Climate Change: A threat to food security and human health

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Human activities are the main drivers of several world problems. This is nothing short of the truth for **climate change**, which is now occurring at an unprecedented and alarming rate. With the industrial revolution came several landmark events such as heavy use and reliance on fossil fuels (e.g., coal, crude oil, and natural gas) to generate heat and electricity, deforestation for wood harvest and land use, and application of modern agricultural practices (e.g., the use of nitrogen fertilizers) to increase farming output and food supply. Undoubtedly, these advances have tremendously transformed humanity and improved our quality of life. On the downside, however, they have also inflicted a collateral damage of shooting up the emissions of **greenhouse gases**, the principal agents of climate change. Remarkably, the atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are currently sitting at 149%, 262%, and 183% above preindustrial levels, respectively.[1] With their intrinsic capacity to trap heat, greenhouse gases (at excessive levels) fuel the record-high global warming that we see today. As a result of increasing temperatures, natural ecosystems face disruptions such as rising sea levels, melting arctic ice, and higher ocean acidification. Many regions experience extreme weather changes such as irregular and more frequent precipitation patterns. Adverse events such as floods, wildfires, heat waves, and droughts have become more incident and furious. These climatic changes are not without consequences to the earth and its inhabitants; they have created new challenges and exacerbated the existing ones. One of such challenges is **food insecurity**.

Food insecurity – defined as limited access to sufficient, nutritious, and safe food – has been a persistent global burden from time immemorial, caused by various factors such as poor income, poverty, inflation, pandemics, conflict, war, and household displacement. The United Nations Food and Agriculture Organization (FAO) reported that 3 billion people worldwide were unable to secure healthy foods as of 2019, while about 2.37 billion lacked access to adequate foods as of 2020.[2] The ongoing climate crisis constitutes yet another major threat to global food security. Without prompt climate interventions, the risk of hunger and malnutrition is projected to rise by 20% by 2050,[3] while cases of stunted children would see an additional increase by 7.5 and 10.1 million by 2030 and 2050,[4] respectively. Painting another picture of the situation at hand, the FAO stated that climate change would substantially impede the progress towards achieving the Sustainable Development Goals to eradicate hunger, food insecurity, and all forms of malnutrition by 2030.[5]

The adverse impacts of climate change on food security are largely due to the **natural vulnerability of every level of the food system**. Elevated CO_2 levels, hotter temperatures, wetter soils, flood, and drought reduce crop yield and breed new pests and weeds, which predispose plants and livestock to disease and death.[6] Also, higher CO_2 concentration depletes the protein, zinc, and iron contents of crops,[7–9] thereby reducing their nutritional value and nutrient availability for physiological functions, with potential negative health implications. Aquatic species face the risk of exposure to harsh physical and chemical conditions, including warmer temperature and higher acidity, salinity, and oxygen concentration. Extreme conditions such as excessive rainfall, warmer temperature, flood, or wildfire may lead to shortage of labour for food processing, transportation, and distribution to consumers. Evidently, our food system is catching a cold from the sneezing climate, with inevitable negative outcomes for food security. We need immediate solutions to intercept climate change on

its track and minimize its toll on the food system and food security. And this is even more critical if we would meet the rising food demands of the 9.9 billion more people estimated by 2050.

Since greenhouse gases are the culprits of climate change, every action to combat climate change must revolve around mitigating their emissions and adapting the vulnerable systems to their negative impacts. Such climate intervention strategy is echoed in the 2015 Paris Agreement, detailing the commitment of many countries to net-zero carbon emissions by 2050, as part of the joint global response to climate change. Achieving this ambitious goal would essentially require both individual and synergistic actions from every sector of a nation. We interviewed Dr. Mumtaz Cheema to learn about some of the ongoing research efforts in the agricultural sector towards mitigating greenhouse gas emissions and strengthening agricultural food production to withstand the climate crisis.

Dr. Cheema hails from Punjab, a province renowned for its largest production capacity of premium quality rice in Pakistan. Being born and raised in an agriculture-oriented family, he was passionately immersed in all things agriculture and devout in his family's business of cultivating rice and wheat. One day, his grandfather said to him in a conversation, "farmers can produce everything except table salt." Dr. Cheema would ruminate on these words for days, and each time, they struck more chords of higher decibels in his mind and elevated his enthusiastic spirit for agriculture. These words sowed the seeds of his perpetual interest in an agricultural research career to explore the science behind a farmer's indispensable role in feeding the world. Launching his academic career in 1993 as a Lecturer in the Department of Agronomy at the University of Agriculture, Faisalabad, Pakistan, Dr. Cheema is currently a Professor of Boreal Ecosystems and Agricultural Sciences at the Memorial University of Newfoundland in the Canadian province of Newfoundland and Labrador. Operating from a state-of-the art research facility, his research program explores productive and sustainable agricultural practices to enhance soil health, crop growth, and yield and quality of produce in the face of climate change.

As Dr. Cheema would realize in his early years, we need agriculture to keep our bellies full and happy. In that same vein, we also need agriculture to rescue us from the ongoing climate crisis and its impacts on food security. This is because the agricultural sector contributes significantly to greenhouse gas emissions, with an annual emission of 25-30% globally[10] and over 10% in Canada.[11] These gases come from various agricultural practices. For instance, manure and nitrogen fertilizer application leads to nitrogen losses and N_2O emissions. Also, producing nitrogen fertilizers requires large quantities of natural gas. Primary sources of methane emissions include enteric fermentation in ruminants, anaerobic decomposition of manure from animal feces, and rice paddies. Large amounts of CO_2 are released from burning carbon-rich fuels (e.g., diesel and gas) to power farm machinery and transport food. According to Dr. Cheema, the agricultural sector seeks best management practices (BMPs) that increase carbon sequestration in the soil, reduce nitrogen losses, and ultimately promote soil productivity and resilience to climate hits. Some of the BMPs studied in his lab include different cropping systems such as cover cropping, crop rotation, and intercropping. These cropping systems reduce fertilizer and manure application, replenish soil nutrients and enhance soil fertility, increase nitrogen uptake and decrease losses, reduce soil erosion, and suppress pests and weeds, all of which maximize crop yields and profits to farmers. In their recent study, Dr. Cheema and colleagues demonstrated, for the first time, that intercropping silage corn with forage soybeans under cool climate boreal ecosystems increased forage production by 28%, phosphatase activity by 26-46% leading to 26-74% more available phosphorus, and microbial biomass in the rhizosphere of podzols, compared to monocropping, which is the most dominant cropping technique[12]. In addition to enhancing soil quality and performance, these findings also highlight the usefulness of intercropping in boosting crop productivity in boreal climates, which are characterized by shorter growing seasons. Future projects in Dr. Cheema's lab aim at examining the capacity of different crop rotations (fava bean, wheat, canola, corn, and barley oats) and nitrogen sources to enhance the physiochemical properties of soil, reduce nitrogen losses, trap carbon, and mitigate greenhouse gas emissions. Funding (up to $4.4 million) for these projects are expected to come from the Agricultural and Agri Food Canada, as part of the government's ongoing efforts to reduce greenhouse gas emissions by 40-45% below 2005 levels by 2030.

Another class of BMPs under investigation in Dr.

Cheema's lab is the use of soil amendments to sequester carbon in the soil and impart resilience to the soil in the face of climate change. An example of soil amendment is biochar, a product obtained after burning agricultural materials (e.g., manure and leaves) under low oxygen conditions. Although a carbon source, biochar has a very low rate of decomposition and helps to stabilize carbon in the soil while enriching soil's organic matter. His research group recently examined whether biochar could lower greenhouse gas emissions from soils treated with dairy manure or inorganic nitrogen. They found reductions in CO_2, N_2O, and CH_4 emissions by up to 26.5%, 93%, and 293%, respectively, pointing to the potential of biochar application in controlling global warming.[13] In the context of climate adaptation, another study from his lab showed that combined application of biochar and silicon prevented the adverse effects of drought stress on maize growth by improving the morphophysiological and biochemical attributes of the seedlings.[14] Other BMPs target improving fertilizer quality and application efficiency to reduce nitrate leaching and N_2O emissions. For instance, armed with the funding support of $15 million from New Frontiers Research Fund Transformation, Dr. Cheema is partnering with the industry and researchers at Dalhousie University to develop nano biofertilizers from fish and marine industrial wastes. In addition to valorizing industrial wastes and increasing revenue, such research initiatives also encourage cleaner and climate-friendly sources of fertilizers.

While discussing these ongoing climate interventions in the agricultural sector, Dr. Cheema also expressed profound optimism in their significant contributions towards achieving the global targets to reduce carbon emissions to net-zero and limit global warming to 1.5 °C by 2050. However, he noted that challenges abound. "To sequester carbon in the soil is not a short-term project, and we may not even see considerable progress within the next five years", he said. One area of challenge to the current efforts is the willingness of farmers to adopt the BMPs. Dr. Cheema acknowledged that despite the benefits of the BMPs discussed above, they are not the most optimal with respect to economic viability. For instance, cover cropping and soil amendment with biochar may come with heavy price tags, sparking hesitation or reluctance to adoption by farmers, who would be ever mindful of the return on their investments. In circumventing such obstacles, Dr. Cheema emphasized the need to place farmers at the centre of every plan and action towards climate mitigation and adaptation in the agricultural sector. He is currently pursuing government research funding opportunities to collaborate with and educate farmers on the benefits of the BMPs. By so doing, farmers can gain first-hand experience testing these BMPs, enabling them to make informed decisions towards adoption. Also, involving farmers in research would facilitate knowledge exchange and feedback for researchers to optimize and tailor BMPs to practical farming operations and conditions. Perhaps, another way to incentivize farmer is to increase government funding support to help offset the expenses of adopting the BMPs. Dr Cheema further indicated that the high cost of running some BMPs may skyrocket food prices downstream and potentially subdue the food purchasing power of consumers. Considering these challenges, careful considerations must be taken to ensure that climate interventions are effective yet economically viable and sustainable for food production and consumption.

Clearly, uneasy lies the road to climate change mitigation and adaptation. Defeating the climate crisis is indeed an enormous and daunting task, but one we cannot afford to shy away from or become pressured into throwing in the towel. In a report released on the last day of February 2022, the U.N. Intergovernmental Panel on Climate Change warned that we have a short and rapidly closing window of opportunity to mitigate and adapt to climate change, and any further delays in action would have us wrestling with dire consequences.[15] As a people, we have made impressive giant strides in tackling a mountain of other issues that plague our existence through creative, active, unwavering, and timely leadership. And it is in that leadership and amalgamation of global ideas and actions that we cast our faith and hope for a planet with a robust and more hospitable climate that will support human rights to food and pave the way for a more nourished, healthier, and happier world.

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