

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 1, January 2017

Effects of Climate Change on Agriculture

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ABSTRACT: Agriculture is a major source of GHGs which contribute to the greenhouse effect and climate change. However, the changing climate is having far reaching impacts on agricultural production, which are likely to challenge food security in the future. Global food security relies on both sufficient food production and food access, and is defined as a state when: 'all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life' (FAO). The principal barrier to food security is currently food access. Sufficient food is produced globally to feed the current world population, yet more than 10% are undernourished.

KEYWORDS: climate change, agriculture, effects, food security, economic, world population

I. INTRODUCTION

Climate change is likely to contribute substantially to food insecurity in the future, by increasing food prices, and reducing food production. Food may become more expensive as climate change mitigation efforts increase energy prices. Water required for food production may become more scarce due to increased crop water use and drought. Competition for land may increase as certain areas become climatically unsuitable for production. In addition, extreme weather events, associated with climate change may cause sudden reductions in agricultural productivity, leading to rapid price increases. [1,2] For example, heat waves in the summer of 2010 led to yield losses in key production areas including: Russia, Ukraine and Kazakhstan, and contributed to a dramatic increase in the price of staple foods. These rising prices forced growing numbers of local people into poverty, providing a sobering demonstration of how the influence of climate change can result in food insecurity. The consensus of the Intergovernmental Panel for Climate Change (IPCC) is that substantial climate change has already occurred since the 1950s, and that it's likely the global mean surface air temperature will increase by 0.4 to 2.6°C in the second half of this century (depending on future greenhouse gas emissions). Agriculture, and the wider food production system, is already a major source of greenhouse gas emissions. Future intensification of agriculture to compensate for reduced production (partly caused by climate change) alongside an increasing demand for animal products, could further increase these emissions. It's estimated that the demand for livestock products will grow by +70% between 2005 and future.

While gradual increases in temperature and carbon dioxide may result in more favourable conditions that could increase the yields of some crops, in some regions, these potential yield increases are likely to be restricted by extreme events, particularly extreme heat and drought, during crop flowering. Crop production is projected to decrease in many areas during the 21st century because of climatic changes.[3,4] This is illustrated in figure 2 which summarises average crop yield projections across all emission scenarios, regions, and with- or without- adaptation by farmers, showing an increasing trend towards widespread yield decreases.

Heat waves (periods of extreme high temperature) are likely to become more frequent in the future and represent a major challenge for agriculture. Heat waves can cause heat stress in both animals and plants and have a negative impact on food production. Extreme periods of high temperature are particularly harmful for crop production if they occur when the plants are flowering – if this single, critical stage is disrupted, there may be no seeds at all. In animals, heat stress can result in lower productivity and fertility, and it can also have negative effects on the immune system, making them more prone to certain diseases.

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Evidence for an increase in heat waves exists from warming that has already occurred, and greater than expected increases in heat wave frequency and magnitude (figure 3). It is difficult to make accurate predictions about the future frequency and magnitude of heat waves, but there is consensus among projections that measurements for both will continue to increase in the UK, in Europe, and at a global scale. The impact of heat waves are expected to be non-uniform, with disproportionately negative effects in less developed countries. Together with other aspects of climate change such as increased drought incidence, they may exacerbate existing issues around food security.[5,6]

II.DISCUSSION

Projected changes in climate are not limited to increases in temperature and heat waves; large changes in rainfall patterns are also expected to occur. While some regions are likely to suffer from more droughts in the future, other regions are expected to face the opposing issues of torrential rains and increased flooding. In coastal areas, rising sea levels may result in complete loss of agricultural land. Warmer climates may also lead to more problems from pests and diseases, and shifts in the geographical distribution of certain pests. For example, insects that serve as a vector for disease transmission are likely to migrate further pole-ward in the future, where livestock have so far not been exposed to these diseases.

The responses of yield to various stresses have been well defined through experimentation in many crops. Quantifying these responses, and identifying when agriculture is most vulnerable to stress, is beneficial in helping to identify the most efficient strategies for adaptation. Crop-level adaptation to climate change is expected to be key in minimising future yield losses and may involve: changing crop cultivars, sowing time, cultivation techniques, and/or irrigation practices. Ongoing research is addressing the challenges of maintaining and/or increasing crop production under global change. Some risks to crop production from climate change and extreme weather events have been identified, [7,8]and strategies suggested to help maintain production. These include: restoring farm type, crop, or cultivar scale diversity into food systems, to improve their resilience and making crop improvements that enhance stress tolerance. Other strategies may include developing pre-defined, international responses to food shortages in order to prevent food price shocks that might reduce people's access to food.

The unimpeded growth of greenhouse gas emissions is raising the earth's temperature. The consequences include melting glaciers, more precipitation, more and more extreme weather events, and shifting seasons. The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere. Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security. Populations in the developing world, which are already vulnerable and food insecure, are likely to be the most seriously affected. In 2005, nearly half of the economically active population in developing countries-2.5 billion people- relied on agriculture for its livelihood. Today, 75 percent of the world's poor live in rural areas.[9,10] This Food Policy Report presents research results that quantify the climate-change impacts mentioned above, assesses the consequences for food security, and estimates the investments that would offset the negative consequences for human well-being. This analysis brings together, for the first time, detailed modeling of crop growth under climate change with insights from an extremely detailed global agriculture model, using two climate scenarios to simulate future climate.

III.RESULTS

The combination of advancing climate change and an already-vulnerable industrial system is a "perfect storm" that threatens farmers' livelihoods and our food supply. The good news is that there are tools—in the form of science-based farming practices—that can buffer farmers from climate damage and help make their operations more resilient and

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sustainable for the long term. But farmers face many obstacles to changing practices, so it's critical that policymakers shift federal agriculture investments to support and accelerate this transition.[11,12]

Climate change trends

Changing precipitation patterns. Rainfall patterns have already begun shifting across the country, and such changes are expected to intensify over the coming years. This is likely to mean more intense periods of heavy rain and longer dry periods, even within the same regions.

Changing temperature patterns. Rising average temperatures, more extreme heat throughout the year, fewer sufficiently cool days during the winter, and more frequent cold-season thaws will likely affect farmers in all regions.

1) Climate change impacts

Floods. We've already seen an increase in flooding in many agricultural regions of the country, including the Midwest, the Southern Plains, and California. Sea level rise is also ratcheting up the frequency and intensity of flooding on farms in coastal regions. These costly floods devastate crops and livestock, accelerate soil erosion, pollute water, and damage roads, bridges, schools, and other infrastructure.[13,14]

Droughts. Too little water can be just as damaging as too much. Severe droughts have taken a heavy toll on crops, livestock, and farmers in many parts of the country, most notably California, the Great Plains, and the Midwest, over the past decade—and science tells us that rising temperatures will likely make such droughts even worse, depleting water supplies and, in some cases, spurring destructive wildfires.

Changes in crop and livestock viability. Farmers choose crop varieties and animal breeds that are well suited to local conditions. As those conditions shift rapidly over the coming decades, many farmers will be forced to rethink some of their choices—which can mean making new capital investments, finding new markets, and learning new practices.

New pests, pathogens, and weed problems. Just as farmers will need to find new crops, livestock, and practices, they will have to cope with new threats. An insect or weed that couldn't thrive north of Texas in decades past may find Iowa a perfect fit going forward—and farmers will have to adapt.[15,16]

Implications

2) Industrial amplifiers

Degraded soils. Typical monoculture cropping systems leave soil bare for much of the year, rely on synthetic fertilizer, and plow fields regularly. These practices leave soils low in organic matter and prevent formation of deep, complex root systems. Among the results: reduced water-holding capacity (which worsens drought impacts), and increased vulnerability to erosion and water pollution (which worsens flood impacts).

Simplified landscapes. Industrial agriculture treats the farm as a crop factory rather than a managed ecosystem, with minimal biodiversity over wide areas of land. This lack of diversity in farming operations exposes farmers to greater risk and amplifies climate impacts such as changes in crop viability and encroaching pests.

Intensive inputs. The industrial farm's heavy reliance on fertilizers and pesticides may become even more costly to struggling farmers as climate impacts accelerate soil erosion and increase pest problems. Heavy use of such chemicals will also increase the pollution burden faced by downstream communities as flooding increases. Farmers may also increase irrigation in response to rising temperature extremes and drought, further depleting precious water supplies.[17,18]

How will these industrially amplified climate change impacts affect people—farmers, residents of rural communities, and all of us who rely on the food farmers produce? In a variety of ways:

- As summer heat intensifies, farmers and farm workers will face increasingly grueling and potentially unsafe working conditions.
- Accelerating crop failures and livestock losses will make farmers with access to insurance or disaster relief programs more reliant on those taxpayer-funded supports, while those without sufficient safety nets will face

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additional challenges. Failing farms and stagnating farm profits will also increase suffering in many rural communities.

- Farming communities will be among the first to feel the ways extreme weather exacerbates agriculture's impacts on water resources—with nearby water supplies polluted or depleted before the damage extends to drinking water and fisheries far downstream.

Nationwide, reductions to agricultural productivity or sudden losses of crops or livestock will likely have ripple effects, including increased food prices and greater food insecurity.

IV. CONCLUSIONS

Business as usual won't protect the future of our food supply—or the well-being of the farmers and communities that produce it. We need to take concrete steps to prepare for climate impacts on agriculture and to reduce both their severity and our vulnerability to them.

We also need to remember that climate change risks aren't distributed equally—and neither are the pathways to climate adaptation. Public policies and institutional practices have long denied communities of color, low-income groups, and tribal communities access to critical resources and decision-making processes, leaving them with fewer options and more risk in the face of climate impacts. So it's crucial to ensure that these communities have a voice in shaping our adaptation strategies.[19]

3) Helping farm communities manage severe impacts

When climate impacts strike, support systems need to be in place to help communities cope and recover:

Shelters and other facilities to provide housing, food, first aid, and other immediate needs for people whose lives have been disrupted or displaced by floods, droughts, fires, or storms.

Investment in local capacity and infrastructure to support people harmed by climate impacts as they rethink or rebuild their lives and businesses. This includes not only infrastructure for communication, transportation, water and sanitation, but also training in new practices and opportunities that build adaptive capacity.

4) Reducing damage by making farms more resilient

Our farms and farm communities don't have to be sitting ducks for climate impacts. Forward-looking farmers and scientists are finding new, climate-resilient ways to produce our food:

Build healthier, "spongier" soils through practices—such as planting cover crops and deep-rooted perennials—that [increase soil's capacity](#) to soak up heavy rainfall and hold water for dry periods;

Make farms stronger by **redesigning them as diverse agroecosystems**—incorporating trees and native perennials, reducing dependence on fertilizers and pesticides, and reintegrating crops and livestock;

Develop new crop varieties, livestock breeds, and farm practices specifically designed to help farmers adapt to evolving climate realities.

5) Addressing the root of the problem

Finally, whatever we do to help farmers adapt to climate change, we still face the urgent need and obligation to reduce the source of the problem as far and as fast as we can. This means [bringing net emissions of heat-trapping gases down to zero](#), and doing it soon.

Fortunately, our farm and food system can be an important part of the solution, both by reducing emissions at every stage of the food production and distribution process, and by [building agroecosystems that can sequester \(store\) more carbon](#).[20]

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