

Agriculture Intensification for Sustenance in Natural Disaster

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ABSTRACT

The agriculture sector plays a crucial role in augmenting the socio-economic development of the nation. Agriculture confronts many disaster or extreme events that limit the ability of global food production and national security. To cope up with these hazards, agricultural intensification is of utmost need. Agricultural intensification is the process of increasing the inputs of agricultural resources to increase the level of yield per unit of land. Several technological interventions that have been developed to mitigate disasters in agriculture include varieties-farming practices with enhanced resilience, practices for improved water efficiency, improved soil management and integrated pest management.

Keywords : Agriculture, Natural disasters, Intensification for sustenance, Agricultural practices

Introduction :

Agriculture continues to provide the security livelihood of over 2.5 billion global population. The agriculture sector directly interacts with the environment and relies on the natural resources for a sustainable production. It plays a crucial role in augmenting the socio-economic development of the nation and it is mandatory to build more agricultural system.

Agriculture robust presently confronts much turbulence, interacting in a hyper connected world and a tremendously changing landscape. Heavy rains have submerged many of the areas which is threatening various humanitarian crisis. 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. Extreme events such as drought, floods, storms, tsunamis, wildfires, pest and disease outbreaks exert worst effects on crop husbandry and all its sectors such as crops, livestock, forestry, fisheries and aquaculture. Agricultural disasters are one type of risk that limits the ability of the global food system to provide complete food and nutritional security. Agricultural value chains provide linkages between global food system actors and mechanisms through which food travels from producers to consumers. Risk in these systems had been addressed by the application of a number of risk management strategies. As populations grow there are emerging pressures on agricultural systems that are increasing their vulnerability and exposure

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to disasters. These pressures will likely require adaptation of agricultural systems to effectively meet the challenges posed. There is necessity for a transformation of sustainable intensification in agriculture both from a perspective of increased production, through high-yielding crops, increased irrigation, mechanization and the role of chemicals that increase production levels (Anonymous, 2008) and from a conservation perspective, in terms of the millions of hectares of forests which otherwise would be converted into farm land, unquantifiable amount of ecosystem services saved and of some 590 billion tons of carbon dioxide prevented from being released into the atmosphere (Burney *et al.*, 2010).

Agricultural intensification is the process of increasing the inputs of agricultural resources (e.g. seeds, labour, fertilizers, pesticides, technologies, knowledge) to increase the level of yield per unit of land. It is the use of advanced tools and techniques, including pesticide and fertilizer applications and the removal of bunds that separate fields that allow for an increasing amount of food or biomass to be produced from a given amount of land. (Bruce *et al.*, 2013). In other word, agricultural intensification is an increase in agricultural production per unit of inputs which may include labour, land, time, fertilizer, seed, feed or cash. It is a process by which farming systems increasingly use high levels of nonrenewable, purchased inputs, e.g., inorganic fertilizers and other agrochemicals to control pest and disease infestation and suppress the inoculum. (Louise *et al.*, 2013).

Agricultural intensification is not always clearly or consistently defined and is often confused with the term intensive agriculture. Unlike intensive agriculture, which could be seen as a specific system of agronomy, agricultural intensification is a general process that can apply, in principle, to any type of agricultural production. Examples of agricultural intensification may range from using new pesticides in intensive agriculture to intensifying the use of indigenous and context-specific knowledge in local farming practices. Although agricultural intensification can take many forms, it always involves the intensification of some types of agricultural input with a view to increase levels of yields.

Intensification occurs when there is an increase in the total volume of agricultural production that results from a higher productivity of inputs or agricultural production is maintained while certain inputs like fertilizers are decreased. Intensification that takes the form of increased production is most critical when there is a need to expand the food supply, especially during periods of rapid population growth.

Sustainable intensification of agriculture is a good approach for reducing the yield gap without exacerbating the current conditions due to disasters which is a big challenge in agriculture. Sustainable agriculture is a broad term that encompasses a variety of approaches like planting resilient and high-yielding crop varieties, intercropping legumes in cereals, bio-diversification, and Integrated Pest Management (Shrestha, 2016).

Agriculture and natural disasters :

The agricultural sector is particularly vulnerable to natural hazards and disasters. Weather and climate conditions are the major during which directly and indirectly affect the agricultural output and lead to sudden disasters. Earthquakes, landslides, flood, drought, fires, and hailstorms are some of the natural calamities that occur every year, at any point, and anywhere, causing threats to the livelihoods of smallholder farmers and their food security. Disasters can cause loss of human and animal life, field crops, stored seeds, agricultural equipment/materials, and their supply systems (e.g. infrastructure) as well as associated indigenous knowledge, thus disrupting not only the immediate growing season but also future seasons (McGuire and Sperling, 2013). Disasters threaten all three pillars of sustainable development such as social, environmental and economical. Agriculture continues to bear the brunt of disaster impacts as new risks and correlations emerge. Over last few decades, weather and climacteric conditions pose a significant challenge to agricultural systems in order to rely on weather and climate. Disasters can be calamitous to crop growth, livestock health, fisheries and aquaculture production. Furthermore, an alarming increase in the number of outbreaks of plant pests and diseases due to climate change is putting large pressures on the human food chain. Drought causes short and medium term water shortages and extreme heat stress on livestock and crops (including fodder) which can be detrimental to yield. In the case of prolonged or repeating droughts it leads to longer term impacts such as land collapse, seawater

intrusion along river systems with reduced water flow and it damages the ecosystem.

Intensification for sustenance under natural disasters :

Sustainable intensification of agriculture is a good approach for reducing the yield gap without exacerbating the current conditions due to disasters which is a big challenge in the agriculture. Sustainable agriculture is a broad term that encompasses a variety of approaches like planting resilient and high-yielding crop varieties, intercropping legumes in cereals, bio-diversification, and Integrated Pest Management (Shrestha, 2016). The adverse effects of climate change will further worsen the stresses on crop plants, potentially leading to sudden damage and yield loss. The natural disasters adversely affect the food supply.

Under natural disaster, the challenge of food security and food production is a burning issue. To fulfill the demand of food supply it is essential to grow high yielding varieties. It is a need to produce substantially higher yields of food for humans and livestock feed.

Crop management strategies to mitigate the adverse effects of natural disasters like drought, is a major issue. Mixed cropping is a better option to overcome disaster. For example, genotypes of beans selected for high capacity to acquire phosphorus often have shallow roots (Lynch, 2007). This can cause problems for crops in water-scarce environments, where deep roots can be advantageous for water scavenging. Mixtures of different seeds can be planted to buffer the crop yield against stress. (Caldwell and Richards, 1989). In Western

Australia wheat yields increased by around 3-fold in 70 years, as rainfall has decreased. This has been achieved largely by changing the planting date of the crop to cover the ground while there is water available in the soil. Intercropping is good option to overcome stress. Particularly, intercropping cereals with vegetables, and maintaining leguminous tree cover to provide shade, wood and mulch, could improve overall ecosystem performance (Gliessman, 1998; Leakey *et al.*, 2005; Scherr and McNeely, 2008). Other options which would not require major scientific advances for their initial implementation, where appropriate, include conservation agriculture, intercropping and agro forestry methods in which plants are protected from stress by other adjacent species. Intercropping has potential in agriculture as a strategy to mitigate abiotic stress.

Fresh water availability is a major limiting factor on agricultural productivity. Improvements in the water use efficiency of plants in irrigated systems present a significant challenge, particularly in the face of climate change. Deficit irrigation can also be used as an effective tool for growth regulation, reducing vegetative growth in favour of reproductive development in fruit crops and thereby enhancing crop yield and crop quality (Loveys *et al.*, 2002). Soils are another essential but non-renewable resource for food crop production. Maintenance of soil fertility, health and nutrient availability is vital. Significant losses in crop yields occur through pests, diseases and weed competition; they account for a major inefficiency of resource use (eg water, fertilizer, energy and labour). Reducing these losses represents one of

the most accessible means of increasing food supplies.

Agriculture intensification is one of the measures to reduce the impact of disasters events. It involves various activities including improvement of land use and management, water management and pest management, and the use of plants and crops which are resistant to extreme biotic and abiotic conditions during disaster events. Several technological interventions have been developed to mitigate disasters in agriculture and some of them are briefly easement below.

a. Varieties with enhanced resilience :

Biotic and abiotic stresses triggered by natural disasters will affect crop productivity. Biotic stresses include plant diseases, harmful insects and weeds. Abiotic stresses include increasing temperature, decreasing water availability, increasing salinity and inundation, and low light intensity. The principle of sustainable production and resource conservation will lead to the development of varieties with enhanced resilience to abiotic and biotic stresses (Pandey *et al.*, 2017). The practice of planting vegetable crops in the highlands for increasing vulnerability of landslides is a simple example of enhanced resilience. However, highland horticultural plants such as potatoes, carrots, broccoli and cabbage can now be grown on low land. Adaptation or shifting the landscape for highland crops also aims to mitigate landslide risk, as farmers are encouraged to plant woody crops on highland areas.

Salinity-tolerant crops :

Salt-affected soils or saline soils occur naturally in low-lying areas due to the

accumulation of free salts in the soil profile. It is a typical problem of semi-arid and arid zones of the world (Corbishley and Pearce, 2007). Genetically modified crops are expected to increase crops ability to sustain growth and productivity in saline soils. Various biotechnologies can facilitate this by accelerating the discovery of genes and speeding up the delivery of crops with improved salt tolerance by using marker selection and genetic modification. Various traits like osmotic tolerance, ion exclusion and tissue tolerance could be incorporated to improve crop salinity tolerance (Roy *et al.*, 2014).

Drought-resistant crops :

Bio-engineering works to produce drought-resistant crops based on the principle of enhancing of the leaf to preserve water. Water loss from the plant by transpiration mostly occurs through leaf stomata; therefore, the plants need to protect themselves with a thicker layer of leaf wax. A recent study by (Pornsiriwong *et al.*, 2017) identified a new method which has helped some plants survive for 50 per cent longer in drought conditions, including essential crops such as barley, rice and wheat. Boosting the chloroplast signal, by breeding, genetic or agronomic strategies could be key for helping plants preserve water and boosting drought tolerance. Boosting the levels of the chloroplast signal also restores tolerance in drought-sensitive plants and extends their drought survival by about 50 per cent.

Cold-tolerant crops :

Cold temperatures are a primary abiotic pressure that negatively affects the morphological development and seed

production of the crop. In of rice case, as it is originally from tropical regions, so it is more sensitive to cold stress than other grain crops.

Heat-tolerant crops :

High temperatures, as result of global warming, are predicted to have an adverse effect on crop growth due to a harmful effect on the plant development cycle. The increasing threat of climatologically extremes, including very high temperatures, might lead to catastrophic loss of crop productivity and result in widespread famine. The most extreme reductions in yield will likely be a result of normal and extreme fluctuations in temperature and global warming in general (Zandalinas *et al.*, 2018). Scientists develop heat-tolerant crops by modifying physiological and biochemical processes of gene expression. These changes are expected to develop gradually and then lead to the development of heat tolerance by acclimation, or in the ideal case, by adaptation. High-temperature stress has a wide range of effects on plants, affecting, for example, their physiology, biochemistry and gene regulation pathways. Therefore, strategies for improving heat-stress tolerance are still elusive (Hasanuzzaman *et al.*, 2013).

Plant resistance to pathogens :

The incidence of many plant diseases has increased in the past 20 years, and continues to pose serious threats, categorized as emerging infectious diseases (EIDs). EIDs on crops caused by plant pathogens can develop into sudden and severe epidemics, owing to the influence of various characteristics of the pathogen, host and environment (Vurro *et al.*, 2010).

For example, red stripe disease in rice was first found in Indonesia in 1987 and has spread all over South-East Asia. Since its first reported appearance, the disease has spread to Malaysia, Vietnam, the Philippines and Thailand (FFTC, 2012). The aim of developing plant resistance to pathogens is to reduce the use of pesticides, taking into account ecological, economic and human health priorities, and to prevent the emergence of new diseases. It also contributes to modifying cultural practices to adopt to a changing global climate and to save phylogenetic resources from the degradation of natural ecosystems (Das *et al.*, 2014). The development of plants that are resistant to pathogens has been practiced in agriculture through increased variant selection, occurring either spontaneously or among crossbreeds, selective breeding or through genetic mutations. Genetically engineered varieties that are resistant to specific pathogens, include varieties that are: (1) resistant to pathogen vector carriers, i.e. varieties resistant to green leafhoppers as transmitters (vector) pathogens; and (2) resistant to the pathogen itself including viruses, bacteria, fungi, nematodes and phytoplasma. The genetic improvement of plant crops by selective breeding is cost-effective and easy to adopt, since the grower only need to use appropriate seeds or other planting material (Evenson and Gollin, 2003).

Systemic acquired resistance (SAR) and induced systemic resistance (ISR) are also the tools to develop the resistance in plants. Systemic acquired resistance (SAR) is a mechanism of induced defense that confers long-lasting protection against a broad spectrum of microorganisms. Changes in cell wall composition,

production of pathogenesis related proteins such as chitinases and glucanases, and synthesis of phytoalexins are associated with resistance (Durrant and Dong, 2004). Chemicals like salicylic acid, beta amino butyric acid, chitosan and bio-control agents' viz. *Trichoderma* spp. activates these mechanisms by triggering the immune response in plants.

Crop plants need to cope up adverse external pressure created by environmental and edaphic conditions with their intrinsic biological mechanisms, failing which their growth, development, and productivity suffer. Microorganisms, the most natural inhabitants of diverse environments exhibit enormous metabolic capabilities to mitigate abiotic stresses. Microbial interactions with plants are an integral part of the living ecosystem, hence they are believed to be the natural partners that modulate local and systemic mechanisms in plants to offer defense under adverse external conditions. Microbial interactions with the plants evoke various kinds of local and systemic responses that improve metabolic capability of the plants to fight against abiotic stresses (Nguyen *et al.*, 2016).

Early maturity short-cycle varieties :

Early maturity, short-cycle varieties fill space and production gaps in the agriculture system. During the dry season, the quick-maturing crops can be planted later and still mature before the end of the season. Short-cycle varieties allow the farmer to harvest the crops and avoid water stressing the plants. For example, vegetables, can be planted early in the season and be replaced later by drought-tolerant crops (Zandalinas, 2018).

b. Farming practices for enhanced resilience :

Globally, natural disasters, especially climate-related disasters, are increasing. The climatic conditions are increasingly varied, and the magnitude of their effects is stronger. The climate change brings new uncertainties, risks and changes to existing risks. One of the most efficient ways for agriculture to adapt to natural disasters and climate change is to increase its resilience. Enhanced resilience agriculture can be achieved by implementing prevention and mitigation efforts in agricultural practices, addressing potential hazards to promote agriculture production systems that meet the demand for food required by growing world population.

Integrated farming system :

An integrated farming system (IFS) combines crops and livestock, where the by-product of one component can be used for another component. IFS contributes to adaptation to climatic change because culturing crops and livestock at the same time gives farmers a range of income options when facing uncertain weather conditions associated with increased climate variability. For smallholder farmers, livestock is a walking bank of assets that can be sold during periods of need if crops fail (Zhu *et al.*, 2011). IFS also contribute to food security and income generation for the rural poor. Furthermore, it contributes to environmental and agricultural sustainability and ecosystem services, because the farm can recycle all wastes: one's trash is needed as another's food.

Crop diversification and rotation :

Diversification has meant growing new types of crops or raising new types of

livestock. Crop diversification aims to increase the crop portfolio so that farmers are not dependent on a single crop to meet daily life needs and generate income. When farmers only cultivate one crop type, they are exposed to high risks in the event of unforeseen climate events that could severely impact agricultural production, such as the emergence of pests and the sudden onset disaster and drought. With diversification, the farmer will increase the chances of dealing with the uncertainty and changes created by climate change. The crops will respond to climate scenarios in different ways, the cold may affect one crop negatively, but production of an alternative crop may increase. In the rotation, farmers change crops and cultivars, and also modify crop management. Two shorter ripening varieties might be a better strategy than a longer maturing variety because the grain formation and ripening periods are pushed to less favourable conditions later in the season with the longer maturing variety.

c. Practices for improved water efficiency :

The Intergovernmental Panel on Climate Change (IPCC) Working Group II predicts that changes in rainfall patterns will contribute to severe freshwater shortages, intensifying flood and drought in some areas (IPCC, 2007). Technology that supports water-efficient practices is important to address potential conditions of natural disasters triggered by climate change.

Water-efficient practices offer a potential gain in net revenue, while also reducing environmental burdens by saving water. Furthermore, enhancing water

availability through improved water-efficient technologies for sustainable water use and management is one of key strategies for increasing agricultural productivity and securing food security. The practices like improving restricted rainfall infiltration, increasing infiltration and reduce run-off by surface residue covers, improved irrigation are useful in improving water efficiency.

d. Improved soil management :

Soil management can support crop productivity, protect and conserve soil resources and reduce the release of greenhouse gases. Improvements in soil management contribute to reducing the risk of land damage due to landslides, floods and or run-off.

Slow-forming terraces :

It helps in improving the natural conditions for agricultural production, decrease the rate of erosion, increase soil moisture and generate positive environmental benefits.

Conservation tillage :

Conservation tillage refers to growing a crop in the residue of previous crop, purposely left on the soil surface. It slows down water movement, which reduces the amount of soil erosion.

Strip cropping :

Strip cropping is used to avoid erosion and is effective in certain soils and topography (Arya *et al.*, 2015). The strip crops check the surface run-off and force them to infiltrate into the ground, thereby facilitating the conservation of rainwater.

e. Integrated pest management :

Integrated pest management (IPM) is an ecosystem approach to crop protection and production that combines different management strategies and practices. The aim of IPM is not necessarily to eliminate all pests but to reduce pest populations to levels where they cannot cause significant loss. It is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations. It combines biological, chemical, physical and crop specific (cultural) management strategies and practices to grow healthy crops and minimize the use of pesticides, reducing or minimizing risks posed by pesticides to human health and the environment for sustainable pest management. It promotes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. It helps in sustainable agriculture by applying sustainable pest control, reducing pesticide residues, enhancing ecosystem services like pollination, healthy soils, diversity of species and increasing income levels and farmers knowledge.

Conclusion :

Natural disasters play a major role in agricultural development and the economic condition of an individual. Environmental degradation is one of the major factor contributing to the vulnerability of agriculture and disrupted nearly all aspects of life. Agricultural intensification can affect greenhouse gas emissions. Need is to build disaster, disease, and climate resilient agricultural systems which will be

capable of improving the nutrition and food security of present and future generations. Agricultural intensification has a positive implication on livelihood security in terms of better economic and social conditions like food security, employment opportunity and improved division of labour; and improved institution. It is essential to identify the risks associated with disasters and climate change and manage them to reduce their impacts. Natural disasters and extreme weather events due to climate change can cause agricultural production losses affecting food security and its components including availability, access, utilization and stability. Agricultural intensification increases the capacity of farming communities, and helps to cope up with more complex challenges in agriculture.

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