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Effects Of Climate Change On Agriculture And Food Supply

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ABSTRACT

Climate change and extreme events will become key factors adversely affecting the food security and increasing undernourishment and malnutrition (Hughes, 2020). Considering the impacts of climate change, agriculture sector including crops and livestock is adversely affected and at risk due to subsequent vulnerabilities caused by climate change. Wheat and rice are among the major food crops that have reacted negatively to global warming in the last three decades, though the yield responses have still been under consideration and satisfied grain yields have been observed in various regions (Raza et al, 2019). Food production (net of food utilized for biofuels) must increase by 70% up till 2050 under the projected mean risen temperature conditions of nearly 4°C to meet the food requirements for an additional 2.3 billion population (totally 9.6 billion; FAO, 2009; Molotolcs et al., 2021). However, to meet this food requirements by end of this century will be more challenging due to uncontrolled and uneven climate changes. Hunger is associated with multiple ranges of concerns, ranging from nutrient deficiencies due to shocks in the accessibility of food to persisting food shortages. There are several intertwined relationships between malnutrition and poverty which subject toward hunger due to limited supply and availability of food in terms of quantity and quality (Siddiqui et al., 2020). Alongside, micronutrient deficiencies in routine diet have become a huge global health concern, impacting nearly one third global population. Micronutrient deficiencies render. Moreover, healthy governance among institutions is necessary to achieve the SGRs through important approaches which involve participatory measures, reflexivity, policy coherence, mitigation, adaptation and most importantly the democratic institutions. Action-based research is necessary to inscribe the climate change impacts on food security and the worldwide challenge to undermine the GHGs emissions from the agricultural sector. Past research findings have defined the dire need for both increased changes in agricultural production systems (like introducing new crop cultivars and better management measures for crops, livestock, fisheries and agro-forestry), and transformational changes (like trade shifts, diet changes, and motivating several environmental services....

INTRODUCTION

The agricultural sector including livestock, fisheries, forest farming and crop production is mostly affected by climate change and extreme events (Awan and Yaseen, 2017). It has been projected that shifts in climatic components will change the cropping seasons, negatively impacting the forest farming and forest farming- based livelihoods (Chisale et al., 2021), and could potentially permanently extinguish the viability of several crop and forest species at regional scales. Climate change is growingly threatening the crop production system of major crops, and it has been projected that expected rise in temperature will severely decline the productivity of major staple food crops such as wheat and rice leading toward various constraints in addressing food insecurity challenges in protracted crises (Maxwell et al., 2012). Climate change brings shifts in the precipitation and temperature which differently disturb the duration of different growth phases of the crops and forest plants (Davidson, 2018). Now a days enough food is produced per unit area to feed the rapid growing population, however, yet nearly 811 million people are acutely suffering from undernourishment, amongst signals of decreasing impulse toward attaining zero hunger (FAQ, 2021b). Meanwhile, malnutrition is sharing a massive toll across several developing and developed countries. Whilst, stunted growth, low height and decreased weight for age are gradually declining, where more than two billion adult individuals, teenagers and children are now obese or ovenveight (Ferreira et ah, 2020). Hence, the consequences are becoming more adverse regarding public health, national economy, livelihoods, and quality of life. These adverse trends coexist with the abating availability of land resources, increased soil and biodiversity degradation, and more intense and frequent extreme weather events, where the impacts of these extreme events and climate change on agriculture amplify the situation. During a special meeting held on 25th of September 2015, the 193 members of the United Nations..

followed the different Sustainable Development Goals (SDGs; total 17) of the 2030 action-based Agenda for Sustainable Development among food systems, global objectives expected to assist the actions of the global communities over the next 15 years (during 2016-2030; EAO, 2021b). This 2030 Agenda of SGRs presents a fairer vision for more peaceful world where no one is left behind. All food systems including agriculture and agro-forestry are critical to achieve the intact set of SDGs where a special focus will be granted on rural development and action-based investments in different farming systems (crops, livestock, forestry, fisheries and aquaculture; Gregersen et al., 2020). This will empower the whole society with more powerful tools in alleviating the poverty, undernourishment, and hunger, and will lead toward more sustainable development. Ending hunger, achieving food security goals, improving healthy nutrition, and promoting sustainable agriculture systems. Ensuring inclusive and quality awareness and education for all communities while promoting long-term learning. Ensuring access to economic, affordable, reliable, sustainable and clean energy resources for all communities. Ensuring and promoting inclusive, comprehensive and sustainable economic growth, employment opportunities and reliable working systems. Reducing inequalities within and among different nations. Ensuring sustainable food production and consumption patterns. Taking urgent and necessary actions in combating climate change vulnerabilities

IMPACT

Agricultural sectors, the impacts of climate change on forest farming and its industries are different depending on the extent of climate variability, geographical features, and forest species. Climate change similar to crop plants change the overall productivity of forests, changing resources management, economic approaches of adaptation, and subsequently forest product harvests globally, nationally, and regionally (Keenan, 2015). In regions where climate variabilities reduce the timber growth, smaller timber volumes will be produced for harvest both in existing forests and those rejuvenated in near future. Moreover, climate change impacts the forest farming and agriculture sector differently which could subject to land use shifts that could be considered as one potential adaptation approach to improve livelihoods. It is concluded that there is a vigorous and reasoned pattern of the climate change impacts on food production and food availability and it has been projected that uneven climate change will adversely impact the areas which are already under the prevalence of undernourishment and food insecurity issues. Systematic analysis of the changes in crop and livestock production across South Asia and Africa predicted that climate changes will decline the overall productivities of major food producing systems by 2050 (Knox et al., 2012; Sultan, 2012). The decline in crop productivities for major crops like wheat, maize, and sorghum will be vigorous, but the analysis was inconclusive and showed contradictive results for other major crops like rice and sugarcane (Knox et. al., 20.12, 2016). There are still some limitations regarding the broad impacts of climate change on food availability, though rational evidences for climate change impacts on crop productivities are available.

Temperature change	Sub – sector	Region	Finding
+1 to +2ºC	Food Crops	Mid-to high latitudes	Cold limitation alleviated for all crops Adaptation of maize and wheat increases yield 10-15%; rice yield no change; regional variation is high
	Pastures and livestock	Temperature	Cold limitation alleviated for pastures; seasonal increased frequency of heat stress for livestock
	Food crops	Low Latitudes	Wheat and maize yields reduced below baseline levels; rice is unchanged Adaptation of maize, wheat, rice maintains yields, at current levels
	Pastures and livestock	Semi-arid	No increase in NPP; seasonal increased frequency of heat stress for livestock Agricultural prices: - 10 to - 30 %
+2 to +3ºC	Food crops	Global	550ppm CO_2 increases C3 crop yield by 17%; this is offset by temperature increase of 2ºC assuming no adaptation and 3ºC with adaptation
	Food Crops	Mid-to high latitudes	Adaptation increases all crops above baseline yield

	Pastures and livestock	Temperature	Moderate production loss in swine and confined cattle
	Fibre	Temperature	Yields decrease by 9%
	Pastures and livestock	Semi-arid	Reduction in animal weight and pasture production, and increased heat stress for livestock
	Food crops	Low Latitudes	Adaptation maintains yields of all crops above baseline; yields drop below baseline for all crops without adaptation
+3 to +5ºC	Food crops	Low Latitudes	Adaptation maintains yields of all crops above baseline; yield drops below baseline for all crops without adaptation
	Pastures and livestock	Tropical	Strong production loss in swine and confined cattle
	Food crops	Low latitudes	Maize and wheat yields reduced below baseline regardless of adaptation, but adaptation maintains rice yield at baseline levels
	Pastures and livestock	Semi-arid	Reduction in animal weight and pasture growth; increased animal heat stress and mortality

Source: Adapted from Easterling et al., 2007

Interactions of elevated CO_2 with other factors: Although and increase in CO_2 in isolation from other factors is shown to increase crop growth and productivity, these effects will often be countered in reality by other changes in the system. Higher temperatures during certain growth stages may be detrimental to yield and quality (Caldwell et al., 2005; Baker, 2004; Thomas et al., 2003). Increased growth caused by elevated CO_2 may lead to greater water demand (Xiao et al., 2005), which in many parts of the world may be combined with increasing pressure on water resources, which may also be declining, and hence become a limiting factor. Climate impacts on crops may depend heavily on the precipitation scenario considered. Similarly, the availability of soil nutrients such as nitrogen and phosphorus may also prove to be limiting factors in the CO_2 response. Studies have shown that high soil N contents increase the relative response to elevated CO_2 concentration (Nowak et al., 2004).

Sudden changes in climate, such as severe weather events, often result in large losses to stock in confined cattle lots, as they have no prior conditioning to these events (Mader, 2003). High temperatures and droughts are likely to induce increases in mortality, yields and conception rates, for animals not accustomed to the higher temperatures (IPCC, 2007).

Interaction with air pollutants: Tropospheric ozone has been shown to have significant adverse effects on crop yields, pasture and forest growth, and species composition (IPCC, 2007). Direct and indirect interactions between global ozone and elevated CO_2 is likely to further modigy plant dynamics (Fiscus et al., 2005; Booker et al., 2005). Although it has been shown that elevated CO_2 may minimise negative impacts form ozone, the interactions between the two have not been considered sufficiently in current risk assessments.

Vulnerability of carbon pools: Climate change has the potential to affect the global terrestrial carbon sink and to further perturb atmospheric CO2 concentrations (Cias et al., 2005; Betts et al., 2004). Land-use planning and management practices, including set-aside policies, reforestation, and N fertilization, irrigation and tillage practices all have the potential to affect future changes in carbon stocks and fluxes. Carbon stored in soil organic matter has been shown to be affected by atmospheric CO2 levels (Allard et al., 2005; Gill et al., 2002), temperature (Ciais et al., 2005), and air pollution (Loya et al., 2003), Booker et al., 2005), although considerable uncertainty remains. These relationships highlight the importance of co-ordinating adaptation and mitigation strategies and considering the effects of climate policy on land-use change and long-term sustainability of production systems (Rosenzweig et al., 2007)

Impact assessments: Results from integrated assessment and crop models over the 20 years indicate consistently that impacts in the agricultural sector are likely to be small in the first half of the 21st century although they are likely to become increasingly negative in the second half, as mean temperatures increase (IPCC, 2007; 2001). However, uncertainties which could potentially alter these findings consists of a range of factors, from the strength and saturation point of the elevated CO2 response of crops grown in real fields rather than experimental plots, to the timing and implementation of adaption strategies and the interaction between mitigation and adaptation strategies (Tubiello et al., 2007).

Food crop farming: The possibility for surprise events that are not considered in impact assessments cannot be ruled out. The most recent IPCC report lists three main factors which have not been considered in modelling to date:

Increases in the frequency of climate extremes may lower crop yields beyond the impacts of mean climate change. Long-term yields may be affected by the increased occurrence of extreme weather events, which may directly damage crops at crucial developmental stages, or may make the timing of field applications more difficult, reducing the efficiency of farm inputs (Porter and Semenov, 2005, Antle et al., 2004).

Impacts of climate change on irrigation water requirements may be large. Recent studies have found that there may be a global increase of net crop irrigation requirements of 5-8% by 2070, with considerable regional variation (Doll, 2002). Increases in water stress are projected for the Middle East and South – east Asia (Fischer et al., 2007; Arnell, 2004). These increases in irrigation water requirements may undermine any potential positive effect of CO_2 fertilization.

Stabilisation of CO_2 concentrations reduces damage to crop production in the long term. Overall impacts on global crop production are projected to be significantly less under lower levels of CO_2 stabilisation (Arnell, 2004; Tubiello and Fischer, 2007) (i.e., at 550ppm compared to 750ppm or a BAU scenario). In the first half of this century, some regions may be worse off with mitigation that without, because of lower CO_2 levels and resulting lack of CO_2 stimulation effects on crops (Tubiello and Fischer, 2007).

Industrial Crops

The AR4 indicates there is limited knowledge regarding the effects of climate change on industrial crops such as oilseeds, gums and resins, sweeteners, beverages, fibres, and medicinal and aromatic plants. Biofuel crops such as maize and sugarbeet will face similar effects as other crops discussed earlier in this report. Reduced rainfall may cause groundnut yields in Niger to reduce, while there may be large increases in cotton yields due to increases in ambient CO2 concentration. However, changes in temperature and precipitation may negate these effects (Varaprasa et al., 2003). Perennial industrial crops may be at greater risk than annual crops, as both damages (temperature stresses, pest outbreaks, increased damage from extremes) and benefits may accumulate with time.

Table 2.2 Impacts on grasslands of incremental temperature change

Local temperature change	Sub-sector	Region	Impact trends	Sign of impact	Scenario Experiment	Source
+0-2ºC	Pastures and livestock	Temperature	Alleviation of cold limitation	+	SIM	Parsons et al., 2001
			Increasing productivity		IS92a	Riedo et al., 2001
			Increased heat stress for livestock	-	IS92a	Turn-penny et al., 2001
		Semi-arid and Mediterranean	No increase in net primary productivity	0	EXP	Shall et al., 2002; Dukes et al., 2005
+3ºC	Pastures and livestock	Temperature	Neutral to small positive effects (Depending on GMT)	0 to +	SIM	Parsons et al., 2001; Reido et al., 2001
		Temperature	Negative on swine and confined cattle	-	Had CM2, CGCM1	Frank and Dugas, 2001

		Semi-arid and Mediterranean	Productivity decline	-	HadCM3 A2 and B2	Howden et al., 1999
			Reduced ewe weight and pasture growth. More animal heat stress			Batima et al., 2005
		Tropical	No effect (no rainfall change assumed)	-to0	EXP	Newman et al., 2001; Volder et al., 2004
			More animal heat stress	-		

Note:

EXP - Experiment; SIM – Simulation without explicity reference to an SRES scenario; GMT – Global mean temperature,

Source: Easterling et al., 2007

The third area of uncertainty relates to societal response to the impacts of climate change on agriculture. Here the uncertainty is characterised less by unreliable data or accurate models, but more fundamentally on contested theories of how societies adapt, the role of agriculture in economic development, and the role of over-arching parameters of global politics and policy choice. Future greenhouse gas emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development socio-economic development, and technological change. The way that society responds to changes in climate, as well as other challenges, is highly uncertain. In order to accommodate this type of uncertainty, global scenarios of alternative futures bring these issues together in the Special Report on Emissions Scenarios (SRES) of the IPCC (Nakicenovic et al., 2000). Box 3.3 (further below) describes the main assumptions underlying each family of scenarios. The scenarios are built on underlying model drivers that attempt to model global population projections and potential futures that attempt to analyse future worlds where, for example, free trade and global market integration occur, while in others, regional development and high environmental degradation drive policy choices (see Nakicenovic et al., 2000); Schiermeier (2006); and Grubler et al., (2006) for discussions of the controversies surrounding these scenarios).

Table 3.1. Number of people in the 2050s with an increase in water stress and with a decrease in water stress, for selected regions

	Scenarios of climate change + market – oriented high growth and convergence, free trade		Scenarios of climate change economic growth and convergence, high environmental consciousness and technological development	
	Population living with increased water stress (mill)	Population living with decreased water stress (mill)	Population living with increased water stress (mill)	Population living with decreased water stress (mill)
OECD Regions				
North-west Pacific	0	546	20	445
Western Europe	183	0	140	6
Central Europe	80	0	59	0
Eastern Europe	15	0	7	0
Australasia	0	0	0	0
Canada	7	0	7	0

United States	85	6	37	0
Meso – America	33	0	34	0
Other Regions				
North Africa	218	3	138	129
West Africa	23	67	23	73
Central Africa	65	0	36	0
East Africa	13	35	100	0
Southersn Africa	56	0	66	0
MAshriq	126	0	119	0
Arabian Peninsula	23	153	4	145
Central Asia	7	0	6	0
South Asia	136	1530	125	1530
South – East Asia	0	6	0	6
Greater Mekong	0	0	0	0
Caribbean	21	0	21	0
South America	46	19	46	6

Notes: All results reported use the Hard CM3 climate model and the IPCC SRES A1 and B1 storylines. Other models give diverging estimates for both increased and decreased numbers. Increased water stress is defined by a change to per capita water availability to below the threshold of 1000 m^3 per capital per year. Reduced water stress is defined by a change to per capital water availability to above the threshold of 1000m^3 per capita per year.

CONCLUSION :

In addition, prediction and evaluation of how climate change impacts would change over time is necessary and integration of this knowledge will be helpful into the forest management decisions and policy makings (Nunes et al., 2022). However, it demands multiple types of new practices, knowledge, and adaptation approaches for suitable forest management decisions. Sharing that integrated knowledge from multiple agricultural, climate change, forestry, and food security disciplines will be helpful in building a shared set up for understanding the future challenges of food security and facilitating improved decision and policy making in the face of severe climate change (Keenan, 2015).

Various studies focused on the impacts of future climate projections under various levels of CO_2 concentrations, and that increased levels of CO_2 likely to enhance crop productivity due to improvements in photosynthesis processes and improved water-use efficiency (WUE) because of high carbon fertilization (Lee et al., 2020). In contrast, it has also been found that crop productivity will increase with less rates in practical than projected in crop models (Long et al., 2006; Ainsworth and Ort, 2010). Therefore, the magnitude of change in crop production will vary branching from global to regional to country to community due to alternative and contrasting projections of crop models. Climate change impacts food production irregularly and unevenly as the impacts are more severe across tropical regions than in higher latitudes. Moreover, it has been projected those countries with a higher hunger index will be affected more severely in crop yield and livestock decline due to climate change..

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