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Impact of Disasters and Climate Change on Agricultural Production and Food Security

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ABSTRACT: A new report released by the Food and Agriculture Organization (FAO) shows that the increasing frequency and intensity of extreme weather disasters such as floods, droughts and megafires as a result of climate change is having a devastating effect on food security and livelihoods. The report highlights the need for stronger disaster risk reduction policies and intensified efforts to build resilience to the adverse impacts of climate change to ensure agriculture's crucial role in achieving a sustainable future. According to the report, the annual occurrence of disasters is now more than three times that of the 1970s and 1980s as a result of our warming climate. Relative to agriculture, industry, commerce and tourism taken as a whole, on its own agriculture absorbs the disproportionate share of 63% of impact from disasters, with the least developed countries (LDCs) and low- and middle-income countries (LMICs) bearing the major brunt of these scourges. Thus, between 2008 and 2018, the impacts of natural disasters cost the agricultural sectors of developing country economies over USD 108 billion in damaged or lost crop and livestock production. Such damage can be particularly detrimental to livelihoods of smallholder and subsistence farmers, pastoralists, and fishers. Over the analyzed period, Asia was the most hard-hit region, with overall economic losses adding up to a staggering USD 49 billion, followed by Africa at USD 30 billion, and Latin America and Caribbean at USD 29 billion.

KEYWORDS: climate change, disaster, food security, agriculture, production, livelihoods, farmers, global warming

I. INTRODUCTION

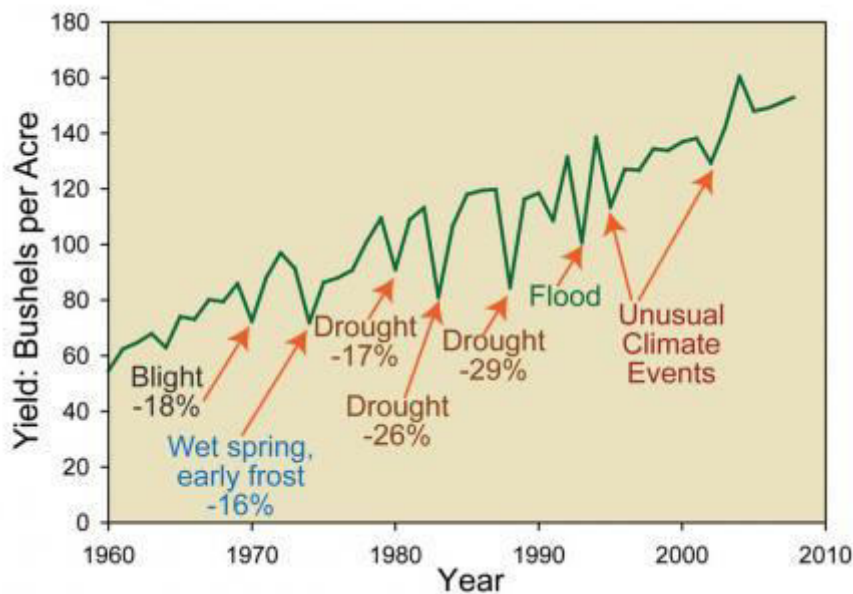
"The upheaval set in motion by COVID-19 may push even more families and communities into deeper distress," said FAO Director-General QU Dongyu in the foreword to the report. "Disaster impact is pervasive and requires immediate efforts to better assess and understand its dynamics, so that it may be reduced and managed in integrated and innovative ways. The urgency and importance of doing so have never been greater". [2] The report identifies drought as the single greatest culprit of agricultural production loss, followed by floods, storms, pests and diseases, and wildfires. Over 34% of crop and livestock production loss in LDCs and LMICs is traced to drought, costing the sector USD 37 billion overall. Drought impacts agriculture almost exclusively. The sector sustains 82% of all drought impact, compared to 18% in all other sectors. Crop and livestock pests, diseases and infestations have also become an important stressor for the sector. Such biological disasters caused nine percent of all crop and livestock production loss in the period from 2008 to 2018. [3] The potential threat of disasters of this category was rendered evident in 2020 when huge swarms of desert locusts ravaged across the Greater Horn of Africa, the Arabian Peninsula, and Southwest Asia, destroying crops and jeopardising food security. Meanwhile, the COVID-19 pandemic is placing an additional burden on agri-food systems exacerbating existing, systemic risks with cascading effects on lives, livelihoods, and economies worldwide. Disasters extend beyond the economic realm having deleterious consequences for food security and nutrition. For the first time ever, this edition of the FAO report converts economic losses into caloric and nutrition equivalents. For example, it estimates that crop and livestock production loss in LDCs and LMICs between 2008 and 2018 were equivalent to a loss of 6.9 trillion kilocalories per year. This equals the annual calorie intake of seven million adults. In Latin America and the Caribbean, disaster impacts during that same time frame convert to a loss of 975 calories per capita per day, accounting for 40% of recommended daily allowance, followed by Africa (559 calories) and Asia (283 calories). [1]

Investing in resilience and disaster risk reduction, especially data gathering and analysis for evidence-informed action, is of paramount importance to ensure agriculture's crucial role in achieving a sustainable future, FAO's report argues. Holistic responses and cross-sectoral collaboration are key in the disaster response. Countries must adopt a multi-hazard and multi-sectoral systemic risk management approach to anticipate, prevent, prepare for and respond to disaster risk in agriculture. [4] Strategies need to integrate not only natural hazards, but also anthropogenic and biological threats, such as the COVID-19 pandemic, and must be based on an understanding of the systemic nature and



interdependencies of risks. Innovations such as remote sensing, geospatial information gathering, drones and disaster robotics, and machine learning are powerful new assessment and data gathering tools that have much to offer in the quest to reduce disaster risks in agriculture. In addition to efficient governance, it is crucial to promote public-private partnerships to address the urgent need for investment in reducing agriculture's susceptibility to disasters and climate change.

FAO's recurring report *The Impact of Disasters and Crises on Agriculture and Food Security* presents the most recent trends in agricultural production loss attributed to disasters across all agricultural sectors. The latest edition covers 457 disasters in 109 countries across all regions and income categories, including for the first time upper-middle- and high-income countries (UMICs and HICs). Of the 109 countries to register disaster-related agriculture loss, 94 are in the LDC and LMIC categories, where 389 disasters hampered agricultural production. Agriculture and fisheries are highly dependent on the climate. Increases in temperature and carbon dioxide (CO₂) can increase some crop yields in some places. But to realize these benefits, nutrient levels, soil moisture, water availability, and other conditions must also be met. [5] Changes in the frequency and severity of droughts and floods could pose challenges for farmers and ranchers and threaten food safety. Meanwhile, warmer water temperatures are likely to cause the habitat ranges of many fish and shellfish species to shift, which could disrupt ecosystems. Overall, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as we have done in the past. The effects of climate change also need to be considered along with other evolving factors that affect agricultural production, such as changes in farming practices and technology. [2]



Graph-1: Despite technological improvements that increase corn yields, extreme weather events have caused significant yield reductions in some years.

Crops grown in the United States are critical for the food supply here and around the world. U.S. farms supply nearly 25% of all grains (such as wheat, corn, and rice) on the global market. [6] Changes in temperature, atmospheric carbon dioxide (CO₂), and the frequency and intensity of extreme weather could have significant impacts on crop yields. For any particular crop, the effect of increased temperature will depend on the crop's optimal temperature for growth and reproduction. In some areas, warming may benefit the types of crops that are typically planted there, or allow farmers to shift to crops that are currently grown in warmer areas. Conversely, if the higher temperature exceeds a crop's optimum temperature, yields will decline.



II. DISCUSSION

Higher CO₂ levels can affect crop yields. Some laboratory experiments suggest that elevated CO₂ levels can increase plant growth. However, other factors, such as changing temperatures, ozone, and water and nutrient constraints, may counteract these potential increases in yield. For example, if temperature exceeds a crop's optimal level, if sufficient water and nutrients are not available, yield increases may be reduced or reversed. Elevated CO₂ has been associated with reduced protein and nitrogen content in alfalfa and soybean plants, resulting in a loss of quality. Reduced grain and forage quality can reduce the ability of pasture and rangeland to support grazing livestock.[7] More extreme temperature and precipitation can prevent crops from growing. Extreme events, especially floods and droughts, can harm crops and reduce yields. For example, in 2010 and 2012, high nighttime temperatures affected corn yields across the U.S. Corn Belt, and premature budding due to a warm winter caused \$220 million in losses of Michigan cherries in 2012. Dealing with drought could become a challenge in areas where rising summer temperatures cause soils to become drier. Although increased irrigation might be possible in some places, in other places water supplies may also be reduced, leaving less water available for irrigation when more is needed.[3]

Many weeds, pests, and fungi thrive under warmer temperatures, wetter climates, and increased CO₂ levels. Currently, U.S. farmers spend more than \$11 billion per year to fight weeds, which compete with crops for light, water, and nutrients. The ranges and distribution of weeds and pests are likely to increase with climate change. This could cause new problems for farmers' crops previously unexposed to these species. Though rising CO₂ can stimulate plant growth, it also reduces the nutritional value of most food crops. Rising levels of atmospheric carbon dioxide reduce the concentrations of protein and essential minerals in most plant species, including wheat, soybeans, and rice. This direct effect of rising CO₂ on the nutritional value of crops represents a potential threat to human health. Human health is also threatened by increased pesticide use due to increased pest pressures and reductions in the efficacy of pesticides. Livestock and poultry account for over half of U.S. agricultural cash receipts, often over \$100 billion per year. Changes in climate could affect animals both directly and indirectly.

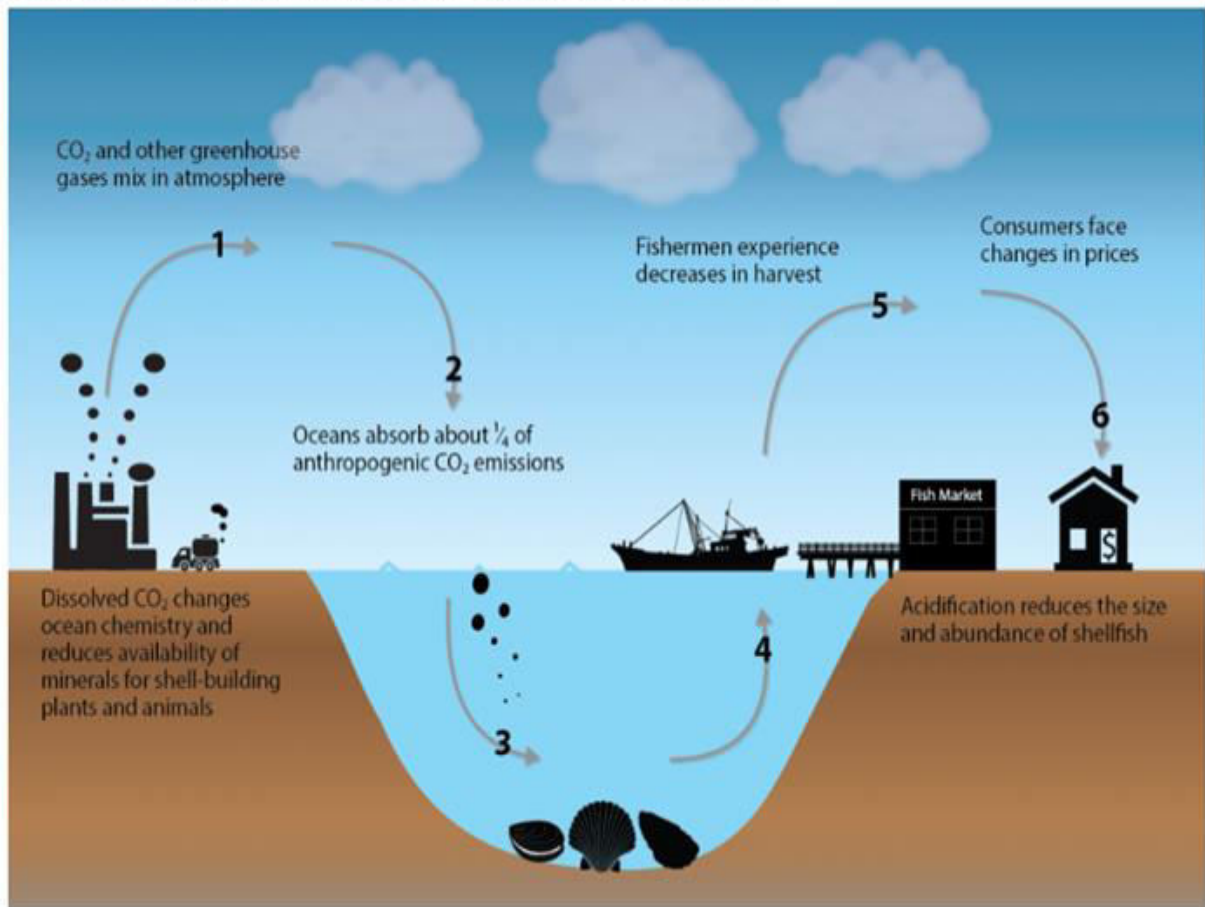
Heat waves, which are projected to increase under climate change, could directly threaten livestock. In 2011, exposure to high temperature events caused over \$1 billion in heat-related losses to agricultural producers. Heat stress affects animals both directly and indirectly. Over time, heat stress can increase vulnerability to disease, reduce fertility, and reduce milk production.[8] Drought may threaten pasture and feed supplies. Drought reduces the amount of quality forage available to grazing livestock. Some areas could experience longer, more intense droughts, resulting from higher summer temperatures and reduced precipitation. For animals that rely on grain, changes in crop production due to drought could also become a problem. Climate change may increase the prevalence of parasites and diseases that affect livestock. The earlier onset of spring and warmer winters could allow some parasites and pathogens to survive more easily. In areas with increased rainfall, moisture-reliant pathogens could thrive. Potential changes in veterinary practices, including an increase in the use of parasiticides and other animal health treatments, are likely to be adopted to maintain livestock health in response to climate-induced changes in pests, parasites, and microbes. This could increase the risk of pesticides entering the food chain or lead to evolution of pesticide resistance, with subsequent implications for the safety, distribution, and consumption of livestock and aquaculture products. Increases in carbon dioxide (CO₂) may increase the productivity of pastures, but may also decrease their quality. Increases in atmospheric CO₂ can increase the productivity of plants on which livestock feed. However, the quality of some of the forage found in pasturelands decreases with higher CO₂. As a result, cattle would need to eat more to get the same nutritional benefits.[4]

Many aquatic species can find colder areas of streams and lakes or move north along the coast or in the ocean. Nevertheless, moving into new areas may put these species into competition with other species over food and other resources, as explained on the Ecosystems Impacts page. Some marine disease outbreaks have been linked with changing climate. Higher water temperatures and higher estuarine salinities have enabled an oyster parasite to spread farther north along the Atlantic coast.[9] Winter warming in the Arctic is contributing to salmon diseases in the Bering Sea and a resulting reduction in the Yukon Chinook Salmon. Finally, warmer temperatures have caused disease outbreaks in coral, eelgrass, and abalone. Changes in temperature and seasons can affect the timing of reproduction and migration. Many steps within an aquatic animal's lifecycle are controlled by temperature and the changing of the seasons. For example, in the Northwest warmer water temperatures may affect the lifecycle of salmon and increase the likelihood of disease. Combined with other climate impacts, these effects are projected to lead to large declines in



salmon populations. In addition to warming, the world's oceans are gradually becoming more acidic due to increases in atmospheric carbon dioxide (CO₂). Increasing acidity could harm shellfish by weakening their shells, which are created by removing calcium from seawater. Acidification also threatens the structures of sensitive ecosystems upon which some fish and shellfish rely. [5]

Figure 1. Ocean Acidification Impact Pathway for Shellfish



III. RESULTS

Climate change is very likely to affect food security at the global, regional, and local level. Climate change can disrupt food availability, reduce access to food, and affect food quality.^[14] For example, projected increases in temperatures, changes in precipitation patterns, changes in extreme weather events, and reductions in water availability may all result in reduced agricultural productivity. Increases in the frequency and severity extreme weather events can also interrupt food delivery, and resulting spikes in food prices after extreme events are expected to be more frequent in the future.[10] Increasing temperatures can contribute to spoilage and contamination. Internationally, these effects of climate change on agriculture and food supply are likely to be similar to those seen in the United States. However, other stressors such as population growth may magnify the effects of climate change on food security. In developing countries, adaptation options like changes in crop-management or ranching practices, or improvements to irrigation are more limited than in the United States and other industrialized nations.[6]

Any climate-related disturbance to food distribution and transport, internationally or domestically, may have significant impacts not only on safety and quality but also on food access. For example, the food transportation system in the United States frequently moves large volumes of grain by water. In the case of an extreme weather event affecting a waterway, there are few, if any, alternate pathways for transport. High temperatures and a shortage of rain in the summer of 2012 led to one of the most severe summer droughts the nation has seen and posed serious impacts to the



Mississippi River watershed, a major transcontinental shipping route for Midwestern agriculture. This drought resulted in significant food and economic losses due to reductions in barge traffic, the volume of goods carried, and the number of Americans employed by the tugboat industry. The 2012 drought was immediately followed by flooding throughout the Mississippi in the spring of 2013, which also resulted in disruptions of barge traffic and food transport. Transportation changes such as these reduce the ability of farmers to export their grains to international markets, and can affect global food prices.

Impacts to the global food supply concern the United States because food shortages can cause humanitarian crises and national security concerns. They also can increase domestic food prices.

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, 1996). The principal barrier to food security is currently food access. [11] Sufficient food is produced globally to feed the current world population, yet more than 10% are undernourished. 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. 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. Worldwide, between 2003 and 2013 - the period analyzed in the study - the average annual number of disasters caused by all types of natural hazards, including climate-related events, almost doubled since the 1980s. The total economic damage caused is estimated at \$1.5 trillion.[7]

Focusing specifically on the impact of climate-related disasters in developing countries, some 25 percent of the negative economic impacts were borne by the crop, livestock, fisheries and forestry sectors alone. In the case of drought, over 80 percent of the damage and losses affected the agriculture sector, especially livestock and crop production.

The FAO report is based on a review of 78 on the ground post disaster needs-assessments conducted in developing countries coupled with statistical analyses of production losses, changes in trade flows and agriculture sector growth associated with 140 medium and large scale disasters - defined as those affecting at least 250,000 people. The report clearly demonstrates that natural hazards - particularly extreme weather events - regularly impact heavily on agriculture and hamper the eradication of hunger, poverty and the achievement of sustainable development. [12] The situation is likely to worsen unless measures are taken to strengthen the resilience of the agriculture sector and increase investments to boost food security and productivity and also curb the harmful effects of climate change. "This year alone, small-scale farmers, fisherfolk, pastoralists and foresters - from Myanmar to Guatemala and from Vanuatu to Malawi - have seen their livelihoods eroded or erased by cyclones, droughts, floods and earthquakes," said FAO Director-General José Graziano da Silva. He noted how the international community recently committed itself to achieving the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction 2015-2030 and is expected to reach a climate change agreement at the COP 21. Measuring progress made in meeting these global targets will require accurate, up-to-date information, including on the impact of disasters, Graziano da Silva stressed. "National strategies for disaster risk reduction and climate change adaptation that support resilience must address the types of disasters with the greatest impact on the agriculture sector, the FAO Director-General said. He noted how sector-specific data on damage and losses are essential for effective policy and practice," and that the FAO study aims to contribute to national, regional and global efforts to develop comprehensive disaster data collection and monitoring systems. [8]



IV. CONCLUSIONS

Drought has an especially detrimental impact - around 90 percent of production losses - on agriculture in sub-Saharan Africa where the sector on average contributes to a quarter of GDP, rising to a half when agribusiness is included. At a conservative estimate, total crop and livestock production losses after major droughts were equivalent to more than \$30 billion between 1991 and 2013 in the region. Drought often has a major cascading effect on national economies as shown in Kenya where between 2008 and 2011 it caused significant losses in the food processing industry, particularly grain milling and coffee and tea processing. Many Asian countries are particularly vulnerable to the impact of floods and storms. For example, crop production losses caused by the 2010 floods in Pakistan directly affected cotton ginning, rice processing and flour and sugar milling, [13] while cotton and rice imports surged. In this case, some 50 percent of the \$10 billion in total damages and losses fell on the agriculture sector. Understanding the impact of different types of disasters is crucial to ensure that the most appropriate policies and practices are implemented. Floods cause more than half of the total damage and loss to crops which are also very vulnerable to storms and drought. Around 85 percent of the damage caused to livestock is due to drought, while fisheries are overwhelmingly affected by tsunamis and storms such as hurricanes and cyclones. Most of the negative economic impact to forestry is caused by storms and floods. Beyond production losses, the study shows how disasters can cause unemployment and erode incomes especially for small scale family farmers, thus threatening rural livelihoods. For instance, the 2010 floods in Pakistan affected 4.5 million workers, two-thirds of whom were employed in agriculture and over 70 percent of farmers lost more than half of their expected income. [9]

Worldwide, the livelihoods of 2.5 billion people depend on agriculture, yet only 4.2 percent of total official development assistance was spent on agriculture between 2003 and 2012 - less than half the United Nations target of 10 percent. Investment in disaster risk reduction is extremely low: only around 0.4 percent of official development aid in 2010 and 2011. FAO stresses that aid should better reflect the impact of disasters on the agriculture sector. Investments into disaster response and recovery should also build resilience to future shocks through risk reduction and management measures, particularly in countries facing recurrent disasters and where agriculture is a critical source of livelihoods, food and nutrition security, as well as a key driver of the economy. [14]

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