IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

IMPACT OF GLOBAL WARMING AND CLIMATE CHANGE ON AGRICULTURAL PRODUCTIVITY

Pallabi Maity

Assistant professor, Matangini Teacher's Training Institute,

Chatra, Ramtarakhat, Purba Medinipur, Pin – 721151

West Bengal, India.

Abstract: **This paper looks at recent research on a number of processes that could affect global agricultural productivity as a result of climate change. This is done to show where there is still a lot of uncertainty. It also shows what a climate model ensemble thinks will happen to important weather, water, and plant-physiological quantities. There haven't been many global-scale analyses, and the ones that have been done can only take into account a small amount of the uncertainty in climate estimates. They also don't take into account things that could be very important, like extreme events and changes in pests and diseases. From an agricultural point of view, it is hard to know how to measure the effects of climate change on drought because different measurements give very different views of future risk. Some farming depends on rain, melting snow, and glaciers from far away, which makes things even more complicated. The indirect effects of diseases, storms, and rising sea levels have not been figured out. The area with the most uncertainty is probably how much the direct effects of a rise in CO2 on plant physiology, along with climate change, will change production.**

Index Terms **- Global warming, climate change, agricultural productivity, CO2.**

I. INTRODUCTION

The world's temperature is going up because greenhouse gas emissions are going up without being stopped. Because glaciers are melting, it rains more, there are more storms, and the seasons are changing because of this. The growth of the world's population and economy, along with the speeding up of climate change, pose a threat to food security around the world. Climate change is quite dangerous to agriculture. Higher temperatures make it harder to grow crops that people want to eat and make it easier for weeds and pests to grow. Changes in precipitation patterns increase the likelihood that crops will fail in the near term and that production will decline over time. Even if certain crops could grow more successfully in specific regions of the globe, climate change is predicted to have detrimental impacts on agriculture as a whole, endangering the world's ability to feed its population. People in underdeveloped countries, who are already at risk and don't have enough food, will probably be hit the hardest. Most of the poor people in the world (75%) live in rural areas. This Food Policy Report has research results that measure the effects of climate change, look at how they affect food security, and figure out how much money needs to be spent to make up for the bad effects on human health.

II. OBJECTIVES

O1. To assess the effect of climate change on global agricultural productivity.

O2. To measure the direct and indirect impacts of climate change on agriculture.

O3. To assess the role of the World Bank Group on the Climate Change Adapted Agriculture.

III. METHOD

This study employs two research methods: a literature review and empirical research. The literature study required locating, tracking down, and analysing publications providing information about the subject at hand. Professional journals, books, dissertations, and papers presented at various conferences were among the materials. The research has been done using secondary data source. The choices of measure of similarity are based on multidimensional Observations. Libraries and internet are used for collecting data.

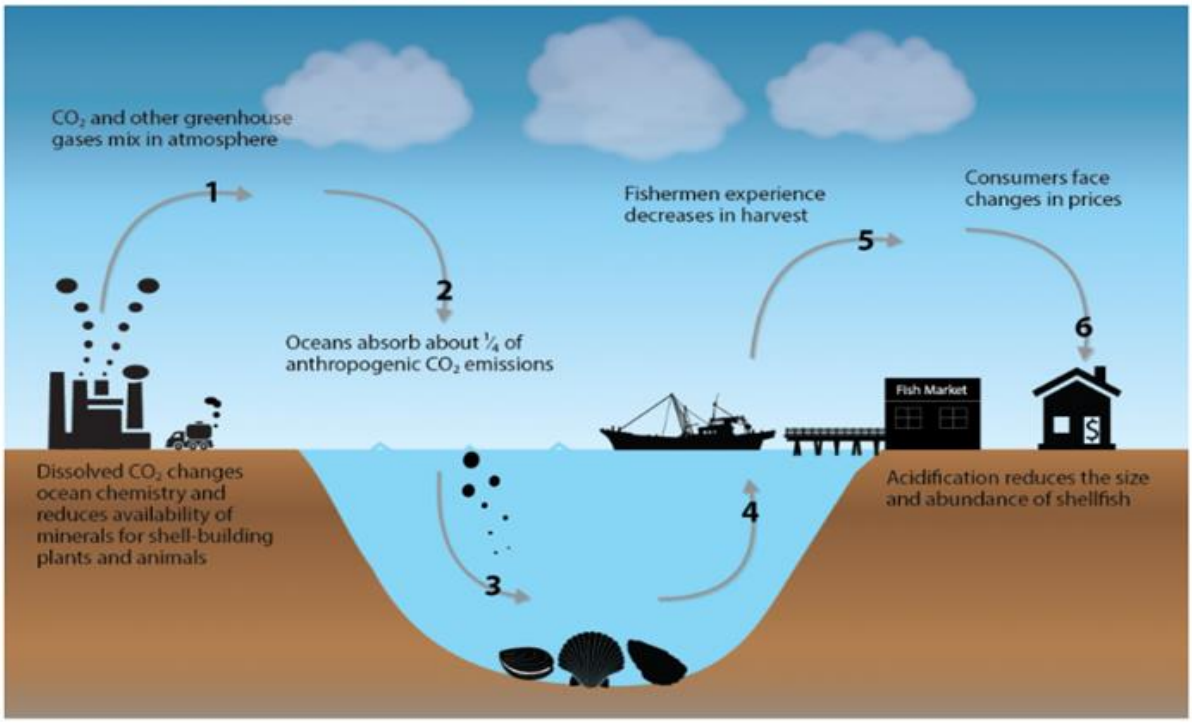
IV. RESULT AND DISCUSSION

Climate's impact on agriculture:

The climate and weather have a big effect on farming. There is still a lot of local adaptation to climate in the form of infrastructure, local agricultural practises, and personal experience, even though farmers often adjust to shifting weather and the fact that each year is unique. As a result, it is anticipated that climate change would have an impact on agriculture, which might be challenging for conventional agricultural techniques but also result in advancement. Numerous ways that climate change can impact agriculture are possible. Over a certain range of temperatures, when it gets warmer, crop yields tend to go down because plants grow faster and make less grain as a result. Also, rising temperatures make it harder for plants to take in and use rain. When the temperature goes up, plants lose more water through their leaves, which speeds up the drying out of the soil. The process as a whole is called "evapotranspiration." Since global warming is expected to cause more rain to fall, the overall effect of rising temperatures on water availability is a race between more evaporation and more rain. Most of the time, the one with the most evaporation-transpiration wins. However, carbon emissions, a significant contributor to climate change, may also benefit agriculture by accelerating photosynthesis in a number of significant "C3" crops (such as wheat, rice, and soybeans). Scientists aren't quite sure what the benefits of carbon fertilisation are, though. We do know, though, that this doesn't help much with "C4" crops like sugarcane and maize, which make up about a quarter of the value of all crops.

The graphic below shows how carbon dioxide emissions affect the shellfish market. When the oceans take in carbon dioxide, it makes the oceans more acidic. Because of acidification, the size and number of shellfish are getting smaller, which means that the harvest will go down and prices for consumers will change.

Figure 1. Ocean Acidification Impact Pathway for Shellfish



Source: US EPA (2015). Climate Change in the United States: Benefits of Global Action

Current Conditions and Forecasts of Global Climate Change:

The IPCC Assessment Report gives scenarios for greenhouse gas emissions by predicting how the concentration of greenhouse gases would change as a result of changes in population and the economy. The Special Report on Emission Scenarios (SRES) has four main scenarios: A1, A2, B1, and B2. It also has three other scenarios that have been changed to reflect the technical focus of the A1 scenario: A1F, A1T, and A1B.

Figure 2. Conceptual diagram of scenarios for estimating climate change

Source : Kim, Chang-Gil and et al. (2009), p.21.

In the A1 scenario, it is assumed that the economy will grow very quickly and reach its peak in 2050. After that, it will start to grow more slowly as new, more effective technologies are put into use. The alternative development of energy technology divides it into three parts. The three scenarios are the balanced energy scenario, the non-fossil energy scenario, and the high fossil fuels scenario.

The scenario A2 describes a world with many different kinds of people, technology that is very advanced but changes slowly, a high rate of population growth, a moderate rate of economic growth, and both.

The B1 scenario predicts that the economy will grow more slowly than in the A1 scenario, but that the population will grow at the same rate. In this case, the economy changes to a service and information economy, and clean and resource-efficient technologies are given priority in the name of sustainable development.

B2 shows a world where people from different places live together in peace. Based on a population and economic growth rate that is midway between A1 and B1, this scenario. Its primary emphasis is on local solutions for environmental, social, and economic sustainability.

Direct impacts of climate change on agriculture:

Changes in mean climate:

The long-term mean climate state has a big effect on agriculture and farming practises in any given place. Local farming communities often have the resources and expertise to support certain farming techniques and a specific set of crops that are known to be productive in the given environment. The ideal approach to farm can alter if the typical weather varies from what it is currently. This implies that in order to maintain production, present practises may need to be modified. Higher temperatures might have a significant impact on agricultural productivity, farm revenue, and food security throughout the growing season. [1] Cereals and cool-season seed crops, which are mid- and high-latitude crops, will probably grow more suited and productive as they travel farther north. [7] At southern Europe, maize, sunflowers, and soy beans are typical crops; but they may also thrive in higher elevations and farther north. [6] [7] Depending on the crop, yields might increase by up to 30% by the 2050s. Planting windows will be longer and overall growth conditions will be better because to global warming. According to Fisher et al. (2005), agricultural productivity will rise significantly over the course of the next century in locations like the Russian Federation. This meant that by the 2080s, more than 245 million hectares had increased by 64%. [5] However, technological advancement might compensate for these shortcomings by the 2050s and result in a 37-101 percent increase in wheat output. [4] If farmers don't adjust, even mild climate change could not be helpful for their industry. This is due to the fact that if growers don't adjust to a longer growing season, an increase in the mean seasonal temperature may cause the period when many existing crop kinds are ready to be harvested to shift earlier. India is partially driven by the dynamic monsoon circulation's anticipated weakening, which would result in less rain during the Indian monsoon, and the increase in atmospheric water content brought on by global warming. [12] However, variations in the quantity of rain that falls during the year may not be as significant to agriculture as variations in the annual mean. Climate models often predict that India will see more rain throughout the remainder of the year, especially during the monsoon season, and less rain during the dry season. However, there is still a significant gap between the models. [3]

Climate variability and extreme weather events:

But changes in the long-term mean climate will have an impact on the world's food supply and may need ongoing adaptation. Changes in how unpredictable weather is from year to year and how severe weather events are may be significant risks to food security. In the past, exceptionally low rainfall has been blamed for many of the largest reductions in agricultural productivity. [10] However, even little variations in the annual average rainfall might have an impact on productivity. The way monsoon rain falls in different places and at different times has a big effect on Indian agriculture. Asada and Matsumoto looked at the link between rainy season "kharif" rice production statistics at the district level and rainfall from 1960 to 2000. It was found that different parts of the world had different responses to extreme amounts of rain. Crop productivity in the upper Ganges basin is vulnerable to drought because the growing season is short and the amount of rain is related to that. On the other hand, the Brahmaputra basin showed that the effects of changing rainfall on agricultural productivity, especially drought, were getting worse, while the lower Ganges basin was more likely to be flooded by heavy rains. Because the way rain falls has changed over time, these correlations have not always been the same. The fact that districts were different showed how important social factors and the development of irrigation technology were.

Extreme temperature:

Since the middle of the 1980s, recent changes in the climate may have affected crop yields across Europe. [15] This may have caused wheat yields to change more from year to year. Based on this analysis, Spain's wheat would become a high-risk crop if the difference between each year's output continued to grow. Even crops grown in the middle of the world could be hurt by very high temperatures if they can't change. Short-term changes in temperature can be dangerous, especially if they happen during important stages of development. When many crops are in bloom, just a few days of very high temperatures (over 32°C) can have a big effect on production. [16] Changes in the growing conditions can cause crop responses that are not linear, show threshold reactions, and are vulnerable to a number of stresses that affect the crop's growth, development, and final yield. Up to a certain point, the rate of crop development usually responds linearly to temperature. Photosynthesis and respiration, two physiological processes involved in crop development, however, react continually and irregularly to temperature. But at temperatures that are most conducive to the process, both growth and development occur. Gene expression and enzyme activity can be changed in the short term by high temperatures. Long term, these things will change how much carbon is taken in, how fast plants grow, and how much they end up producing. How high temperatures affect a crop's yield in the end may depend on how far along it is in its growth. According to Wollenweber et al. (2003), plants naturally warm up, and their production is significantly impacted when they briefly reach critical temperatures of 35°C around anthesis. However, high temperatures didn't seem to have a significant impact on growth and development throughout the vegetative stage. [19] Reviews of the scientific literature suggest that temperature thresholds, particularly for processes like blooming and grain filling, are well characterised and strikingly constant across species. The output may be significantly decreased if the plants are exposed to temperatures exceeding 42°C after flowering, even for a brief period of time, even though groundnut is often produced in semi-arid regions with temps over 40°C. [17] When maize is heated above 36 °C, the pollen doesn't work as well. When the temperature is in the mid-30s, rice grains become sterile, while wheat may reverse the effects of cold weather on spring growth.

The average yield suffered during the summer of 2018 in several regions of the globe, particularly in Europe, due to heat waves that may have been brought on by climate change. How the weather behaves in August will decide whether or not additional crops fail. Losses are almost the same as they were in 1945, the year of the worst harvest in recent memory. For the third time in the previous four years, there was a shortage of wheat, rice, and maize across the globe in 2018. Governments and food producers were compelled to release food from storage as a result. Cattle's ability to develop and breed, as well as how much food they consume and how much milk and meat they produce, may all be impacted by heat stress. When temperatures get too high, it's hard for animals to keep their metabolism going. Because of this, they eat less, move around less, and lose weight. Because of this, animals can't make as much food. The way heat affects animals depends on where they live and what kind of animal they are.

Drought:

There are different ways to talk about drought, which often show different points of view. Holton et al. (2003) say that the effects of drought are what make it important. For definitions to be used by decision-makers in a practical way, they should be specific to a certain region and to a certain effect or use. It is easy to distinguish between a socioeconomic drought, which is characterised by poor economic growth, an agricultural drought, which is characterised by dry soil and increased plant water stress, and a meteorological drought, which is typically characterised by low rainfall. [8] In order to calculate the yield reduction rate (YRR) brought on by climate change, compared the long-term trend in yield—which they claim is driven by advancements in technology and infrastructure—with actual annual yields. According to them a linear relationship between YRR and a drought risk index based on the PDSI could explain 60–75% of observed YRRs for the four key cereals using national-scale data (wheat, barley, maize, and rice). Right now, the average YRR for rice is between 5.82 and 11.98 percent (maize). By 2050, the yield losses caused by drought for the most important crops will go up by more than 50% if the linear relationship between the drought risk index and YRR stays the same.

Because of climate change, droughts and floods are making it harder to grow food, and bad weather is happening more often. Floods can do a lot of damage to crops, stop farming, put workers out of work, and wipe out the food supply. Droughts can also damage or kill crops. In countries that aren't very well off, drought makes poverty even worse and leads to famine and poor nutrition. Droughts can cause crops to fail and grasslands for animals to graze to disappear. Some farmers might decide to leave a dry area for good and start farming somewhere else.

Heavy rainfall and flood:

Food production could be hurt by having too much water. Heavy rainstorms that cause flooding can destroy a lot of crops, and too much water can also make the soil waterlogged, stop oxygen from getting to the plants, and slow their growth. One of the indirect effects is that farming takes longer to do.

Tropical hurricanes:

A tropical cyclone is a low-pressure system that isn't on a front and is over tropical or subtropical seas. Thunderstorms that are organised and there is apparent cyclonic surface wind circulation are present. In the eastern North Pacific and North Atlantic, severe tropical cyclones with sustained winds of at least 74 mph are referred to as "hurricanes", but in the western North Pacific, they are referred to as "typhoons".

The indirect effects of climate change on agricultural productivity:

Diseases and pests:

Climate change and more CO2 in the air may also have an indirect effect on crops by making pests and diseases worse. Due to how complicated these relationships are, we still don't know the full effects on crop yield. There are signs that aphids and other pests are around [13].

Studies show that in response to CO2, plants make less of the insect-killing chemical jasmonic acid, which they release when they sense an attack. Without this defence, beetles can easily eat the leaves of soybean plants, which hurts crop production. This is a problem for many plant species, not just soybeans, because their defences are weakened by high CO2 levels.

Insects, bacteria, and fungi used to die in the winter because it was so cold. Fungal plant diseases like soybean rust and stripe and brown/leaf rust are moving farther north because winters are getting wetter and warmer. Soybean rust is a disease that kills plants and can wipe out whole fields in just a few days. This costs farmers billions of dollars in crop production. Another example is the Mountain Pine Beetle outbreak in British Columbia, Canada. Because the winters there were too warm to stop or stop the beetle larvae from growing, millions of pine trees died. Floods and heavy rain are also making it easier for other plant pests and diseases to spread. On the other hand, aphids, whiteflies, and locusts like it when it's dry, which is why they are pests.

Invasive species, weeds, and plant pathogens:

Weeds have shorter life cycles than crops and would benefit from CO2 fertilisation, just like crops. Since most weeds are C3 plants, they will likely compete with C4 crops like maize even more than they do now. But if the temperature goes up, weedkillers might work better.

Some places would get more rain because of global warming, which would lengthen the wet seasons and make the air more humid. Together with rising temperatures, these can make it easier for diseases caused by fungi to spread. In a similar way, higher temperatures and humidity may cause insects and disease carriers to show up more often. The interactions between pathogens and their hosts, especially the rates of infection and the resistance of the host plant, can change depending on the weather. Plant diseases also affect how much it costs to treat and take care of infected crops and how much it costs to grow other plants that might make less money.

According to research, climate change could cause the early stages of plant diseases that hurt crops to change. Plant diseases spread when the animals that carry them move to places with better conditions. This happens when the weather and temperature change because of climate change. This makes disease losses in farming get worse.

Changes in the environment may favour monocrops, which make up most farms, over weeds, which have a more diverse range of needs. Weeds have an advantage in changing climates because they have a wide range of genes, can cross-breed, and grow quickly. Because of these traits, they can change and adapt faster than most farms' crops, which are all the same. This gives them a biological edge. Herbicides will work less well because CO2 levels are going up, which will make weeds more resistant to them.

Changes in water availability owing to remote climate changes:

Changes in the climate that happen far away could be very important. Doll and Siebert (2002) say that between 40% and 45% of the world's food is grown on irrigated farmland, which is less than 20% of all farmland. Rivers, which depend on weather conditions far away, are often used to get water for irrigation.

At the moment, only a few rivers around the world have enough space to handle big changes in run-seasonality. [2] When there aren't enough storage places, a lot of the water that runs off in the winter will quickly go into the sea. A glacier retreat in the Himalayas is also backed up by the fact that there haven't been many direct observations of it. Large rivers like the Indus, Ganges, and Brahmaputra get water from these glaciers. The exact amount isn't known, but it is thought to make a big difference in the flow of rivers during the wet season. Nearly 500 million people now get their drinking water and water for farming from these rivers. Climate change could make the Indus and Ganges rivers flow less often and stop during the dry season. [9] The lack of water in the area is expected to get worse in the future as the population grows and more people move there.

Average rise in sea level:

Sea level rise is a natural result of a warmer climate. This is because the water in the ocean expands when it gets warmer, and melting land glaciers add more water to the ocean. It's possible that this could cause coastal land to flood in the long run, especially in places where it's hard or impossible to build or change sea walls. When it comes to agricultural yield, it's clear that areas with low-lying coastal agriculture and a lot of sea level rise are the most at risk. Because the soils near rivers are so rich, many large river deltas have a lot of farmlands, and many small island nations are also low-lying. When the average sea level goes up in the coming decades or centuries, it could flood agricultural areas and salty groundwater. However, since it takes a long time for big ice sheets to melt and for heat to reach the deep ocean, the worst impacts could not manifest for hundreds of years. The West Antarctic Ice Sheet (WAIS), the East Antarctic Ice Sheet (EAIS), and the Greenland Ice Sheet (GIS), which are all regarded to be vulnerable, would all result in an increase in sea level of 5 metres, 60 metres, and 7 metres, respectively, if the major ice sheets melted. Maximum eustatic sea-level rise of around 2 metres by 2100 is theoretically feasible, but it is very improbable. This is due to how quickly these ice sheets might melt and how much sea level has risen before in climates with comparable conditions. [14]

Non-climate impacts related to greenhouse gas emissions: impacts of changes in atmospheric composition:

CO2 fertilization:

The effects of carbon fertiliser depend on the type of plant, the air and soil temperature, and how much water and nutrients are available. The effect of carbon fertilisation could be good for net primary production (NPP). There is some evidence, though, that CO2 fertilisation may not always cause plants to grow faster and store more carbon because it speeds up photosynthesis.

Soil moisture and runoff may be better indicators of water resources than precipitation and meteorological drought indices because they show how much water is really available for agricultural use. Because these values are so important to the hydrological cycle, they are often used in climate models that are based on physics. Even with a lot of CO2 fertilising the soil, places like Africa and India could still lose up to 5 percent of their land by 2050. If the effects of CO2 fertilisation aren't taken into account, these losses could reach 30%. In fact, it is expected that, without CO2 fertilisation, all areas will lose output due to climate change by 2050. Existing world-scale studies, on the other hand, have only looked at a small number of the climate model predictions that are available right now.

Ozone:

Ozone is a major secondary air pollutant that has been shown to reduce crop yields by a lot at the levels that are currently in the air. Even though ozone precursor emissions are going down in North America and Europe, they are going up quickly in Asia and other parts of the world.

In many ways, ozone makes it harder for farmers to grow crops. First, the market value of goods, like crops, that are damaged right away and are easy to see goes down. Also, ozone makes leaves turn yellow and slows down photosynthesis, which both affect total output. A lot of studies in North America and Europe have looked at these kinds of yield drops. [11] But there isn't much evidence left in other places, like Asia. So, we don't know much about what will happen in these areas.

Other indirect impacts from changed conditions:

Climate change, which will raise food prices and cut food production, is expected to make future food insecurity much worse. As a result of trying to stop climate change, energy costs may go up, which could cause food prices to go up. Due to drought and rising demand for water in agriculture, there may not be enough water to grow enough food. As the weather in some places makes it hard to grow crops, there may be more competition for land. Extreme weather events that are caused by climate change could also cause sudden drops in agricultural production, which would cause prices to go up quickly. The Intergovernmental Panel on Climate Change (IPCC) claims that the climate has altered significantly since the 1950s and predicts that in the second half of this century, the mean surface air temperature would increase by 0.4 to 2.6°C (depending on future greenhouse gas emissions). A significant source of greenhouse gas emissions already comes from agriculture and the food production industry as a whole. If agriculture is made more intensive in the future to compensate for productivity declines (partly brought on by climate change) and rising demand for animal products, emissions may rise even more. The demand for products connected to cattle is anticipated to increase by 70% between 2005 and 2050.

Effects on forests and forestry:

The IPCC's Sixth Assessment Report, which came out in 2022, said that over the past few years, tree deaths have been going up around the world. Large waves of tree death have often been linked to warmer and drier-than-average conditions in forests in the temperate and boreal biomes. People have been watching tropical forests for a long time, and it seems that climate change has started to make more trees die and change how they grow back. Climate change has also been linked to tree deaths. This is because there are unique links between the life cycles of trees and pest species.

Climate smart agriculture (CSA):

CSA is a method of managing landscapes that considers the links between rapid climate change and food security, including crops, livestock, forests, and fisheries. CSA is aiming to accomplish these three objectives at once:

1. Enhanced productivity: Produce more food at a faster rate to increase income and ensure that everyone has access to adequate food, particularly the 75% of the world's poor who reside in rural regions and rely heavily on agriculture.

2. Greater resiliency: decrease susceptibility to pests, diseases, droughts, and other climate-related risks and shocks; improve capacity for growth and adaptation in the face of longer-term challenges including shortened seasons and unpredictable weather patterns.

3. Less pollution: Try to make less pollution per calorie or kilogramme of food produced, stop farmers from cutting down trees, and find ways to get rid of carbon dioxide from the air.

Climate Change Adapted Agriculture and the World Bank Group:

The World Bank Group is now putting more money into agriculture that is good for the climate (WBG). In its first Climate Change Action Plan (covering 2016–2020) and its next update (covering 2021–2025), the World Bank promised to work with countries to make climate-smart agriculture that increases production, makes farms more resilient, and reduces emissions.

The Bank's help to CSA has an effect all over the world:

A project in Bangladesh aims to make it easier for livestock farmers to adapt by improving animal health and reducing climate change by increasing the amount of emissions and making production more efficient. This includes making changes to how animals are fed, how they are kept healthy, how they are bred, how manure and waste are handled, and how milk is chilled and moved. Through an initiative that makes it easier for local governments to manage fisheries resources and protect biodiversity, the Philippines is improving climate resilience at the same time. The Bank is assisting Uruguay in achieving sustainable agricultural production in a variety of ways, including by creating strategies for soil management and establishing an Agricultural Information and Decision Support System. As part of the project for sustainable production in formerly agriculturally used areas, Brazilian researchers looked into ways to expand agriculture in a way that supports low-carbon agriculture and makes private businesses more profitable.

The Colombia Mainstreaming Sustainable Cattle Ranching Project showed that silvo pastoral systems (SPS), which can be paired with other tools for landscape management, technical assistance, and incentives, can help farmers and the environment achieve great results.

The goal of the Morocco Green Generation Program-for-Results is to improve the commercial and environmental performance of the agri-food value chains. It also hopes to assist more young people in rural regions in finding employment. It will increase people's resistance to the consequences of climate change in terms of the four components of food security—availability, access, stability, and usage. It will help with agroecology to make farmers more resistant to climate change, better extension services for CSA practises, and precision agriculture. The Agriculture Modernization Project in North Macedonia will help the country reach its Intended Nationally Determined Contributions (INDC) goals by putting in place measures to adapt to and reduce the effects of climate change, as well as measures to reduce GHG emissions from agriculture. The Climate Smart Agriculture Project in Kenya seeks to strengthen the resilience of small-scale agricultural and herding communities to the dangers of climate change. To do this, climate-smart farming practises need to be expanded, agricultural research and seed systems need to be improved, and services for advice, the market, the climate, and the market need to be supported.

Conclusion:

There are several ways that agriculture might be impacted by climate change. Climate change's indirect consequences on agriculture include Severe temperature, drought, heavy rain and flooding, tropical cyclones, and other extreme weather phenomena are examples of climate variability. Climate change's indirect consequences on agriculture include Invasive species, weeds, and plant infections; variations in water availability due to distant climatic changes; the average increase in sea level; diseases and pests; and others. Non-climate effects of greenhouse gas emissions include CO2 fertilisation, ozone, and other effects of changes in atmospheric composition. Effects on forests and forestry are some other indirect effects of the altered environment. During the growing season, higher temperatures may have a substantial effect on agricultural output, income, and food security. Certain farming methods and crops that are proven to be fruitful in the specific region are often supported by local agricultural groups, who frequently have the means and know-how to do so. Over the next century, agricultural production will increase dramatically. Because of global warming, planting windows will be longer and overall growth conditions will be better. By the 2050s, yields may rise by up to 30%, depending on the crop. The average yearly rainfall may vary somewhat, which might have an effect on production. Indian agriculture is greatly impacted by the way the monsoon rain falls in various locations and at various times. Food security may be significantly at risk from changes in how unpredictable the weather is from year to year. The effects of high temperatures may extend to crops cultivated in semi-arid areas. Temperature swings that last just a short while, particularly if they occur during critical developmental phases, might be harmful. Floods may cause significant agricultural damage, halt production, and lay off people. Crop failure and the disappearance of grazing areas for animals are two effects of droughts. Increased CO2 levels and climate change may indirectly affect crops by making pests and illnesses worse. Because of the wetter and warmer winters, fungus plant diseases including soybean rust, stripe and brown/leaf rust are spreading further north. Due to increased precipitation in certain areas brought by global warming, the rainy seasons would last longer and the air would become more humid.

Climate changes that take place far away might be crucial. On irrigated farmland, between 40 and 45 percent of the world's food is produced. Water for irrigation is often obtained from rivers, which are subject to distant weather conditions. The Indus and Ganges rivers may flow less often as a result of climate change. A warmer temperature is a natural consequence of sea level rise. In the long term, this can result in coastal land flooding. The worst effects, however, could not become evident for hundreds of years since it takes a long time for large ice sheets to melt. Indicators of water resources such as precipitation and meteorological drought indices may not be as accurate as soil moisture and runoff. By 2050, countries like India and Africa might still lose up to 5% of their territory. These losses might exceed 30% if the effects of CO2 fertilisation are not taken into consideration. The climate has allegedly changed dramatically since the 1950s, according to the Intergovernmental Panel on Climate Change (IPCC). The average surface air temperature would rise by 0.4 to 2.6°C by the middle of this century (depending on future greenhouse gas emissions).

REFERENCES

[1] Battisti, D. S.& Naylor, R. L. (2009). Historical warnings of future food insecurity with unprecedented seasonal heat. Science, Vol. 323, No. 5911, pp. 240-244. doi:10.1126/science.1164363

[2] Barnett, T., Adam, J. & Lettenmaier, D. Potential impacts of a warming climate on water availability in snow-dominated regions. Nature 438, 303–309 (2005). https://doi.org/10.1038/nature04141

[3] Christensen, J. H., et al. (2007). Regional climate projections. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds , Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K. B., Tignor M.& Miller H. L.), pp. 847–940. Cambridge, UK: Cambridge University Press.

[4] Ewert, F. et al. (2005). Future scenarios of European agricultural land use I. Estimating changes in crop productivity. Agriculture, Ecosystems & Environment, Vol. 107, Issues 2–3, pp.101-116. doi:10.1016/j.agee.2004.12.003

[5] Fischer, G. et al. (2005). Socio-economic and climate change impacts on agriculture: an integrated assessment, 1990-2080. Philosophical Transactions of Royal Society B, Vol. 360, Issue. 1463, pp. 2067-2083. doi:10.1098/rstb.2005.1744

[6] Audsley, E. et al. (2006). What can scenario modelling tell us about future European scale agricultural land-use, and what not? Environmental Science & Policy, Vol. 9, Issue 2, pp. 148-162. doi:10.1016/j.envsci.2005.11.008

[7] Olesen, J. E., et al. (2007). Uncertainties in projected impacts of climate change on European agriculture and terrestrial ecosystems based on scenarios from regional climate models. Climatic Change 81, 123–143 (2007). https://doi.org/10.1007/s10584-006-9216-1

[8] Holton, J. R. et al. (2003). Encyclopedia of atmospheric sciences. New York, NY: Academic Press.

[9] Kehrwald, N. M. et al. (2008). Mass loss on Himalayan glacier endangers water resources. Geophysical Research Letters, Vol. 35, L22503. doi:10.1029/2008GL035556

[10] Sivakumar, M.V.K., Das, H.P. & Brunini, O. (2005). Impacts of Present and Future Climate Variability and Change on Agriculture and Forestry in the Arid and Semi-Arid Tropics. Climatic Change 70, 31–72. https://doi.org/10.1007/s10584-005-5937-9

[11] Morgan, P. B. et al. (2003). How does elevated ozone impact soybean? A meta-analysis of photosynthesis, growth and yield. Plant Cell & Environment, Vol. 26, Issue. 8, pp. 1317-1328. doi:10.1046/j.0016-8025.2003.01056.x

[12] Meehl, G. A., et al.2007Global climate projections. Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds, Solomon S., Qin D., Manning M., Chen Z., Marquis M., Averyt K. B., Tignor M.& Miller H. L.), pp. 747–846. Cambridge, UK: Cambridge University Press.

[13] Newman, J. A. (2004). Climate change and cereal aphids: the relative effects of increasing CO2 and temperature on aphid population dynamics. Global Change Biology, Vol. 10, Issue. 1, pp. 5-15. doi:10.1111/j.1365-2486.2003.00709.x

[14] Rohling, E. et al. (2008). High rates of sea-level rise during the last interglacial period. Nature Geosci 1, pp. 38-42. https://doi.org/10.1038/ngeo.2007.28

[15] Porter J. R.& Semenov M. A. (2005). Crop responses to climatic variation. Phil. Trans. R. Soc. B 360, 2021–2035. doi:10.1098/rstb.2005.1752

[16] Wheeler T. R. et al. (2000). Temperature variability and the yield of annual crops. Agriculture, Ecosystems & Environment, Vol. 82, Issues 1-3, pp. 159-167. doi:10.1016/S0167-8809(00)00224-3

[17] Vara Prasad P. V. et al. (2003). Super-optimal temperatures are detrimental to peanut (Arachis hypogaea L.) reproductive processes and yield at both ambient and elevated carbon dioxide. Global Change Biology, Vol. 9, Issue. 12, pp. 1775-1787. doi:10.1046/j.1365-2486.2003.00708.x

[19] Wollenweber B. et al. (2003). Lack of interaction between extreme high-temperature events at vegetative and reproductive growth stages in wheat. Journal of Agronomy and Crop Science, Vol. 189, Issue. 3, pp. 142-150. doi:10.1046/j.1439-037X.2003.00025.x