Review Article

Examining the intersection of Agricultural Production, Farm revenue, Gender dynamics and Adaptation strategies in the face of climate change

ABSTRACT :

In recent times the context of climate change has become a complex and multifaceted issue as it affects agricultural production by altering weather patterns and by shifting the growing seasons of the crops, increasing pest and disease prevalence, thus reducing the yield, affecting the quality of the produce and threatening the food security in both the global and regional level. The farm revenues fluctuate significantly due to the unpredictable yields and the increased costs associated with the adaptation measures. Greater financial instability due to the changing climate scenario is faced by small and marginal farmers, as it affects market dynamics, potentially leading to price volatility. It also exacerbates the existing gender inequalities in agriculture by making them more vulnerable to the challenges of adopting climate-resilient practices, access to resources, education and decision-making opportunities which can hinder their ability to adapt to climate change.Thus the intersection of crop production, farm revenue and gender disparity under climate change highlights the need for integrated approaches to address the impacts of climate change.

Keywords: Climate change, gender disparity, farm revenue, food security.

1. INTRODUCTION:

One of the most pressing problems being confronted by the globe now is climate change. It is described as notable variations in the long-term averages of meteorological variables, such as temperature and precipitation, that have been computed (WMO & OMM, 1992)[66]. The most evident characteristic of the climate is the atmospheric element of the climatic system. It's frequently described as "average weather". The mean and variations of temperature, precipitation, and wind across periods that span from months to millions of years are typically used to characterize climate (IPCC,2007)[22]. The most recent decades indicate that growing human activity that altered the composition of the Earth's atmosphere was the cause of major changes in the global climate. Subsequently, there has been a 150%, 40% and 20% increase in the concentration of greenhouse gases such as methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O), respectively (Parry, 2007)[49]. The most predominant greenhouse gas in the atmosphere is CO_2, which comes from industrial operations and fossil fuels at a rate of 65%, forestry and other land uses at 11% and other sources include methane (16%), nitrous oxide (6%) and fluorinated gases (2%) (Pachauri, 2007)[47]. In fact, climate change *per se* is not necessarily disastrous, but the problems arising out of its extreme events that go beyond prediction pose danger across the sectors of the economy including agriculture (Swaminathan and Muraligopal, 2017)[61]. The latest UN report on climate change (UNFCCC, 2022)[63] necessitates the ardent necessity for humankind to limit the global rise in temperature to 1.5 ^{0}C by the end of the century through quantitative climate actions. For its part, India has committed itself to scale down its net carbon emissions by 45 per cent from the present levels by 2030 to combat climate change and achieve the status of a net zero-emitter economy by 2070 (PIB, 2023)[50].

The agricultural sector will witness the effects of climate change and variability due to the alterations in the water and land regimes. The impacts of climate change include, water scarcity, soil infertility, drought and desertification and incidence of pests and diseases on crops that lead to decreasing agricultural productivity in vulnerable areas (Rosenzweig and Hillel,1995)[54]. The high cost of inappropriate adaptation, or the incomplete or inadequately designed implementation of climate change programmes, is another expectation. Without a doubt, the spread of human settlements into vulnerable regions like low-lying coastlines, deltasand other climate-sensitive places in emerging nations has rendered the anticipated issues worse (Burton, 2001)[10]. Climate variability, an increase in the frequency of extreme events like droughts and floods, variations in precipitationand fluctuations in temperatures can all lead to agricultural losses. A higher incidence of droughts is likely to put more strain on water supplies for a variety of reasons, including plant transpiration and allocation (Rosenzweig and Hillel,1995)[54]. On the other hand, higher rates of soil erosion, the leaching of agricultural pesticides, and runoff that carries nutrients and animal waste into water bodies might result from increases in rainfall intensity in other areas. Even though it's unclear from present climate estimates how extreme events and variability will vary among agro-climatic zones, larger rates of change are anticipated to result in higher adjustment costs (Adams, 1998)[1]. The agricultural sector faces significant challenges due to climatic unpredictability, including intensified crop damage, reduced productivity, and higher production and operating expenses. It causes farmers' income to decline, which in turn causes poverty and inequality and makes farmers less likely to engage actively in agriculture (Chuang 2019)[12].Figure 1 shows that climate variables such as Rainfall and CO_2 emissions have a positive significant effect on cereal production,but as temperature increases the production decreases therefore having a negative significant effect on the cereal production (Kumar et al.,2021)[35].

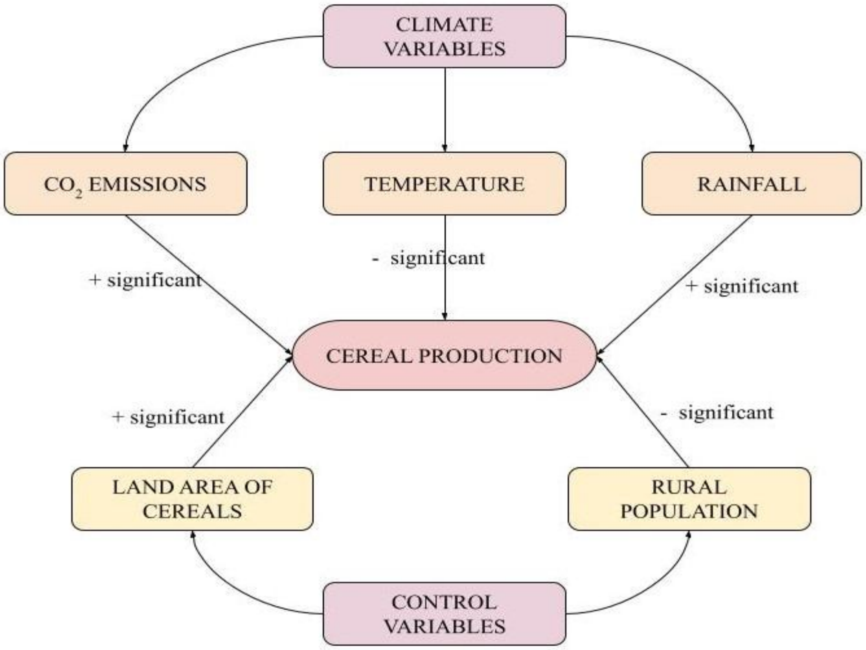

Figure 1: Impact of climate and control variables on cereal production

2. IMPACT OF CLIMATE CHANGE ON GLOBAL AGRICULTURE:

Food security and agriculture are seriously threatened by climate change and crop yield has decreased globally due to extreme weather events. By the end of the twenty-first century, sea levels are expected to have risen by 59cm and the average global temperature will haveincreased by 2.0 to 6.4 °C.The occurrence of heat waves, droughts, floods and erratic precipitation patterns has increased due to the unprecedented temperature rise. The productivity of agriculture, present-day cropping systems and the food security of people both locally and worldwide are all significantly impacted by these changes.Since 1961, the historical impact of anthropogenic climate change (ACC) has decreased worldwide agricultural total productivity (TFP) by roughly 21%; this slowdown is equal to the loss of the previous seven years of productivity gain (Ortiz *et al.,*2021)[45].The study byKnox *et al.* (2012)[31] reported that in both Japan and South Asia, the estimated mean change in crop yield by 2050s is -8%. The mean yield decreases were calculated to be − 17% (wheat), − 5% (maize), − 15% (sorghum)and −10% (millet) in Africa and − 16% (maize) and − 11% (sorghum) in South Asia and for rice, there was no discernible mean change in yield.Projected Impacts of climate change on the yields of major crops in different regions of the World are discussed in Table 1. Based on the most conservative climate change estimates (regional warming of 3°C), the net cereal production in South

Asia is expected to fall by at least 4 to 10% by the end of this century (Lal, 2010)[37].The findings supported the long-term association between agricultural productivity and climate change variables; however, the short-term relationship between agricultural productivity and CO_2 emissions was the only one that could be established. Furthermore, it has a positive effect in the short run but turns to show a negative effect in the long run indicating that atmospheric carbon fertilization can, to some extent, increase agricultural output (Ozdemir, 2022)[46].

Table 1: ProjectedImpacts of climate change on the yields of major crops in different regions of the World

Region	Crop	Period	Impact (yield)	Reference
China	Maize	2041–2070	(↓)7.6–32.1%	Jiang, 2021[23]
	Maize	2030	(↓) 30%	Xiao et al., 2016[67]
	Maize	2070	(↓) 2.92-3.11%	Basche et al., 2016[9]
	Maize	2100	(↓) 3–12%	Chen, 2016[11]
	Wheat	2030	(↓) 17.5%	Yang et al., 2017[71]
	Wheat	2050	(↓) 9.4%	Xie, 2020[68]
	Wheat	2070	(↓) 19.4%	Ju et al., 2005[24]
	Rice	2050	(↓) 4.9–8.6%	Xiong, 2009[69]
	Rice	2070	(↓) 20%	Ju et al. ,2005[24]
	Soybean	2100	(↓) 7–19%	Chen,2016[11]
	Cotton	2030	(↓) 5.5%	Rahman et al., 2018[52]
Asia	Rice	2030	(↓) 6.3%	Masutomi et al., 2009[38]
	Wheat	2030	(↓) 7.7%	Asseng et al., 2017[5]
	Rice	2040–2069	(↓) 15.2%	Habib-ur-Rahman,2022[20]
	Wheat	2040–2069	(↓) 14.1%	Habib-ur-Rahman,2022[20]
Asia (South)	Rice	2050	(↓) 17%	Aryal, et al., 2019[4]
	Wheat	2050	(↓) 50%	Knox et al., 2012[31]
	Maize	2050	(↓) 6 %	Bandara, and Cai, 2014[7]
	Sorghum	2050	(↓) 11%	Naresh et al., 2019[43]
USA	Maize	2030	(↓) 50%	Xu et al., 2016[70]
	Cotton	2030	(↓) 17%	Adhikari et al., 2016[2]
USA(South & Central)	Maize	2050	(↓) 45%	Aryal, et al., 2019[4]
Africa	Maize	2050	(↓) 3.6%	Estes et al., 2013[15]
	Cotton	2030	(↓) 17%	Williams et al., 2015[65]
Pakistan	Rice	2080	(↓) 1.9%	Knox et al., 2012[31]
	Wheat	2080s	(↓) 27%	Bandara, and Cai, 2014[7]
	Sugarcane	2050	(↓) 2.2%	Aryal, et al., 2019[4]
	Cotton	2030	(↓) 5.23%	Bandara, and Cai, 2014[7]
Australia	Sugarcane	2030	(↑) 20%	Singh et al., 2011[58]
Australia	Cotton	2030	(↓) 17%	Williams et al., 2015[65]

Sri Lanka	Rice	2030	(↓) 0.41%	Knox et al., 2012[31]
	Wheat	2030	(↓) 4.10%	Knox et al., 2012[31]
	Cotton	2030	(↓) 9.71%	Aryal, et al., 2019[4]
Nepal	Wheat	-	(↑) 8.6 - 18.4%	Aryal, et al., 2019[4]
	Maize	2050	(↓)9.3% - 26.4%	Knox et al., 2012[31]
	Sugarcane	2030	(↓) 5.69%	Bandara and Cai, 2014[7]
	Cotton	2030	(↓) 9.21%	Knox et al., 2012[31]
Bangladesh	Rice	2080	(↓) 10%	Aryal, et al., 2019[4]
	Wheat	2050	(↓) 60%	Aryal, et al., 2019[4]
	Sugarcane	2030	(↓) 1.6%	Knox et al., 2012[31]
	Cotton	2030	(↓) 7.94%	Knox et al., 2012[31]
Indonesia	Rice	2030	(↓) 11%	Naylor et al., 2007[44]
Switzerland	Sugarcane	2030	(↓) 9%	Knox et al., 2012[31]
Iran	Wheat	2030	(↓) 37%	Valizadeh et al., 2022[64]

3. IMPACT OF CLIMATE CHANGE ON INDIAN AGRICULTURE:

Due to climate change, India's annual average temperature increased by 0.6°C between 1990 and 2021. Consequently, the country has experienced numerous extreme weather events; during the 2016 drought, a heat wave caused much of northern India to remain above 40°C for weeks at a time, raising the risk of heat-related illnesses like exhaustion, stroke, and even death.The surface air temperature between 1901 and 2000 shows a notable 0.4°C warming throughout that time. The West Coast, Central India, the Interior distribution of temperature changes. In contrast, a cooling tendency was noted in various regions of Southern India and the Northwest. Table 2, shows the impact of climate change on agricultural production at different time periods and at varying parts of India. By the 2050s, central India's winter rainfall is predicted to drop by 10 to 20 percent. At the same time, semi-arid regions in western India will likely receive more rainfall than usual due to rising temperatures (Rupakumar et al., 1992)[55].

Table 2: Impact of climate change on Agricultural Production in India

Author(s)	**Time**	Region	**Econometric model(s)**	**Results**
Barnwal and Kotani (2013)[8]	1971–2004	Andhra Pradesh	Quantile regression	Monsoon crops are more sensitive to climate change than winter crops
Mishra and Sahu (2014)[39]	1993–2009	Odisha	Multiple regression	Temperature => - agriculture production
Praveen and Sharma (2019b)[51]	1967–2016	India	Multiple regression	Temperature, rainfall => - agriculture production
Guntukula (2020)[18]	1961–2017	India	Multiple regression	Rainfall => + non-food crop production rainfall => - food crop production

Singh et al. (2019)[59]	1966–2011	India	FGLS	Climate change => - agriculture production
Baig et al. (2020)[6]	1985–2016	Somalia	ARDL	Cultivated land => + crop production Temperature => - crop production, rainfall => + crop production

FGLS, feasible generalized least square; ARDL, autoregressive distributed lag
Source: Kumar et al. (2021)[35]

According to PRECIS (Providing Regional Climates for Impact Studies) estimates, the Punjab region of India is expected to witness an upsurge in both the minimum and maximum temperatures by the middle and end of the twenty-first century. Additionally, it is anticipated that there will be extremely high heat waves from March to June and extremely low temperatures in December and January (Kaur, 2016)[28]. Following data from the Food and Agriculture Organization (FAO) released in 2016, there would be a reduction in the production of the primary cereal crops by the year 2100 (20–45% in maize yields, 5–50% in wheat, and 20–30% in rice) if the present circumstances of GHG emissions and climate change persist. Thus, it is imperative to set actions and policies into effect and adapt to them to help mitigate the effects of climatic variability. The future impacts of climate change on the yields of major crops in India discussed by various authors are given in Table 3.

Theagriculturally productive areas in the coastal regions of Gujarat and Maharashtrawill be more seriously affected as they are highly susceptible to salinization and inundation. Additionally, standing crops in these areas are more vulnerable to cyclonic damage. Ironically, Madhya Pradesh, where soybeans are farmed on 77% of the land under cultivation, would profit from an increase in atmospheric carbon dioxide. For instance, a study (Lal et al.,1999) [36] demonstrated that if atmospheric carbon dioxide concentration doubles, soybean yields may increase by as much as 50%. Soybean yields, however, may potentially fall if the anticipated rise in carbon dioxide coincides with this increase in the temperature.

Table 3: Future impacts of climate change on the yields of major crops in India

Crops	Year	Yield reduction	Reference
Rice	2080	(↓) 40%	Knox et al., 2012[35]
Wheat	2030	(↓) 5.2%	Gupta et al., 2017[19]
	2050	(↓) 6 to 23%	Kumar et al., 2014[34]
	2080	(↓) 15 to 25%	Kumar et al., 2014[34]
Maize	2030	(↓) 20%	Bandara, and Cai, 2014[7]
Sugarcane	2060	(↓) 4.69%	Jyoti and Singh, 2020[25]
Cotton	2030	(↓) 7.01 %	Aryal, et al., 2019[4]
Groundnut	2050	(↓) 5.36 %	Palanisami et al., 2009[48]

Using the marginal impact analysis technique, the sugarcane yield for India and the various states in the different climate change scenarios (i.e., the 2040s, 2060s, 2080s, and 2100s) were projected. The yield was projected to decline by 3.84%, 4.69%, 5.55%, and 6.62% in India by 2040s, 2060s, 2080s, and 2100 respectively. The results clearly show that the yield of sugarcane may decline in all states, while Assam state may be in a highly worsened position, as the sugarcane yield is likely to be decreased by 12.31%, 14.31%, 15.25% and 21.40% by the 2040s, 2060s, 2080s, and 2100s, respectively. Maharashtra, Uttar Pradesh, Karnataka, Tamil Nadu, Gujarat, Andhra Pradesh, Haryana, and Bihar contribute approximately 99% of the sugar produced and the yield in these states is also projected to decline(Jyoti and Singh, 2020) [25]. Table 4 provides a detail on the projected changes in the temperature and precipitation in various regions of India.

Table 4: Projected Changes in Climate in India: 2070-2099

	Region	Jan.-Mar.	Apr.-June	July-Sept.	Oct.-Dec
Temperature Change (°C)	Northeast	(↑) 4.95	(↑) 4.11	(↑) 2.88	(↑) 4.05
	Northwest	(↑) 4.53	(↑) 4.25	(↑) 2.96	(↑) 4.16
	Southeast	(↑) 4.16	(↑) 3.21	(↑) 2.53	(↑) 3.29
	Southwest	(↑) 3.74	(↑) 3.07	(↑) 2.52	(↑) 3.04
Precipitation Change (%)	Northeast	(↓) 9.30	(↑) 20.30	(↑) 21.00	(↑) 7.50
	Northwest	(↑) 7.20	(↑) 7.10	(↑) 27.20	(↑) 57.00
	Southeast	(↓) 32.90	(↑) 29.70	(↑) 10.90	(↑) 0.70
	Southwest	(↑) 22.30	(↑) 32.30	(↑) 8.80	(↑) 8.50

Source: Cline (2007)[13]

4. IMPACT OF CLIMATE CHANGES ON FARM INCOMES:

Producers and consumers constantly react to changes in crop and livestock yields, food prices, input prices, resource availability, and technological advancements, resulting in highly dynamic agricultural systems (Adams et al.,1998)[1].When assessing the agricultural impact, Sanghi, Mendelsohn, and Dinar (1998)[56] also made an effort to take adaptive possibilities into account. They estimated that nationwide net revenues would drop by 12.3% in response to a 2°C increase in mean temperature and a 7% increase in mean precipitation.According to the study in Tamil Nadu by Palanisami et al. (2009)[48], farmers in Perambalurwill be most affected by the HADCM3 scenario, losing almost 3,000 rupees per acre, followed by farmers in Trichy, who will lose roughly 2,740 rupees per acre. Mishra et al. (2016)[40] by using a random effect panel model that included all conceivable meteorological and non-climatic variables, examined how climate change is affecting agriculture in the Indian state of Odisha in which agricultural input, output and the necessary price data were gathered over 17 years, from 1993 to 2009. The findings indicate that the interaction terms and summer rainfall were negatively significant, which in turn had an adverse effect on the net revenue. Bullocks were found to have a negative significant impact, whereas non-climatic variables like irrigation, tractors, etc., had a positive significant impact. According to the results, net revenue may vary by -4, 2.67, and 9.57% for every 5% increase in rainfall and a rise in temperature of 2° C, 3° C, and 4° C, respectively.

Table 5: Predicted percentage change in farm net revenue

Region	Change (Temperature)	% Change (Net Revenue/ha.)	Study
India	(↑) 2°C to 3.5°C	(↓) 9-25 %	Kavi Kumar & Parikh (1998)[30]

India	(↑) 2° C	(↓) 3 to 6%	Sanghi, Mendelsohn (1998)[56]
India	(↑) 2° C	(↓) 8%	Kumar and Parikh, (2001a)[32],(2001b)[33]
India	(↑) 2° C & 8% Rainfall	(↓) 12%	Sanghi& Mendelsohn (1998)[56]
India	(↑) 2° C	(↓) 8%	Kumar (2014)[34]
Trichy (TN)	(↑) 1°C	(↓) 79%	Palanisami et al., (2009)[48]
Cuddalore (TN)	(↑) 1°C	(↓) 34%	Palanisami et al., (2009)[48]
Perambalur(TN)	(↑) 1°C	(↓) 33%	Palanisami et al., (2009)[48]
Karnataka	(↑) 1°C	(↓) 17-21%	Kalli, (2022)[26]

If nothing else changes, a 2°C increase in temperature for any seasonal month results in a net income reduction of INR 1594 for January, INR 566 for April, and INR 204 for July, based on the average exchange rate throughout this period of $1 = INR 45. On the other hand, these witnessed an increase of about INR 728 in October (Kar and Das, 2015)[27].The changes in the farm net revenues due to changes in the temperature and rainfall that have been captured by various authors have been listed out in the Table 5 and Table 6 shows the simulation of temperature and precipitation effects on net revenue (in INR) during different seasons.

Table 6: Simulation of temperature and precipitation effects on net revenue (in INR)

	Winter	Summer	Monsoon	October
Temperature effects (+2 °C increase)	(↓) 1,594.17	(↓) 565.64	(↓) 204.37	(↑) 728.09
Precipitation effects (+7 % increase)	(↑) 105.67	(↓) 95.37	(↓) 8.55	(↑) 90.34

Average net revenue (per hectare in real terms) is INR 12,263.56
Source: (Kar and Das, 2015)[27].

Felix *et al*. (2018)[16], reported that different farms experience different marginal effects of precipitation on net revenues. In kharif, rabi, and summer, rainfed farmers' net revenue would rise by C1401, C2325, and C933, respectively, with a 1 mm increase in precipitation. In a similar vein, irrigated farmers' net revenue would rise by C754 in the Rabi season and C13 in the summer with a 1 mm increase in precipitation. Increasing precipitation during the entire growing season boosts both farms' net revenue and for every farm, a 1 mm increase in precipitation would result in a net revenue increase (C848) during the rabi season and C90 during the summer.The marginal impact of climate on the net revenue of different farms estimated by the author has been presented in Table7 and the impacts of climate change over time *ie.,*1956-1970, 1971-1985 and 1986-1999 are shown in Table 8.

Table 7: Marginal impact of climate on net revenue

Indicators	Particulars	Rainfed	Irrigated	Overall
Temperature	Kharif Temperature	(↓) 22738.21	(↑) 16529.72	(↓) 17316.30

(^{0}Celsius)	Rabi Temperature	(↓) 52340.89	(↓) 3463.19	(↓) 3767.64
	Summer Temperature	(↓) 4437.312	(↓) 4058.18	(↓) 21133.86
Rainfall (mm)	Kharif Rainfall	(↑) 1400.93	(↑) 23.44	(↑) 45.38
	Rabi Rainfall	(↑) 2325.42	(↑) 754.06	(↑) 848.24
	Summer Rainfall	(↑) 933.039	(↑) 13.25	(↑) 89.70

Source: Felix *et al*. (2018)[16]

Table 8: Climate Change Impacts Over Time

Scenario	1956-1970		1971-1985		1986-1999	
	Impacts (Billion Rs)	% of 1990 Net Revenue	Impacts (BillionRs)	% of 1990 Net Revenue	Impacts (Billion Rs)	% of 1990 Net Revenue
+2°C /7%	-53.70	-6.1	-76.8	-8.7	-188.7	-21.3
+3.5°C/14%	-297.4	-33.6	-303.4	-34.3	-754.9	-85.3
India-Specific CC Scenario	-219.6	-24.8	-153.6	-17.4	-544.4	-61.5

Source: Kavi Kumar (2009)[29]

5. GENDER DISPARITY IN COMBATING CLIMATE CHANGE:

All forms of livelihood are at risk from climate change. Nonetheless, the vagaries of climate disproportionately affect those who work in agriculture, especially women. Out of 146 nations, India ranked 127th in the World Economic Forum's 2023 Global Gender Gap Index, having some of the lowest levels of economic involvement and opportunity for women. Women are particularly vulnerable to climate change because of these gender disparities as well as social norms, stigma, low literacy rates, restricted rights, low mobility, lack of financial resources and a muted voice in decision-making. Climate change is also likely to exacerbate pre-existing patterns of gender disadvantage (UNDP 2007)[62].

Women are particularly vulnerable to climate change because of these gender disparities as well as social norms, stigma, low literacy rates, restricted rights, low mobility, lack of financial resources, and a muted voice in decision-making. Climate change is also likely to exacerbate pre-existing patterns of gender disadvantage (UNDP 2007)[62]. According to a 2015 study by the International Food Policy Research Institute (IFPRI), women are more likely than men to notice the effects of climate change on reduced water availability (18% vs 9%), agricultural productivity (87% vs 72%), and livestock problems (17% vs 8%). In fact, women are more sensitive to the effects of climate change than men are. In comparison to their male counterparts, the percentage share of female operational holders has increased from 12.79% in 2010–11 to 13.87% in 2015–16. Additionally, the area operated by women has increased from 10.36% in 2010–11 to 11.57% in 2015–16 (MoAFW 2018)[41]. Despite these increases, the level of ownership has remained relatively low. Figure 2, shows the percentage share of operational holdings between males and female across different size of land holdings. A recent study, conducted by the International Union for Conservation of Nature (IUCN), found strong evidence indicating a positive causal relationship between climate change and gender-based violence These changes also pose a threat to women's land rights through desertification, soil degradation, and increased competition over demand for arable land.

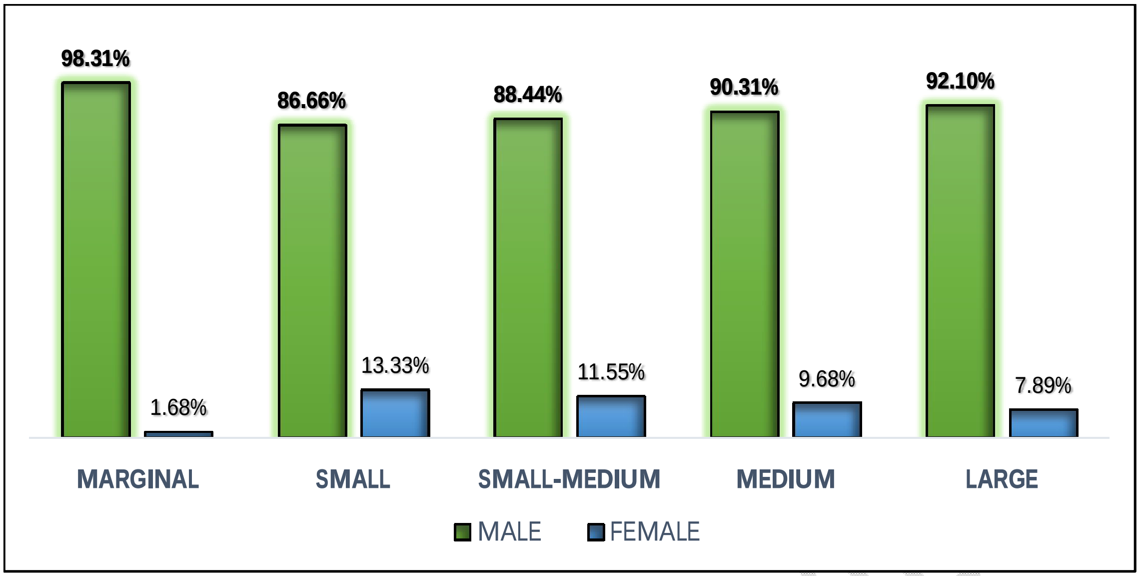

Figure 2: Percentage share of operational holdings by Gender - All India

Source: Agricultural Census (2015-16)

Nonetheless, the majority of rural financial programs in India are created with the intention of benefiting the male head of the home; this ignores the fact that women are productive participants in the agricultural sector with their own set of financial constraints and requirements (Fletschner and Kenney 2014)[17]. A report claims that only 5% of women have been issued Kisan Credit Cards in India (Seethalakshmi 2017)[57].Approximately 22.44 crore of the 40.98 crore recipients of the PMJDY scheme are female. Even with this large number, almost half of the newly created accounts are inactive. According to National Bank for Agriculture and Rural Development (NABARD) research, only 8.9% of women had access to financial education and information sessions (NABARD, 2016)[42]. All state governments were asked to "emphasize the gender-based strategiesin the context of climate change to (make certain) their involvement in the implementation process" by the approval committee for the State Action Plan for Climate Change (SAPCC) at the Ministry of Environment, Forest & Climate Change (MoEF&CC) in 2012. (Alternative Futures, 2014)[3]. Odisha was the first state to implement a climate budget, in February 2020. In the agriculture sector, the government invested INR 11,68,564.22 lakh in women-specific programs in 2019–20. This is a significant increase over the INR 3,36,074.67 lakhs spent in the previous fiscal year.

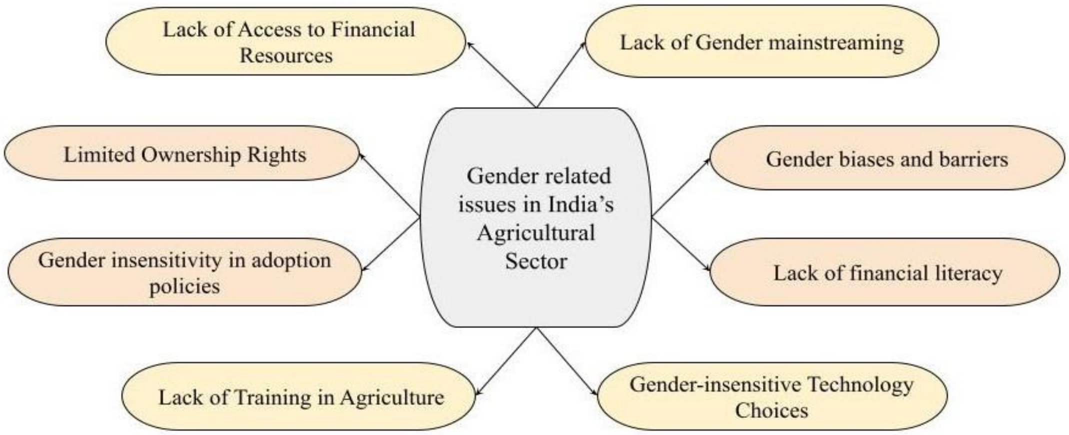

Figure 3: Gender Issues in Indian Agriculture

Gender issues including those listed in the figure 3must be mainstreamed into national and all regional climate action plans to better support women working in agriculture and reduce their vulnerability to climate change. In the context of national priorities in adapting to climate change, the inclusion of "gender" and "women" has increased dramatically; nonetheless, the focus on gender-related climate adaptation in the agriculture sector should be much stronger. To reduce the vulnerability of agricultural households, increasing public awareness of climate change and extending financing facilities for implementing adaptation measures, notably bolstering women's ability to adapt to it.

6. FARMER'S ADAPTATION STRATEGIES TO CLIMATE CHANGE:

Through the adoption of climate-smart and resilient agricultural techniques, the detrimental consequences of climate change can be mitigated, ensuring food security and sustained agricultural production. Since adaptation can reduce the negative consequences of climate change on sustainable production, it is the greatest strategy for coping with climatic variability and change. Defensive adaptation combined with innovative technology may reduce the erratic and adverse effects of climate change on agricultural productivity. In Table 9, Reilly and Schimmelpfennig (1999)[53] provide the various adoption measures and their adjustment time, utilized by the farmers to combat climate change.

Table 9: Adaptation measures and Adjustment time by the farmers

Adaptation Measure	Adjustment Time (years)
Variety Adoption	3-14
Dams and Irrigation	50-100
Variety Development	8-15
Tillage Systems	10-12
Opening New Lands	3-10
Irrigation Equipment	20-25
Fertilizer Adoption	10

Source: Reilly and Schimmelpfennig (1999)[53]

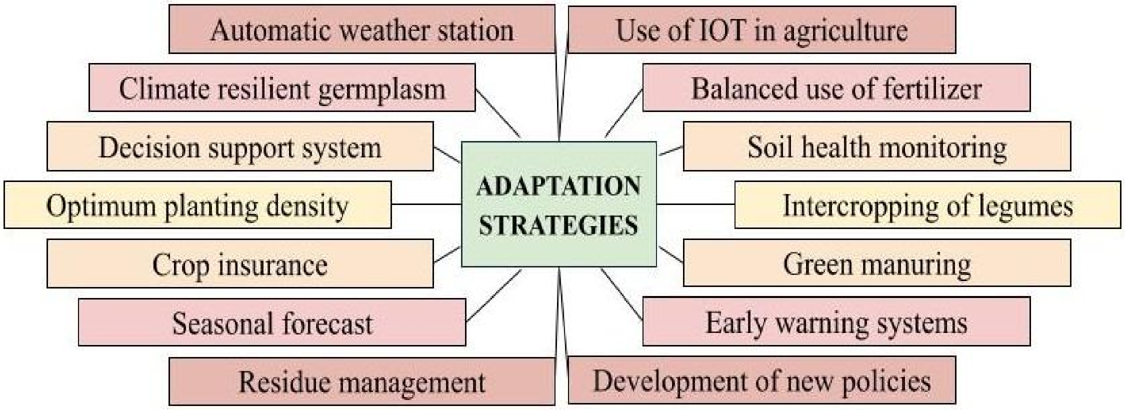

Figure 4: Farmer's Adaptation Strategies for CSA

The term "Climate Smart Agriculture" refers to a collection of integrated technology and methods that concurrently increase farm productivity and financial return, improve climate change adaptability, and reduce greenhouse gas (GHG) emissions. (Hussain *et al.*, 2022)[21]. By using adaptive techniques, CSA can mitigate the extensive negative consequences of climate change on farm households, production, and profitability. As a result, emerging nations like India are restructuring, reforming, and realigning their agricultural sectors to better understand the relationship between climate change, sustainable agriculture, and farm livelihoods (Das and Ansari, 2021)[14]. Different levels of adaptation, such as those of farmers, economic agents, and the macro level, may be feasible. For instance, Reilly and Schimmelpfenng (1999)[53] suggested the relative pace at which different measures are adopted. Autonomous and policy-driven adaptation are the two categories of adaptation measures that Stern (2007)[60] offers for both the short and long term. Figures4 and 5, show the adaptation and the mitigation strategies to be followed by our farming communities.

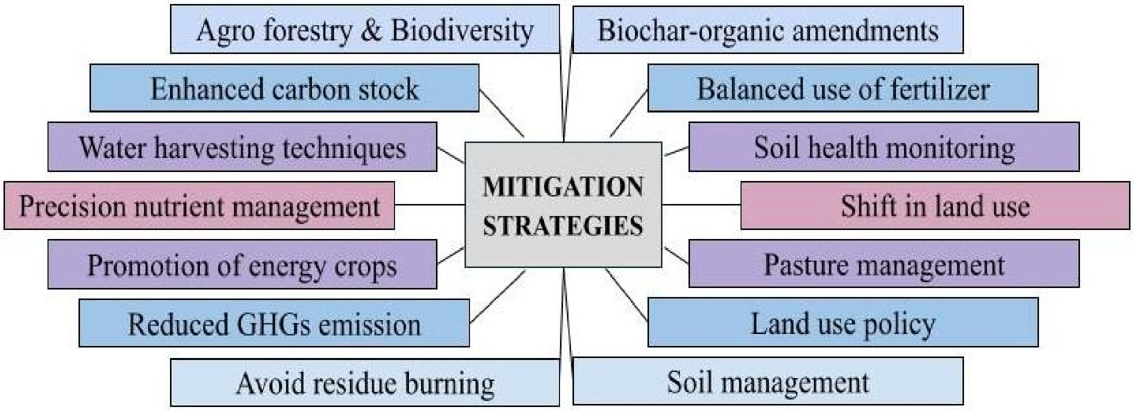

Figure 5: Farmer's Mitigation Strategies for CSA

7. CONCLUSION:

It is evident that the rising temperatures and changes in precipitation levels have been and will significantly affect the production of crops. Food security in many parts of the globe is under major threat due to crop failures and yield losses, which will move millions of people into poverty. These climate changes not only significantly affect the small and marginal farmers, the gender biasedness in the agricultural sector also disproportionately impacts the women farmers as they are deprived of financial literacy, technology adoption and decision-making authority.Therefore, a context-specific and comprehensive solution and strategies involving various stakeholders must be adopted by the farming community to build a climate resilient farming with guaranteed and fair outcomes for better livelihood considering the environmental factors and socio-economic conditions of the society.

Disclaimer (Artificial intelligence)

Author(s)herebydeclarethat NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of manuscripts.

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