainable agriculture are better able to cope with hurricanes, droughts, and other extreme weather events than conventional farmers.[88] Sustainable farming practices can restore the productivity of degraded soils in the arid tropics, improving agriculture yields to a greater extent than synthetic fertilizers.[89] Sustainable agriculture utilizes wild and cultivated landscapes natural pests control strategies to enhance the resilience of ecosystem to climate change related disturbances.[90] Agro bio-diverse food production systems can resist climate changes in the geographic range of pests, disease vectors invasive species through biological control of insects, weeds, pathogens.[91] Sustainable agricultural systems rely on the diversity crops, landscapes, fields and farm activities to buffer the impacts natural disasters and to provide alternative sources of fuel, medicine, and food.[92]

Finally, sustainable agriculture promotes food security by protecting the livelihoods of small farmers and indigenous communities.[93] Sustainable farming practices protect and enhance the traditional knowledge and skills that will play an essential role in adapting to climate change.[94] This knowledge will enable

---

[79] See Bellarby et al., *cool farming: climate impacts of agriculture and mitigation potential* (aug. 3, 2024 5:59 pm) http :! ! Marktcheck, greenpeace . At/uploads/ media/coolf arming_report_ finalwebo 1 .pdf.

[80] Id.

[81] Supra at 171.

[82] Tim J. Lasalle & Paul Hepperly, Regenerative Organic Farming: A Solution to Global Warming (May 3, 2025 at 5:58 PM) http://www.rodaleinstitute.org/files/ Rodale_Research_Paper-07_3 0 08 .pdf.

[83] Tim J. Lasalle & Paul Hepperly, Regenerative Organic Farming: A Solution to Global Warming (May 3, , 2025 at 5:58 PM) http://www.rodaleinstitute.org/files/ Rodale_Research_Paper-07_3 0 08 .pdf

[84] IPCC, Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of theIntergovernmentalPanelonClimateChange499, 515(May 3, 2025 at 5:59 PM) http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3 -chapter8.

[85] Id at 499.

[86] Id.

[87] Tim J. Lasalle & Paul Hepperly, Regenerative Organic Farming: A Solution to Global Warming (May 3, 2025 at 5:58 PM) http://www.rodaleinstitute.org/files/ Rodale_Research_Paper-07_3 0 08 .pdf.

[88] See Climate Change Project, The Use Indigenous and Rural Communities (Platform for Agrobiodiversity Briefing Paper), (May 3, 2025 at 6:03PM) http://www.agrobiodiversityplatform.content/uploads/2009/09/P AR_climate-

[89] Tim J. Lasalle & Paul Hepperly, Regenerative Organic Farming: A Solution to Global Warming (May 3, 2025 at 5:58 PM) http://www.rodaleinstitute.org/files/ Rodale_Research_Paper-07_3 0 08 .pdf.

[90] Id.

[91] See Climate Change Project, The Use Indigenous and Rural Communities (Platform for Agrobiodiversity Briefing Paper), (May 3, 2025, at 6:03PM) http://www.agrobiodiversityplatform.content/uploads/2009/09/P AR climate-.

[92] Supra at note 181.

[93] See Climate Change Project, The Use Indigenous and Rural Communities (Platform for Agrobiodiversity Briefing Paper), (May 3, 2025, at 6:03PM) http://www.agrobiodiversityplatform.content/uploads/2009/09/P AR_climate-.

[94] Tim J. Lasalle & Paul Hepperly, Regenerative Organic Farming: A Solution to Global Warming (May 3, 2025, at 5:58

farmers to help to climate change by adjusting the timing and location of crop cultivation, breeding seeds suitable for changing thermal and hydrological conditions, conditions, changing the timing of irrigation, modifying the management of nutrients, and applying water-conserving technologies.[95] While inaugurating the triennial conference by the International Agricultural Economists on August 3, 2024, the Prime Minister of India stated that challenges before sustainable agriculture and food system can only be tackled with the holistic approach of "One Earth, One Family and One Future".[96]

Conclusion

In conclusion, global warming may result in detrimental impacts on food supply and security, especially in developing countries. Even if developing countries adapt to climate change, they will not be able to completely avoid the problems associate with climate change. Furthermore, these harmful outcomes of climate change in developing countries and potentially positive outcomes in developed countries will probably increase the gap in wealth, access to food, and health between rich and poor countries.

The climate, food, and agro biodiverty crises highlight the urgent need for reform of global agricultural policies[97]. Because agriculture both generates and sequesters GHGs, climate change may serve as a catalyst agricultural policy reform that promote sustainable agriculture as integrated solution to the food, climate and agro biodiversity crises.[98] Sustainable agriculture produces fewer GHGs emissions than industrial agriculture, increases the ability of soils to sequester carbon, protects plant genetic resources, reduces the risks associated with climate change (such as floods and droughts), preserves traditional knowledge, and promotes food security by supporting 1 livelihoods of small farmers.[99] In addition, sustainable agriculture is highly productive. Sustainable agriculture can produce enough food on a global per capita basis to sustain both current and projected future populations without increasing the amount of land devoted to agricultural production.[100] Indeed, sustainable agriculture in the global south is at least eighty percent more productive than conventional agriculture.[101] Numerous studies have concluded that sustainable agriculture has significantly increased the agricultural yields in Asia, Latin America, and Africa, increased the incomes of small farmers, benefited the environment, reduced dependence on external inputs, and kept alive rural communities deep reservoir of traditional knowledge.[102] The food security argument and the call for a new wave of technological innovations, thus,

PM) http://www.rodaleinstitute.org/files/ Rodale_Research_Paper-07_3 0 08 .pdf.; See Climate Change Project, The Use Indigenous and Rural Communities (Platform for Agrobiodiversity Briefing Paper), (May 3, 2025, at 6:03PM) http://www.agrobiodiversityplatform.content/uploads/2009/09/P AR_climate-.

[95] International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), Agriculture at a Crossroads: Synthesis Report 5 1 (May 3, 2025, at 7:33PM) http://www.agassessment.org/reports/ IAASTD/EN/Agriculture%20at%20a%20Crossroads_Synthesis%20Report%20%2 8English%29.pdf.

[96] Agricultural transformation in India a lesson for others: PM, The Hindu, May 4, 2025, at 8.

[97] Carmen g. Gonzalez, *climate change, food security, and agrobiodiversity: toward a just, resilient, and sustainable food system* ,22 (3) fordham environmental law review, 516, 493-522 (2011).

[98] carmen g. Gonzalez, *climate change, food security, and agrobiodiversity: toward a just, resilient, and sustainable food system* ,22 (3) fordham environmental law review, 516, 493-522 (2011).

[99]Tim j. Lasalle & paul hepperly, regenerative organic farming: a solution to global warming (aug. 3, 2024 at 5:58 pm) http://www.rodaleinstitute.org/files/ rodale_research_paper-07_3 0 08 .pdf.

[100]Tim j. Lasalle & paul hepperly, regenerative organic farming: a solution to global warming (aug. 3, 2024 at 5:58 pm) http://www.rodaleinstitute.org/files/ rodale_research_paper-07_3 0 08 .pdf.

[101]Jules n. Pretty et al., resource-conserving agriculture increases yields in developing countries, 40 envtl. Sci. & tech. 1114 (2006).

[102]See u.n. conference on trade and dev. (unctad) & u.n. env't programme (unep), organic agriculture and food security in africa (2008), (aug. 3, 2024 at 7:48 pm) http://www.unep-unctad.org/cbtf/publications/ unctad_ditc_ted_2007_15.pdf; int'l fund for agric. Dev., the adoption of organic agriculture among small farmers in latinAmericaandthecaribbean(2003),availableathttp://www.ifad.org/evaluation/public_html/eksyst/doc/thematic/pl/organic.pdf; nicholas parrott & terry marsen, the new green revolution: organic and agroecological farming in the south(2002),warming(May.3,2025,t 7:48 pm) http://www.greenpeace.org.uk/multimedifiles/live/fullreport/4526.pdf; pretty, reducing food poverty by increasing sustainability in developing countries, 95 agric. Ecosystems & env't 217 (2003); jules n. Pretty & hine, the promising spread of sustainable agriculture in asia, 24 nat. Resources f. 107 (2000); jules n. Pretty, can sustainable agriculture feed africa? New evidence on progress, processes and impacts, 1 env't, dev.

become a potential lever for the reconfiguration of agricultural and food regulations, and, more particularly, once again question the scope of the principle of precaution**.**[103]

…..x…..

Sustainability 253 (1999).

[103] Antoine Bernard De Raymond And Frédéric Goulet, *Science, Technology and Food Security: An Introduction,* 25(1), Science, Technology & Society, 15, 7-18, (2020)