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Natural Disaster : Mitigation Leveraging Agricultural Intensification

Sujoy Saha[1], Sneha Bhosale[1], Ratna Thosar[1]

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ABSTRACT

Natural disasters are the ultimate consequences from increased carbon footprints that has the severe impact on the food security, leading to increased vulnerability. Natural disaster destroys agricultural production by reducing crop yield thereby making the farmers in developing economies under greater risk and uncertain conditions. Various sustainable mitigation strategies like community capacity building for disaster risk reduction, storm-related strategies, crop diversification according to different planting seasons, propagation of disaster resistant crops, development of seed banks and nurseries, setting up of post-harvest facilities, better land-use and crop planning, community participation for traditional rain water harvesting, crop Insurance and artificial intelligence have to be adopted to tackle the hazards of natural disasters.

Keywords : Natural disasters, Modes and variation, Pre-mitigation strategies, Sustainable strategies

Introduction

With the onward march of the dial hour, the burgeoning population is responsible for increased carbon footprints which in turn has a cascading effect on the dwindling natural resources of the Earth. Natural disasters are the ultimate consequences of it.Natural catastrophes include earthquakes, droughts, floods, high temperatures, epidemics, wildfires, insect illness, storms, landslides, mass migration (dry), and volcanic activity. The frequency and severity of natural disasters have increased globally. Disasters threaten all three pillars of sustainable development: social, environmental, and economic. This is happening more rapidly and unpredictably than anticipated, across multiple sectors, dimensions, and scales. Agriculture continues to bear the brunt of disaster impacts as new risks and correlations emerge. Disasters have a severe impact on food security, leading to increased vulnerability (FAO, 2018). In recent years, there has been a greater understanding of the repercussions of natural disasters to reduce disaster-related losses (Marin and Modica, 2017). The agriculture sector is risk-prone, especially farmers in developing economies who faced risk and uncertain conditions. Natural disaster destroys agricultural production by reducing crop yield, making irrigation water unavailable, and potentially increasing evapotranspiration (Trinh *et al.*, 2021). According to FAO (2018), the

1- ICAR-National Research Centre for Grapes, Plant Pathology, ICAR- National Research Centre for Grapes, P.B. No 3, Manjri Farm, Solapur Road, Pune, Maharashtra, India, 412 307

agricultural sector accounted for around 16% of overall damage, 31% of total disaster loss, and 23% of total damage and loss worldwide. Damage to agricultural productivity poses substantial concerns to food security, particularly in countries where the majority of people rely on agriculture.

Natural disasters: modes and variation

1. Storm related disasters

Cyclone-related disasters are classified as cataclysmic - a large-scale, rapid-onset event causing extensive damage and destruction. Following such an event, there may be a tremendous amount of suffering and chaos, and secondary disasters such as landslides. The most immediate and visible impact of storms on agriculture is the damage to standing crops, livestock, household property, production assets, and physical infrastructure. This may result in food supply shortages at household, community, and sometimes national levels and almost always causes a reduction in livelihood security and related problems of access to food for poor households. The extent to which storm-related disasters are of local or national significance depends on the intensity of the storm, the area affected, the stage of crops at the time of the storm, the level of preparedness, and the size of the country. While the agricultural impact of storm-related disasters at the national level may be limited, the implications for livelihoods in damaged areas can be far-reaching, thus affecting national food security.

In addition to destroying crops and affecting food supply, storms can also affect land quality and production potential. Storm surges can flood coastal areas with saline water, resulting in the salinity of agricultural land. If the surge occurs after the main rainy season, effects on cropping and yields are greater as the salt is not quickly diluted. In some areas, good topsoil may be washed away, exposing less cultivable soil layers. The impact of a storm on the soil depends on the preceding climatic conditions (soil moisture, water level). It is also affected by factors such as topography and soil type, including soil depth, moisture holding and drainage capacity. Impacts also depend on land use and farming practices that influence the organic matter content and permeability of the soil. The richer and more permeable the soil, the less likely it is to be washed away during a storm.

2. Flood

Flood is one of the most common natural disaster globally and under the influence of climate change and economic development, the extent of flood events are expected to increase (Jonkman and Kelman, 2005; Anonymous, 2007). The tangible and intangible losses due to floods in India are increasing due to the speedy growth of population and increased encroachments of the flood plains for habitation, cultivation and other developmental activities. Due to flood exposure, Indian agriculture has experienced massive losses like crop loss especially standing crops and yield reduction, damage to soil, damage to machinery, damage to stored inputs, damage to roads, etc. Agricultural areas are frequently located in floodplain areas and therefore this area is particularly targeted. Climate change is a major driver

which intensifies the hydrological cycle thereby increasing the magnitude and frequency of extreme floods. In six years (2015-21), India lost 33.9 million hectares of cropped area due to floods (Anonymous, 2022).

3. Cyclone

All the components of the agriculture sector especially those which are in coastal areas are affected by cyclone through direct damage by high-speed wind, torrential rain and extensive flooding. High tide may also affect agriculture by bringing in saline water and sand mass thereby making the fields unsuitable for agriculture. The indirect effects include infection and disease of crop plants. Agricultural marketing and trade is adversely affected due to lean season of animal, fish and crop production. Past cyclones have brought about so much of destruction in Indian agriculture. The recent Cyclone Fani's damage to standing crops was estimated to peg at around 150 crore and it also severely damaged the harvested crops stored in the open (Anonymous, 2019).Cyclone Yaas, in May 2021, affected nearly 5,700 hectares of agricultural land. In cyclone Jawad, standing crops on more than 578,000 hectare in around 131 blocks of 12 districts were severely damaged (Anonymous, 2023).

4. Hailstorm

Hailstorm with powerful winds can physically damage crops across large areas. The falling hailstorms and strong winds bend and break plants and also strip them of leaves and bark. A small piece of hail can even destroy vegetables like cabbage, lettuce, tomatoes, etc. in grapes, severe hailstorm in 2023, have caused a loss of yield due to berry cracking (Anonymous, 2023). Months of hard work by farmers can be destroyed almost instantly (Nag, 2018). The indirect effects of hailstorm is quite significant in grape leading to bunch rot and berry drops.

5. Rainfall

Rainfall is a mandate for crop husbandry. Reduction in rainfall may lead to low yields from rain-fed crop production. Lack of water shows adverse impacts on plant cells while excessive water also shows adverse impacts on crops. Waterlogged conditions in soil can be detrimental to vine crops and vegetables while parched conditions do affect cereal crops especially paddy (Bhadouria *et al.*, 2019). Therefore, rainfall can have either positive or negative effects on agriculture yield, which are region or area-specific. A study also found that excessive rainfall reduced U.S. corn yield by as much as 34% relative to the expected yield (Li *et al.*, 2019).

6. Temperature

Agricultural production faced challenges due to increases in temperature under a warming climate with an intensified water cycle (Li *et al.*, 2019). It has been predicted that the increase in average global temperature will be 0.2°C each decade. Due to global warming, it is difficult for to adapt a new climate. In general, plants show substantial growth due to an increase in air temperatures up to a point. After that, extreme heat may slow down the process of growth and reduce moisture content, which in turn reduce agricultural productivity (Bhadouria et al., 2019).High temperature

in March, 2004 adversely affected crops like wheat, apple, mustard, rapeseed, linseed, potato, vegetables, pea and tea across the state of Himachal Pradesh in India. The yield loss was estimated between 20% and 60% depending upon the crop (Prasad and Rana, 2006).

Pre-mitigation strategies to counter natural disasters :

Disaster preparedness can significantly reduce the disaster impact. The disaster preparedness can be done with knowledge transfer to the people who live in the prone area. They can learn from the experience, but knowledge transfer is still crucial in pre-disaster risk reduction management. Low-cost adaptation technology that farmers can apply is the suitable method to adapt toward disaster.

Agroforestry, which is combining crops and trees, is widely practiced among farmers in disaster-prone areas. This system can help to protect the crops and land from erosion. This farming method also can be used as mitigation strategies for volcano, earthquake and landslide disasters. In the fire-prone forest area, agroforestry can help restore the land through the trees and at the same time, this system also provides food through the crops, thereby enabling farmers to choose whether to consume by themselves or sell the crops.

Farmers conduct adaptation toward natural hazards by changing planting dates and crop varieties and increasing the use of fertilizers and pesticides. Education regarding sustainable agriculture can be the method to reduce the overused chemical materials. The mitigation education is applicable for all pre-disaster mitigation strategies. Farmers tend to use existing farmers groups to transfer and share innovations, including disaster risk mitigation techniques. Furthermore, other mitigation education methods like use of posters, the internet, social media, and other channels may be adopted.

Natural disaster : sustainable mitigation strategies

The process of community capacity building for disaster risk reduction starts with community-based risk assessment. Assessment of prevalent hazards and the vulnerabilities and capacities of the community is done with the active involvement of local people. By applying participatory techniques, people are engaged in a process of analysis of the situation and the risks they face. Imparting awareness to farmers on drought and flood-resistant crops is another instance in this line. Some of the agricultural strategies to be adopted are mentioned below (Murshed, 2003).

Storm-related strategies

Storm- related disasters should not be seen solely in terms of their immediate and visible impact but also in terms of their implications for the long-term development process and national and international goals to eradicate poverty and to reduce undernourishment. Storms cannot be prevented, but storm-related disasters can be prevented through appropriate human intervention. In order to reduce agricultural vulnerability and break out of the cyclical trap of disaster and response, it is important to design a strategy intimately linking disaster-management

schemes with long-term development programmes.

The strategy should include long-term measures for reducing agricultural vulnerability to storm related disasters properly integrated with the overall development programme of the storm and flood-prone areas, and the country as a whole. An early-warning and storm-forecasting system needs to be developed. A preparedness plan for relief and rehabilitation in the event of such disasters, should be implemented.A long-term development programme to reduce agricultural vulnerability through proper land-management practices including reforestation may help to reduce climatic changes and the resultant environmental damage induced by deforestation and other forms of land-use practices which threaten sustainability. Innovative environmentally-motivated financing of sustainable agriculture tied to carbon trading -such as that proposed under the Clean Development Mechanism associated with the Kyoto Protocol- could also contribute to efforts to reduce storm and flood damage (Ref: COAG/01/5 on climate change). At the country level, governments may take such an approach into account when designing strategies for sustainable agriculture and for disaster prevention.

A long-term development programme for reducing agricultural vulnerability to storm related disasters should be developed on the basis of land-use evaluations, vulnerability and risk assessments, inventory of traditional community land-management practices and local coping strategies, as well as an assessment and identification of crop, livestock, fisheries and forestry practices and farming systems suitable for vulnerable areas. There are many examples of land- use planning, agricultural, forestry and fisheries practices that increase resilience and reduce susceptibility to storm damage, if applied in an appropriate context. Examples of storm disaster mitigation through the introduction of changes in agricultural system includes: Introducing more storm-resistant crops (e.g. ginger, pineapple, roots and tubers) and diversified cropping systems that offer insurance against crop losses.

Maintenance of mangroves in storm and flood prone areas to serve as windbreaks and buffer zones could be a crucial strategy as the protective role of trees and mangroves was clearly demonstrated during the storm and tidal floods during spring 1991 in the Bay of Bengal. Making greater use of soil-conservation and water-management practices that reduce vulnerability to floods could also be on area of focus. Constructing small-scale embankments, dams, canals and improved drainage systems for the protection of arable and grazing land from flood and tidal waves in coastal areas, can be adopted as well.

Diversification of crops according to different planting seasons

Crop diversification means growing more than one crop in an area. Diversification can also be implemented to replace low-value commodities with high-value commodities, such as vegetables and fruits. This can help mitigate the effects of failure of the main crop on farming families due to prevalent hazards; e.g. drought or flood. If the main crop fails, the farmers

still can harvest products during the two other seasons. As a result, the number of months people face food shortage could be reduced (Volsi *et al.*, 2022). Crop diversity encompasses several aspects, such as crop species diversity, varietal diversity within crop species, and genetic diversity within crop species. It is recognized as one of the most feasible, cost-effective, and rational ways of developing a resilient agricultural cropping system. For example, the growing of rice in high water table areas replacing oilseeds, pulses and cotton; promotion of soybean in place of sorghum in vertisols (medium and deep black soils) etc.

Propagation of disaster resistant crops

Disasters disrupt farming and damage certain crops, which may result in form of food shortage. The re-introduction of the already forgotten indigenous crops and the campaign to cultivate them could awaken and remind residents the importance of such crops. They are easily grown and do not require a lot of inputs. Their use can be propagated by planting community nurseries/demo farms and through educational campaigns. Disaster-resistant crops and other indigenous crops can serve as a staple food source in times of disasters. Genetically modified crops could be of major importance. Genetically modified versions of soybean, maize and cotton were seen to be successful in terms of pest control and yield improvement (Clement *et al.*, 2011). In USA drought-tolerant maize (MON87460, produced by Monsanto) was planted by over 2,000 farmers on over 50,000 hectares (ha). In 2018, the Government of Indonesia approved the use of adrought-resistant sugar cane variety (NXI-4T, Nusantara Plantation Research) (Martignago *et al.*, 2020). Other drought-resistant varieties of maize, sugar cane, wheat, and rice are being used in field trials across the globe in Argentina, Brazil, India, South Africa and Uganda. Salt-tolerant varieties in rice, wheat and mustard crops are currently being grown in India on about 1.19 M ha area annually (Kumar *et al.*, 2020).

Development of seed banks and nurseries

Establishment of seed banks and nurseries at the community level can ensure a stable supply of seedlings, seeds, cuttings and other plant materials. Seed stocks can be used in times of emergency for rehabilitation of damaged croplands. Most seed banks focus on traditional rice and corn seeds, which are more resistant to pests and less sensitive to changing climatic conditions. These varieties are slowly disappearing because hybrid varieties are promoted in the market. This highlights the importance of community-based seed banks. Nurseries propagate fruit trees, forest trees, forage trees, bamboo and other plants useful for people in times of crisis. Seed banks and nurseries could strengthen people's existing livelihoods and increase the presence of fallback resources in the community's seed bank and nursery. They should be provided training on seed bank and nursery management. They can also formulate policies for the approval of the farmers regarding the repayment of seeds, operation and maintenance of the nursery, and the sustainability of the seed bank and the nursery. There are some 1,500 seed banks around the world, including the Svalbard Global Seed Vault, located on

the remote Norwegian island of Spitsbergen in the Svalbard archipelago. It is considered the world's largest germplasmcenter. Also known as the 'vault at the end of the world', this dystopian-universe building was opened in 2008 in the middle of the ice and functions as a huge warehouse where more than one million seed samples from all over the world are stored.

Setting up of post-harvest facilities

The post-harvest losses from natural disasters are mostly neglected. It is not only the standing crops that are being destroyed but also harvested crops stored in the silos, agriculture farmhouses, etc. are also affected. Farmers have very poor storage and transportation facilities which becomes more critical for perishable fruits and vegetables. Reports showed that about 34% of fruits, 44.6% of vegetables, and 40 of combined fruits and vegetables were unsold in the market (Pandey, 2018). As such, there should be proper and sufficient storage structures where natural disasters cannot affect them. However, vegetables and fruits are stored for shorter duration. Other processes like cleaning, milling, packaging, marketing, etc. should preferably be located close to the points of production in rural areas.

Better land-use and crop planning

For development in the floodplains, careful management of technology so as not to obstruct but to use floods for good purposes through better land use and crop planning has to be an essential ingredient of any policy. In other words, it is necessary to promote ecologically appropriate policies for human settlements and agriculture in the floodplains. Suitable short-duration strains of paddy and other crops, which can withstand flooding for a few days, have to be developed.

People in the eastern floodplains of the Ganga and Brahmaputra in India and those in Bangladesh have a long tradition of living in harmony with floods. The living style, habitations, and crops grown were all evolved taking into consideration the climate and the flood-proneness of the area. Ancient people inhabiting the floodplains took care not to block the natural drains, preserved the natural beds and depressions, and cultivated only those crops that could stand submergence. This tradition is gradually vanishing with changing economic and social conditions. There can be no doubt that the countries of the Ganga-Brahmaputra-Meghna region must adopt ecologically appropriate policies for human settlement, and agricultural and industrial development, besides promoting the protection of wetlands for flood moderation (Biswas, 2008).

Encouragement of proper land use management and sustainable agriculture practices

The fast deterioration of the environment due to external pressures (logging, mining, multinational plantations, and encroaching settlers) increases the vulnerability of people to various hazards withthe introduction of new hazards. Therefore, conservation of the environment through tree plantation, rehabilitation ofwatersheds, mitigation of soil erosion, and replenishment of forest reserves is important.

Community participation for traditional rain water harvesting

Ever since the beginning of civilization, human beings have adhered to some practices or the others to protect themselves against drought and floods. The traditional rainwater harvesting techniques in different parts of the world bear testimony to sincere efforts toward community action and water preservation. The success story of 'Sukhomajri' (India) is an indicator of the power of traditional wisdom, people's participation and the community's deep sensitivity to the environment (Dhameja, 2001). Joint Forest Management, 'Van panchayats' and 'Panipanchayats' are some more examples of effective people's participation and their faith in traditional practices.

Crop insurance

Crop insurance plays a crucial role in managing risks and building resilience in the agricultural sector. By providing financial protection against losses caused by unforeseen events, such as droughts and crop failures, agricultural insurance helps smallholder farmers recover from setbacks and continue their farming activities.Crop insurance streamlines loss assessment procedures and helps in building up a huge and accurate statistical base for crop production.

In India during the 2016–17 and 2018–19 crop years, insurance programmes paid out $4.33 in claims for every $1 of premium paid by farmers. Other programs with substantial government subsidies include the national rice insurance scheme in Thailand ($680 million per year), the PROAGRO programmes in Brazil ($250 million per year), and the PCIC programme in the Philippines ($130 million in 2019). Some examples of agri-insurance promoted in India were Weather-Based Crop Insurance Scheme (WBCIS), Coconut Palm Insurance Scheme (CPIS) and Unified Package Insurance Scheme (UPIS).

Artificial intelligence

Artificial intelligence (AI) is used to deal with big data, for calculations, forecasts, predictions of natural disasters, and the establishment of the possibilities to escape and prepare for hazardoussituations (Dineva, 2023).Artificial intelligence (AI) and its domains, i.e., machine learning (ML) and deep learning (DL), are being increasingly used to predict, forecast, detect, monitor, and assess natural disasters in the context of agriculture. Zhang et al. (2021) predicted agricultural drought in China by modeling a standardized soil moisture index (SSI) with a meta-Gaussian model based on precipitation and soil moisture data.Saha et al. (2021) used ANN to develop a spatial drought vulnerability index for effective monitoring and risk reduction in Karnataka state of India.Adikari et al. (2021) used hybrid machine learning model, wavelet-coupled adaptive neuro fuzzy inference system (WANFIS), and deep learning algorithms, CNN, and LSTM, to forecast floods and droughts in arid and tropical regions of Australia. Rainfall and discharge data of Darling River Basin and Sekong River Basin were used to forecast floods and droughts with CNN at higher accuracy as compared to WANFIS. Munawar et al. (2021) used unmanned aerial vehicle (UAV) imagery to develop and train CNN model for real-time food detection in Indus River of Pakistan.

Conclusion

Natural disasters are born in the cradles of abuse of natural resources and irresponsible human behavior. They have time and again threatened human civilization and if not deterred now, they will be the major cause of destruction which will be difficult to regain. Agriculture is pivotal for sustenance of human beings, irrespective of nations, people, and environment. The intensification of agriculture is a mandate for this sustenance to continue over time. The use of time-honored technologies with the participation of human beings could be the only way to domesticate the menace of natural disasters.

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