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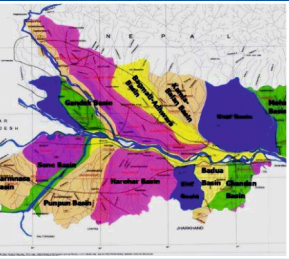

CENTRE FOR DISASTER MANAGEMENT (CDM)

Centre for Disaster Management
Lal Bahadur Shastri National Academy of Administration,
Mussoorie - 248179, Uttarakhand

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Director's Message

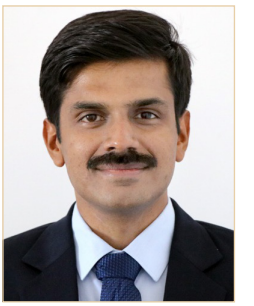
India, due to its unique geographical and geological conditions, is vulnerable to various natural disasters. In India, the incidents of flood, drought and other natural disasters are on the rise and pose a tremendous challenge to the society in general and administration in particular. Each disaster heightens the sense of urgency to equip ourselves better in coping and managing them. In this context, the training of Civil servants in Disaster Management assumes critical significance.

There is a need to move from the paradigm of responding to disasters to building resilience against disasters in all aspects of decision making. A key challenge to administrators would be increasing the level of awareness in the society regarding the cost of disasters and to build resilience specifically in infrastructure and community in general. It gives me immense pleasure to note that Centre for Disaster Management, Lal Bahadur Shastri National Academy of Administration is bringing out the edited Journal "Disaster Response and Management" Volume-X, No. 1 for the year 2023-24 under the project "Capacity Building on Disaster Management for IAS/Central Civil Services Officers" sponsored by National Disaster Management Authority (NDMA), Government of India, New Delhi. This is the compilation of research articles providing insights about recent trends in Disaster Management. I hope this volume will add to the knowledge base for Disaster Management in the country and will be useful for both the Officers Trainees and the Administrators in the field. It can also serve as a good reference material for ATIs and CTIs for their in house courses.

I hope this compilation will be useful for both the Officer Trainees and the Administrators in handling disasters and emergency situations across the country. I want to congratulate the CDM team for this publication and also place on record my appreciation for the contribution made by the faculty & staff of the CDM who contributed in various capacities for bringing out this Journal.

(Sriram Taranikanti)

Abhiram G. Sankar, IAS
Deputy Director & Director
Centre for Disaster Management



Preface

The Centre for Disaster Management (CDM), Lal Bahadur Shastri National Academy of Administration (LBSNAA), Mussoorie is a training and research Centre working under the aegis of LBSNAA, Mussoorie. The Centre is involved in training IAS and other Group-A civil service officers at induction as well as at in-service level in various aspects of disaster management, besides undertaking, action research projects, documentation of best practices, development of case studies, etc.

The magnitude and frequency of disasters has increased drastically in terms of human, economic and environmental losses. Under the conventions on SDGs, Paris agreement, Sendai framework for Disaster Risk Reduction, there is a need to document the research carried by individuals in the field of Disaster management to achieve the committed goals of India as a signatory.

Disaster Response and Management in recent times, received increased attention, both within the country and abroad. In a caring and civilized society, it is essential to deal effectively with the devastating impact of disasters. It is our pleasure to publish Volume-X, No. 1 of the Journal "Disaster-Response and Management" for the year 2023-2024. The journal will provide an insight to administrators about the recent trends in response, planning and scientific interventions towards Disaster Risk Reduction.

I would like to thank the Centre for Disaster Management, Lal Bahadur Shastri National Academy of Administration who have been able to compile by faculty and staff of CDM who have contributed in various capacities for bringing out this Journal.

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(Abhiram G. Sankar)

Contents

Climate Change and Indian Agriculture: Adaptation and Mitigation

Ch. Srinivasarao, G. Ranjith Kumar and Pankaj Kumar Singh*

Abstract

Climate and agriculture are inextricably linked to global dynamics. Agriculture is negatively impacted by even little climatic changes, which lowers productivity. The average atmospheric temperature rises as a result of the global warming phenomenon, which has turned into a major trend that is changing the climate and having a big impact on the future of the entire planet. Extreme temperature and rainfall changes are endangering agricultural productivity, which could have an impact on both the livelihoods of a large portion of the people and the global food security. Additionally, as a result of increased anthropogenic activity including urbanization, industrialization, deforestation, agriculture, and changes in land use patterns, the rate of climate change is accelerating considerably more quickly. According to the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), Carbon Dioxide (CO2) is the main cause of the most global warming. In order to boost the output of agriculture, evaluation of the effects of the impact of global climate changes on agriculture must be taken into account. The Indian government should offer farmers value-added agricultural services so that they may adjust to some extent by changing their farming methods to mitigate any climate vulnerabilities in future. To help small and marginal farmers resist the effects of climate change, adaptive measures must be put in place in a timely manner at both the farmer and policymaker levels.

Key words: *Climate Change, Agriculture, Adaptation, Mitigation.*

1. Introduction

Climate change is the burning challenge to the world, developing countries like India is severely affected by this problem. Agriculture, natural resources and Nation's food securities are at stake due to climate change. Greenhouse gases (GHGs) are the main reason for the global warming and abrupt climate changes. As per the World Meteorological Organisation, among all GHGs Carbon Dioxide (CO_2) playing major role in climate change due to its higher (76%) percentage of contribution to global warming compared to other GHGs like methane (CH_4), nitrous oxide (N_2O) and

CFC etc. The Intergovernmental Panel on Climate Change (IPCC) fourth assessment report made it clear that 0.74 ^{0}C of temperature increased globally from previous 100 years and it estimated that increased from 1.8-4.0 ^{0}C by 2100. Where as in India it is increased at the rate of 0.42 ^{0}C. However, GHG emissions are increased every year due to huge pressure on natural resources to satisfy the needs of increased population (Srinivasarao *et al.,* 2020). The concentration of CO_2 reached 413.2 ppm in 2020 and is 149 percent more of pre-industrial level (1970) when human activities started disrupting earth's natural equilibrium. (WMO GREENHOUSE GAS BULLETIN, 2021). As far as GHG emissions related to food consumption are concerned, CO_2 is the most important GHG, followed by CH_4 and N_2O (Pathak *et al.*, 2015). Carbon emission occurs during various stages of life cycle of food products. The main sources contributing to emission of GHGs in India are Industries, Agriculture and inefficient waste management with total emission of 334 Mt CO_2 eq.

The Green Revolution (GR) in India encouraged the usage of chemical fertilizers and pesticides, high- yielding varieties under irrigation fed hundreds of millions from starvation which transformed the country from "hungry nation" to "self-sufficient nation" (Siegel, 2018). Despite the fact that India has achieved "self-sufficiency" in the production of food grains through Green Revolution, which brought lot of environmental problems (such as decreased soil fertility, waterlogging, ground and surface water pollution, intensified pests and diseases) as well as socioeconomic issues (such as higher farm input prices and regional disparity) (Cummings, 2019). All of these issues have been exacerbated by climate change, which also poses a serious threat to Indian agriculture in general and food security in particular. India is also identified as one of the highly vulnerable countries to climate change (INCCA, 2010). Recent investigations revealed a considerable rise in temperature, frequent heat waves, droughts, extremely rare instances of precipitation, and high cyclonic activity (Ray et al., 2019). Due to the food demand of increasing population, total food grain production has to be increased from 310.74 Mt in 2020-21 to 377 Mt by 2050 as per the estimation given by Ministry of agriculture, India. Frequency of droughts in India, resulting in threat to food production in India is presented in Table 1.

Climate change exposed the agricultural sector in a number of ways. For instance, in 1966 significant yield losses are reported due to frequent droughts. As per the studies, in the absence of warmer nights and less rainfall, rice yield would have increased by over 4% (Auffhammer et al., 2012). Climate change will result in yield reductions between 4.5 and 9% in the short run (2010–2039), whereas, in the long run (2070–2099), it will drastically reduce the yields at least by 25 percent in the absence of

adaptation measures. The crop water demand is also likely to upsurge with the prolonged warm weather conditions and will need more irrigation (Venkateswarlu and Singh, 2015).

Table 1: Probability of occurrence of drought in different regions of India

Region	Frequency of occurrence of drought
Assam	Very rare, once in 15 years
West Bengal, Madhya Pradesh, Konkan, Bihar and Odisha	Once in 5 years
South interior Karnataka, Eastern Uttar Pradesh and Vidarbha region of Maharashtra	Once in 4 years
Gujarat, East Rajasthan, and Western Uttar Pradesh	Once in 3 years
Tamil Nadu, Jammu & Kashmir, and Telangana	Once in 2.5 years
West Rajasthan	Once in 2 years

Source: Adapted from NRAA (2013)

However, excessive groundwater extraction and irrigation have already caused a significant drop in groundwater levels; if irrigated agriculture is continued, even locations that are experiencing more precipitation due to climate change would require excessive groundwater extraction. Crop loss causes farmer struggles, inflation, and other serious economic repercussions. According to Singh et al. (2019), the yearly average agricultural losses caused by extreme weather events alone result in losses that are projected to be equal to 0.25 percent of India's GDP. As per the Department of Economic and Policy Research (DEPR) by 2050, climate change depress the living standards of nearly half of its population and could cost the Indian economy 2.8 percent of its GDP. Unless adequate mitigation policies are in place, India could lose anywhere from 3 to 10 percent of its GDP annually by 2100 due to climate change.

Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of majority of the population dependent on agriculture, excessive pressure on natural resources and poor coping mechanisms (Srinivasarao et al., 2019). The warming trend in India over the past 100 years has indicated on increase of 0.60°C. The projected impacts are likely to further aggravate field fluctuations of many crops thus impacting food security. There are already

evidences of negative impacts on yield of wheat and paddy in parts of India due to increased temperature, water stress and reduced number of rainy days. Significant negative impacts have been projected with medium-term (2010-2039) climate change, e.g. yield reduction by 4.5 to 9%, depending on the magnitude and distribution of warming. Since agriculture makes up roughly 15% of India's GDP, a 4.5 to 9.0% negative impact on production implies cost of climate change to be roughly at 1.5% of GDP per year

Enhancing agricultural productivity, therefore, is critical for ensuring food and national security for all, particularly the resource poor small and marginal farmers who would be affected most. In the absence of planned adaption, the consequences of long- term climate change impacts could be severe on the nation's food security and SDGs. To overcome the existing food issues, all world health organization (WHO) members adopted the United Nations' 17 Sustainable Development Goals (SDG) in 2015, which include achieving zero hunger or zero undernourished population by 2030. Various agriculture and allied sectors such as field crops, horticulture, livestock, fishery, and poultry are strongly associated with several United Nations SDGs and more importantly zero hunger, nutrition, and climate action, and others.

2. Extreme climatic events and impacts

India's natural environment, economy, and society are all being affected by climate change more frequently and intensely. Extreme difficulties that India is currently confronting include heatwaves, floods, monsoons, and dwindling groundwater supplies. Risks associated with heat waves have been especially expensive to GDP and public health. As of April 26, 2022, 15 Indian states were struggling with the effects of heat waves on human health, agriculture, and water supplies. India has suffered damages from floods totalling $26.3 billion USD, which is more than 0.5% of its GDP. Specifically, Indian sub-continent is highly vulnerable to all kinds of existing climate change issues and lot of cropped areas being affected which is threat to country's food security (Figure 1)."

Globally, climate change is already having a significant physical influence on local communities, and the number and size of these communities will only increase. With notable regional variations, the average global temperature has increased by around 1.1°C since the 1880s. This brings higher probabilities of extreme temperatures and an intensification of hazards. A changing climate in the next decade, and probably beyond, means the number and size of regions affected by substantial physical impacts will continue to grow. This will have direct effects on five socioeconomic systems: livability and workability, food systems, physical assets, infrastructure services, and natural capital.

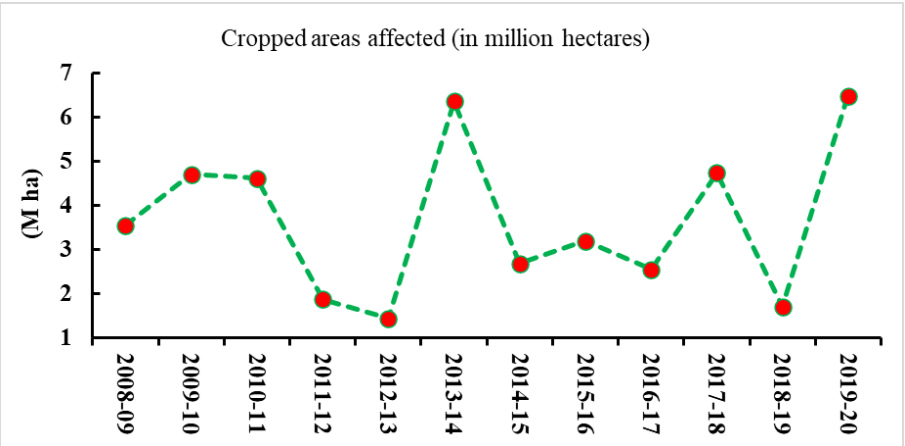

Figure 1: year wise cropped areas affected due to extreme natural events in India **(Source:** Envistats 2023)

a) ***Droughts:*** Drought is one of the most frequently occurring natural disasters in India. As a result of increased frequency and expanded coverage in recent years, about 1/3rd of the country is either suffering drought or a desert area. These regions are suffering from poor agricultural productivity and are also suffering from slow economic growth. They have highly fluctuating agricultural production and incomes from year to year, as well as a relatively high prevalence of poverty. Drought has both direct and indirect effects on agricultural output. Agricultural productivity has declined by up to 40% in rainfed areas due to severe droughts. This is why farmers in rainfed areas have abandoned farming as their primary source of income. Neglecting dryland farming while forming policies is the biggest lack in policy design for countering droughts in India. Rainfall data over the last century shows that there has been a severe drought every 8 to 9 years. India have endured 22 severe droughts between 1871 and 2002. With a 19 percent rainfall shortfall impacting more than 85 million people and roughly 60 percent of agriculture in 1987, the drought may have been the worst of the 20th century. Drought and food security are intimately linked. rainfed agriculture is particularly significant to India's economy, 42% of the country's arable land is situated in areas that are prone to drought.

b) ***Floods:*** Compared to droughts, floods are more localized and often last for a shorter period of time, from a few hours to a few days. Floods can be divided into several categories, including riverine flooding (severe rainfall over extended periods), flash flooding (heavy rainfall on steep slopes or in populated areas with poor drainage), coastal flooding (storm surge), and pluvial flooding (rainfall on a flat surface). River basins,

hilly, coastal, and occasionally urban areas are the places most likely to experience regular flooding. Various floods of various forms commonly occur in India, usually during the SW monsoon season, the main rainy season. Additionally, during the NE monsoon season, floods occur in south peninsular India (Dhar and Nandargi, 2003). The majority of floods in India are closely associated with heavy rainfall events, and not all of these heavy rain events translate into floods. In addition to rainfall extremes, other variables such as prior soil moisture, storm length, snowmelt, drainage basin characteristics, urbanization, dams and reservoirs, and proximity to the shore are all associated to flood occurrences (Sharma *et al.,* 2018). In addition, several other factors, such as infrastructure, siltation of rivers, deforestation, and backwater effect, can accelerate the impacts of floods.

c) Cyclones: The term "cyclone" comes from the Greek word "*cyclos*," which means a snake's coils. Cyclone is a significant wind and pressure event in the atmosphere. They are usually accompanied by violent storms and bad weather. The air circulates inward in an anticlockwise direction in the northern hemisphere and clockwise in the southern hemisphere. They are violent whirls spiralling upward from the ocean surface to great heights, sometimes up to the tropopause and moving across the ocean, generally from east to west. They are characterized by huge pressure deficit at the centre, cyclonic circulation, violent winds and severe weather. Tropical revolving storms (TRS) form in the vast expanses of the warm tropical oceans. TRSs are known as 'cyclones' in the Indian Ocean, 'Typhoons' in the Western Pacific, 'Hurricanes' in the Atlantic and Eastern Pacific, 'Baguios' in the Philippine region and 'Willy Willies' in the Australian waters. There are two types of cyclones: tropical (temperate) and extra-tropical. Tropical cyclones generated in the regions between the Tropics of Capricorn and Cancer are known as tropical cyclones. A tropical cyclone is a large meteorological system formed over tropical or subtropical waters, where they are organised into surface wind circulations. Extra-tropical cyclones take place in temperate zones and high latitude regions, though they are known to originate in the Polar Regions. There are 13 coastal states and union territories (UTs) in the country, encompassing 84 coastal districts which are affected by tropical cyclones. Among these, four states (Tamil Nadu, Andhra Pradesh, Odisha and West Bengal) and one UT (Puducherry) on the east coast and one state (Gujarat) on the west coast are highly vulnerable to cyclone disasters. Hurricane winds, heavy rain, and storm surge are the main causes of damage and destruction brought on by cyclones. Hurricane wind damages houses, uproots plants and trees and torrential rain creates flood and damages to standing crop. Generally,

cyclones strike in November and December while the rice crop is in the blossoming to grain-filling stage, causing destruction and devastation. Storm surge is also greatly responsible for the greatest damage, 90% of fatalities are related to the sudden onslaught of water and rise in sea level brought on by hurricane winds, which frequently extend nearly 25 km inside the coast (Kumar *et al*., 2014).

d) ***Heatwaves:*** Heatwaves are extreme temperature that can become fatal to the living organisms. Frequency and intensity of heatwaves are raising in India adversely affecting all allied sectors of agriculture including dairy, poultry, fishery, etc. Heat waves along with lack of water availability have a serious impact on the nation's food security. In some countries it is defined by using the heat index, which is a combination of temperature and humidity, or by using the extreme percentile of temperature. Heatwaves usually develop over Northwest India and move slowly eastward and southward, but not westward. Sometimes, under favourable conditions, any region in situ can also experience heat waves. As a result of climate change, global temperatures as well as the frequency and severity of heatwaves will increase in present century. Extreme heat can cause crop damage, reduced yields, and higher food prices, affecting both farmers and consumers. But heatwaves don't just impact agriculture and farming. They can also lead to significant labour loss, periods of high inflation, elevated healthcare and energy costs.

e) ***Hailstroms:*** Hail is a solid form of precipitation. Hail is possible within most thunderstorms produced by cumulonimbus clouds. Hail formation requires environments with strong upward motion of air and/or lowered heights of freezing level. In the middle latitudes hailstones are formed near the interior of continents while in tropics, they tend to be confined to higher levels of freezing. Based on the size of hailstones, the possible damage can be anticipated. During 2014 and 2020, India experienced episodes of abnormally widespread and untimely hailstorm events. The conversion of number of thunderstorms into hail storm events in India shows increasing trend day by day. The damage with hails is determined by the size ranges and the number of hailstones that fall per unit area during a hail fall, wind force during the event and the property of the target. The extent of crop-hail damages also varies depending on the stage of occurrence of hail during the crop growing season. Even a short episode of hail can cause severe injury to crops, fruit trees, both downgrading the quality and causing subsequent losses due to diseases like blight, mould, canker and fruit rots. Hailstroms can cause severe damage to arable crops, orchard crops, and farm structures apart from seriously injuring livestock, poultry and humans (Jaybhaye, 2022).

f) ***Sea water intrusion:*** The seawater intrusion (SWI) in the aquifers of the coastal region is a common phenomenon across the world. As the sea levels rise, in combination with increased groundwater pumping can increase saltwater intrusion in groundwater aquifers and the "salt front" (location of the freshwater-saltwater line) may progress further upstream. This encroachment may be further exacerbated by drought, reduced rainfall or changes in water use and demand. Sea water intrusion has numerous adverse effects on agriculture, which include everything from a shift in the types of crops that can produce decent yields and the salinization of soil and water. Acres upon acres of farmland have been lost each year because they become saturated with high-salinity water. When the soil and water contain high salinization, it's difficult for most crops to grow. Saltwater may negatively impact the quality of water by promoting certain nutrients in the fertilizers that farmers typically use. The nutrients that are produced when saltwater interacts with soil will travel through agricultural ditches until they reach coastal bodies of water like marshes and creeks. At this point, the high levels of nutrient application can lead to high amounts of algae growth. Once the algae die off, the bacteria in the surrounding water will break down the plant, which consumes all of the oxygen that's present in the water. When oxygen levels are too low, many species of fish will die. As per the studies that saltwater intrusion can reduce crop yields by more than 17% (Cheng *et al*., 2021).

3. Adaptations strategies and co-benefits of mitigation in agriculture

The effect of change in frequency and magnitude of natural disasters on agriculture sector is devastating by placing many lives and livelihoods of various communities at risk. Specifically, agriculture sector is already threatened by land degradation, less water availability and biodiversity losses became even more vulnerable to climate change. Proper adaptation strategies must require to combat the climate change impacts. Agriculture sector majorly contributes to three greenhouse gas (GHGs): CO2 (from soil tillage and residue burning); methane (livestock sector and paddy fields) and N2O (from N fertilizers). The global warming potential of methane is 28 times more than CO2 and N2O is about 300 times than CO2. Various agriculture technologies and best practices contribute to climate change adaptation and has co-benefits of mitigation of GHGs in agriculture sector.

3.1 Crop based interventions: Crop based interventions are mainly focused on promoting the cultivation of crops and varieties that can fit into new cropping systems and seasons, developed varieties with altered duration that can overcome the transient effects of change. Release of varieties for high temperature, drought and submergence tolerance, evolving varieties

which respond positively in growth and yield to high CO_2. In addition to novel crops and varieties which can withstand coastal saline and salt water inundation, high fertilizer and radiation use efficiency cultivars are also needed. Exploring crop germplasm for beneficial characteristics and agricultural biodiversity are crucial areas that should be fully utilized. For the purpose of assisting crop breeding studies, it is necessary to collect and preserve seeds, plants, and plant components that are tolerant to temperature, water, and other atmospheric challenges brought on by climate change. Establishing seed banks can be vital in conditions with great climate variability and unpredictability. GHG mitigation potential of the various crop based interventions are mentioned in Figure 2.

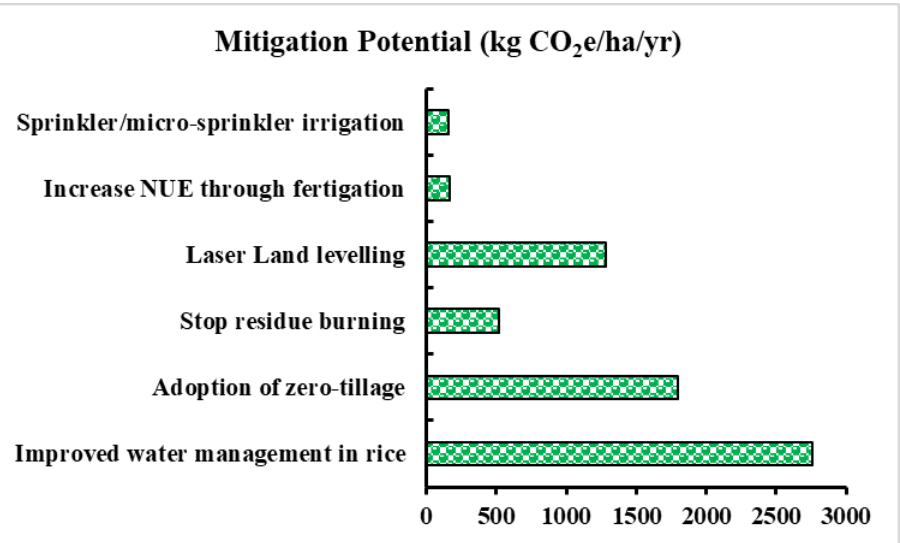

Figure 2: *GHGs mitigation potential of various crop based innervations* (***Source:*** *Sapkota et al., 2019)*

This facility will offer an effective way to re-establish crops destroyed by significant catastrophes and extreme weather events. All of the wild ancestors, land races, extant varieties, contemporary varieties, and breeding stocks should be thoroughly reviewed and re-evaluated in order to identify any previously overlooked or unidentified features that would be more advantageous in the current climatic situations (Kumar *et al.,* 2023). Crop varieties, particularly for the *rabi* cropping season, should have characteristics of early flowering (photo- and temperature-insensitive, but development-related onset of flowering), early maturity, and high produce as an additional strategy to benefit from faster growth under higher temperatures. By avoiding blooming to coincide with the hottest time, improved and novel agronomic and crop production strategies, such

as adjusting planting dates to limit the effect of high temperature increase-induced spikelet sterility, can be utilized to reduce yield instability (Gadgil, 1995). Changes to the cropping calendar to take advantage of the wet period and prevent extreme weather events throughout the growing season are one of the adaptation method that might be used to lessen the negative effects of increasing climatic variability as it is typically encountered in arid and semi-arid tropics of the country. During the vulnerable stage of crop growth, crop varieties that are resistant to lodging may withstand severe winds. Improved crop management, including intercropping and crop rotation, integrated pest control, and agroforestry and afforestation programs, will also be a key part of India's strategic adaptation to climate change. In grazing fields, pasture improvement through planned grazing processes, enclosures for recovery, or enrichment planting is crucial to combat encroaching changes.

1) **Inter/relay cropping:** Intercropping is a successful tactic that, given the current state of climate change, can be used to achieve desired results. In comparison to sole cropping systems, grain-legume intercrops provide a number of potential advantages, including stable yields, better resource management, a decrease in weeds, pests, and diseases, an increase in the protein content of cereals, and less N leaching (Perdona and Soratto, 2020). In addition to boosting productivity and system sustainability, intercropping also increases farmers' income, employment, and lessens their vulnerability to climate anomalies. By enhancing ecosystem services and conserving natural resources, intercropping pulses, green manure, and cover crops with cereals, vegetables, and fruits improves system sustainability (Das *et al.,* 2019).

2) ***SRI cultivation:*** Under the aberrant climatic conditions, System of Rice Intensification (SRI) has significant advantages. The main components of this technology are the following: rice plants are spaced optimally to allow for more growth of roots and canopy and to keep all leaves actively photosynthesizing; rice seedlings are transplanted when young with two leaves, quickly, shallowly, and carefully, to avoid trauma to roots and to minimize transplant shock; and rice plants are kept moist rather than continuously saturated to reduce anaerobic conditions and improve root growth and diversity of aerobic soil organisms (Ramarao, 2011). SRI utilizes less water than other rice cultivation methods, hence it may be a way to mitigate climate-related risk. Given their bigger root systems and stronger stalks, SRI plants' resistance to lodging brought on by wind and/or rain is a beneficial characteristic for extreme floods. The agronomic and financial risks that farmers experience as a result of climate

change are reduced by this method (Thakur and Uphoff, 2017).

3) ***Integrated farming systems (IFS):*** Integration of various enterprises like field crops, horticultural/fruit crops, forest trees, green manures, fodder, livestock, poultry, fish and vermin compost in a farming system can improve the input use efficiency and carbon sequestration into soil and plant biomass. This helps in efficient land management could help in judicious use of inputs and mitigating GHG emission into the atmosphere (Pathak, 2014) and increase the income and standard of living of small and marginal farmers. A part of GHG emitted could be sequestrated in to the plant biomass and stored for an extended period of time in IFS system. Crop residues and organic manures incorporated into the system could also sequester GHGs and mitigate emission to some extent (Meera *et al.,* 2019).

4) ***Pulse based cropping systems:*** Incorporation of pulses in the main production systems raise the SOC levels and obviate the need for chemical fertilizers and thereby reduce GHG emissions. According to Lemke et al. (2007), pulses contribute to both subsequent crops' N needs as well as their own. Due to its lesser need for fertilizer, pulses actually aid in reducing GHG emissions. Legumes can significantly lower the emission of GHGs like CO_2 and N_2O. Legumes produce 5 to 7 times less greenhouse gases (GHGs) per unit area than other crops do, and they also let Carbon Sequestration into the soil at an average rate of 7.21g kg^{-1} dry matter (Stagnari *et al*., 2017).

3.2 Horticultural crops: Extremely high temperatures have a negative impact on citrus fruit setting as well as the transpiration losses experienced by vegetable crops. On young trees especially, high temperatures have a blistering or scorching impact on the flowers. High temperatures during flowering are known to have a negative impact on the fruit setting stage of oranges. High temperatures can cause fruit trees including apricot, cherry, and apple trees to experience moisture stress, which can result in sunburn and cracking signs. In litchi plantations, the increase in temperature during the ripening period causes fruit to burn and break (Kumar and Kumar, 2007). Flooding has a significant impact on the majority of vegetable crops, particularly tomato. Vegetable crop yields will be lowered by 5 to 15% if the ozone concentration exceeds 50 ppb/day (Raj, 2009). Salinity and alkalinity were major obstacles to the effective cultivation of grapes, but the discovery of appropriate rootstocks has made this process extremely productive. If we take a look at crops like the potato, tomato, cauliflower, and cabbage, we can see that they are thermo sensitive and that they were only productive in long-day, temperate conditions. But even in subtropical and mild subtropical and warmer temperatures, the introduction of heat tolerant cultivars and adjustments to production

system management have made it possible with extremely high yield. The development of production methods should be prioritized in order to increase water use effectiveness and accommodate the dry and hot circumstances. In order to fight the predicted increase in temperature and water stress periods during the crop-growing season, strategies like shifting sowing or planting dates can be used. To improve the nutrient use efficiency soil amendments along with fertilizers should be applied. Maintaining soil moisture reserves and providing irrigation during crucial stages of crop growth crucial. The use of plastic mulches and crop leftovers as mulches, among other crop management techniques, helps to preserve soil moisture (Singh, 2013).

3.3 Soil and water management: Sustainable agricultural ecosystems may play a significant role in the adaptation to climate change and other environmental issues, depending on the usage and management of the land. Technologies that are based on resource conservation encompass INM, SSNM, in situ moisture conservation, rainfall collection and recycling, effective irrigation water usage, conservation agriculture, and energy efficiency in crop production and irrigation, etc. GHG mitigation potential of the various soil based interventions are mentioned in Figure 3.

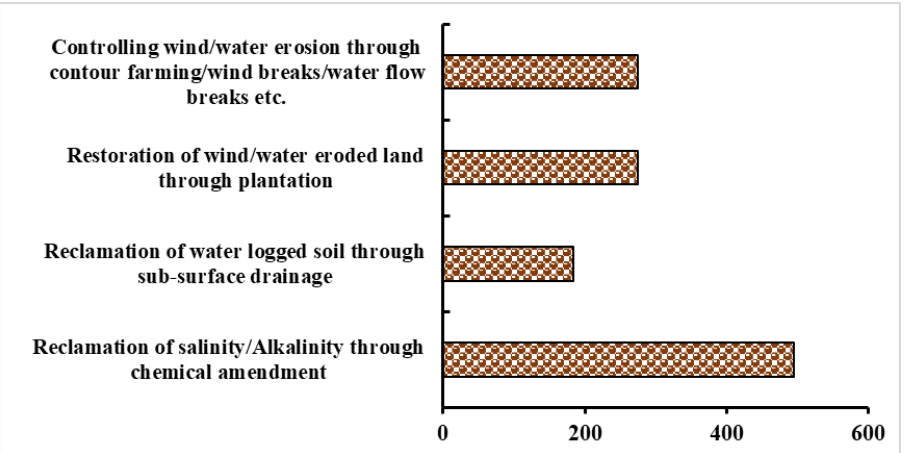

Figure 3: GHGs mitigation potential (kg CO2e/ha/yr) of various soil based innervations (Source: Sapkota et al., 2019)

1) ***Integrated Nutrient Management (INM):*** Based on their availability and cost-effectiveness, INM practices include the judicious combination of nutrient sources of mineral fertilizers with organic sources such as cattle manures, crop residues, urban/rural wastes, composts, green manures and bio-fertilizers, etc. Moreover, rather than increasing GHG emissions, the application of organic manures along with inorganic fertilizers increased the SOC content. The Integrated

Plant Nutrient System (IPNS) uses INM principles to reduce N_2O and CH_4 emissions, and increase soil C storage in soil management systems. The production of fertilizer is an energy-intensive process that uses a significant amount of fossil fuel. The need of fertilizers would be reduced by supplementing the crop with organic amendments to meet demand, which would ultimately lower the emission of GHGs. By using integrated nutrient management techniques, such as composting solid wastes and agricultural residues, dependence on chemical fertilizers and greenhouse gas emissions both can be reduced (Srinivasarao *et al.*, 2020).

2) ***Balanced nutrition/SSNM:*** Judicious fertilizer application is a key element of the SSNM strategy, which provides a dual effect, lowering GHG emissions while also increasing yields in environments with high CO2 levels. According to the International Plant Nutrition Institute, Site-Specific Nutrient Management (SSNM) aims to optimize the supply of soil nutrients over time and space to match the nutritional requirements of crops. It is based on four guiding principles known as the "4 R" (Right Product, Right Rate, Right Time, and Right Place). Effective nutrient management should boost both crop yield and climate resilience (Thornton and Herrero 2014). SSNM reduces the quantity of total reactive nitrogen (NH_3, NH^{4+}, NO^{3-}, NO^{2-}, NO, and N_2O) lost to the environment (via leaching or volatilization) by minimizing the amount of N utilized. SSNM approach reduces the fertiliser consumption up to 30% in rice, leaching losses were decreased by 90% and N_2O emissions by 50% in wheat (Matson *et al.,* 1998).

3) ***Conservation tillage (Minimum tillage/Zero-tillage/No-tillage:*** Intensive tillage elevates soil carbon emissions, which eventually lowers SOC accumulation. Conservation tillage (CT), in contrast to conventional tillage, has the potential to reduce carbon emissions from fossil fuels in agriculture. Intense soil cultivation degrades soil organic matter (SOM), producing CO_2, which lowers the soil's overall carbon (C) level. Conventional soil tillage accelerates the oxidation of organic carbon and causes significant CO_2 emissions into the atmosphere. Implementation of CT along with residue retention can improve SOM, reduce CO_2 emissions, and boost SOC sequestration. Reduced tillage, minimal tillage, and no-tillage can be used to maintain native soil C and stop soil erosion (Abdalla *et al.,* 2013). No-tillage or zero-tillage techniques use less heavy agricultural equipment and hence produce less machine-related pollution than conventional tillage methods. As a result, conservation tillage significantly reduces the overall usage of fossil fuels and greenhouse gases. Adopting

conservation tillage might sequester 25 Gt of carbon dioxide over the next 50 years (Tanveer *et al*., 2019).

4) ***Residue management:*** Thermo-chemical process of turning surplus residues into biochar (slow pyrolysis) is an effective management technique that is becoming more and more popular, because it has the potential to reduce the global warming effects by fixing the carbon that is already present in raw biomass and improving the sequestration of GHGs into the soil. biochar can recovers the 50% of initial biomass carbon as compared to 3% during burning *in-situ*. In India, biochar may be made from the residues of maize, castor, cotton, and pigeonpea, and it may capture 4.6 Mt of carbon dioxide into the soil each year (Venkatesh *et al.,* 2015). The annual sequestration of 12% of the carbon (C) present in the current anthropogenic CO2 emissions may be achieved through the sustainable management of biochar amendment to soil. It will also boost CH_4 uptake from soil and long-term carbon sequestration in soil (Srinivasarao *et al.,* 2013). In India, turning organic waste into biochar might be a practical technological solution for long-term mitigation of climate change (Srinivasarao *et al.,* 2020).

5) ***Mulching:*** soil mulching has the potential to reduce the GHG emission and increase the SOC content by adding organic matter to soil (Jordan *et al*., 2010). Increased soil C sequestration due to organic amendments/ mulches aids in SOC storage, and climate change mitigation. When high-residue-yielding crops are cultivated or when terminated cover crop residue is still present on the surface, which can be used as covering material on some reduced-tillage systems.

6) ***Micro irrigation:*** Micro irrigation is an approach for coping with and reducing the effects of climate change. The use of sprinkler and drip irrigation systems applies water drop by drop to a crop's intended root zone. The mitigation of roughly 12 $MtCO_2e\ year^{-1}$ can be achieved through improved water management strategies in rice farming, such as switching continuously flooded rice fields to alternate soaking and drying. The efficient use of water and energy will be required to achieve the water and energy conservation. For every 1% increase in irrigation efficiency, GHG emissions are reduced by 2.1%, while water use efficiency rises by 50–90% (Shah, 2009).

7) ***Controlled/Slow Release Fertilizers:*** The potential method for lowering GHG emissions in wetlands is N management. Increased Nitrogen Use Efficiency (NUE), soil test-based N application, use of advanced technological fertilizers like controlled release fertilizers (CRF) or slow release fertilizers (SRF)/Nitrification inhibitors, and

integrated use of manure and fertilizers to decrease dependence on synthetic fertilizers are all effective mitigation options with minimal environmental impact. In addition to increasing N_2O emissions, the use of chemical fertilizers may also increase CO_2 and CH_4 emissions, which will further contribute to global warming.

8) ***Organic manures:*** Depending on the availability of the resources, farmers can apply a wide variety of organic manures to soils, including farmyard manure (FYM), vermin compost, green manure, and azolla, which are important components of INM or IPNS. Agriculture has the potential to reduce GHG emissions because of organic manures increase soil SOM content, boost soil carbon sequestration (carbon sinks), and slow the release of stored carbon back into the environment. Increased soil organic carbon (SOC) storage does not, however, automatically suggest a role in the fight against climate change (Tesfai *et al.,* 2016).

3.4 Livestock, Poultry and Fishery: Climate change has a stronger impact on biological productivity, or the aggregate of those processes affects individual organisms or species directly. Any species with particular traits will grow and develop in accordance with how resilient they are and how well they can adapt to environmental changes. Numerous aspects of animal productivity, reproduction, health, and adaptability are impacted by changes in the global climate. Higher temperatures cause an immediate alteration in an animal's body physiology, including an increase in body temperature (>102.5°F), blood flow, and respiration rates (>70–80/minute). Animal production and reproduction are both directly impacted by unexpected changes in climate by 58 and 63.3 percent, respectively (Singh *et al.,* 2012). High ambient temperatures promote the body's efforts to release heat, elevating body temperature, increasing water consumption, and decreasing feed intake. Under heat stress exposure, feed conversion also considerably declines (Padua *et al.,* 1997). Compared to meat breeds, dairy breeds are more susceptible to heat stress. While low milk-producing animals are immune to heat stress, higher milk-producing breeds are more susceptible to its effects due to an increase in metabolic heat generation (Dash *et al.,* 2016). Dry matter intake and milk yield are decreased by an increase in temperature and temperature humidity index value above the crucial threshold level. Additionally, it interferes with an animal's physiology (West, 2003). Heat stress not only causes animals to produce less milk, but it also has a significant impact on the milk's quality. From 10 to 25% of milk output can be lost due to heat stress. Reduced feed intake during thermal stress may cause a 50% reduction in milk production, and changes in lactogenic hormone levels may be responsible for the remaining 50% (Johnson 1987). Estradiol, the main reproductive hormone, is drastically depleted by heat stress. Reduced ovarian follicular development driven by suppressed

peripheral gonadotrophin concentration as a result of heat stress may lead to decreased estrogen concentration. Poultries are particularly susceptible to temperature-related problems, such as heat stress. Chronic heat stress in broiler hens causes endocrinological changes that increase lipid buildup, inhibit lipolysis, and induce amino acid catabolism (Geraert *et al.,* 1996). Due to their selection for quick growth and feed efficiency, poultry are more vulnerable to heat stress than other farm animals. Selection for heat tolerance has not been a major consideration by farming community, because heat tolerance means reduced performance. Heat stress causes poultry to consume less feed, which decreases body weight, egg production, and meat quality. It also thins the eggshell and encourages egg breakage (Lin *et al.,* 2006). Heat stress has a deleterious impact on the eggshell's strength, weight, ash content, and thickness. Compared other animals poultries also more susceptible to cold stress due to their low body volume, they are often kept in heated chambers when raised in colder regions. Fish growth and development may improve seasonally as a result of rising environmental temperatures, however populations that live outside of the thermal tolerance zone have increased dangers. The mortality of fish and its geographic distribution will be impacted by a 1°C increase in temperature. Fish hatcheries in West Bengal and Orissa that breed Indian main carps move their mating season from June to March as a result of temperature increases of 0.37°C to 0.67°C (DARE/ICAR Annual Report, 2008-09).

4. Mitigation Strategies

4.1 Renewable energy: Reducing greenhouse gas emissions, increasing energy independence, and saving money are advantages of using renewable energy in agriculture. However, challenges including up-front investment costs, barriers to new technology adoption, and the need for technical training should be addressed in order to ensure a successful deployment. 20 percent of electricity is used in agriculture, primarily at subsidised prices from the grid supply based on fossil fuels. Many agricultural activities, including irrigation and cold storage, can be powered by solar energy. To reduce the demand for fossil fuels and grid-based electricity, solar water pumps, for instance, provide a dependable supply of crop irrigation. Solar pumps increase agricultural production while reducing carbon emissions, which is advantageous for both farmers and the environment. Solar energy can also be utilized to power agro-processing facilities and dry crops in order to further decrease post-harvest losses and enhance food security. Additionally, wind energy can be applied in agricultural operations to provide clean energy for a range of needs. Wind turbines may generate electricity for farms and small communities, reducing their reliance on fossil fuels. The utilization of wind energy can be quite advantageous in

regions with predictable wind patterns. Wind energy has the potential to help Indian farmers increase revenue, reduce operating costs, and mitigate climate change (Bhat *et al.,* 2017).

In order to promote the use of renewable energy in farming, the Indian government has already undertaken significant efforts. Farmers are urged to use renewable energy sources with the aid of initiatives like the Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM). The creation of supportive frameworks and incentives by policymakers should continue in order to speed the conversion of Indian agriculture to renewable energy. Incorporating renewable energy sources into Indian agriculture is a practical way to combat climate change. Solar and wind energy applications can provide steady, safe power for various agricultural operations, reducing greenhouse gas emissions and enhancing climate resilience. India's objectives of creating agricultural techniques that are both sustainable and climate resilient would require the usage of renewable energy.

4.2 Fertilizer strategies: Climate change brings significant challenges to Indian agriculture, which have an impact on agricultural productivity and food security. To overcome these challenges, it is essential to adopt cutting-edge fertilizer strategies that increase crop yields while also mitigating climate change. Fertilizers are accurately applied in precision agriculture in accordance with the particular needs of the crops. Modern tools like GPS and remote sensing enable farmers to apply fertilizers precisely, reducing waste and environmental damage. While crop yields are maintained or even improved, fertilizer consumption can be reduced by 20–25% as a result of precision farming. This lowers the nitrogen runoff into aquatic bodies and reduces the GHG emissions, which are linked to fertilizer production. Organic farming depends on natural nutrient sources and composting to lessen the carbon footprint of fertilizer production (Chen *et al.,* 2017). Utilizing nitrogen-fixing cover crops and applying fertilizers at the right time are additional nutrient management strategies that can maximize fertilizer use and minimize environmental damage. By selecting crop varieties that are suited to changing climatic circumstances, one can lessen the demand for fertilizers. These types were developed to thrive in difficult settings, thus they may require fewer nutrients for optimal growth. The utilization of climate-resilient crop cultivars is a crucial part of India's agricultural climate change mitigation strategy. Innovative fertilizer application methods have a number of benefits, such as improved soil health, reduced GHG emissions, and increased resource use efficiency. But the need for farmer education, access to technology, and high upfront costs are barriers to its implementation (Ladha *et al.,* 2016). Innovative fertilizer methods are crucial for Indian agriculture to reduce climate change. Climate-resilient

agricultural types, organic farming, improved fertilizer management, and precision agriculture can boost agricultural output while minimizing the environmental effect of agriculture. India must engage in research, instruction, and extension services to help these initiatives by providing farmers with the knowledge and tools they need to employ environmentally friendly fertilizer practices.

4.3 Soil Carbon Building: Soil carbon sequestration is the process of absorbing and storing carbon in soil. Improved soil carbon sequestration contributes to a reduction in climate change by removing carbon dioxide (CO_2) from the atmosphere and storing it in the soil. Between 0.4 and 1.2 Gt of carbon may be stored annually in agricultural soils all over the world thanks to efficient soil carbon management systems. This method may be essential for reducing atmospheric CO_2 levels and so assisting in climate change mitigation (Lal, 2004). The ability of soils to store and release essential nutrients is improved when soil carbon increases their cation-exchange capacity (CEC) results higher crop productivity which is crucial for Indian agriculture's ability to adjust to changing climatic conditions. The soil's capacity to hold water rises as its carbon concentration rises (NAAS, 2021). Improved soil carbon sequestration aids in greater water retention in countries like India where variable rainfall patterns and water scarcity are frequent occurrences. Agricultural development and drought resistance are supported by advancements in water retention (Gupta *et al.,* 2018). Despite

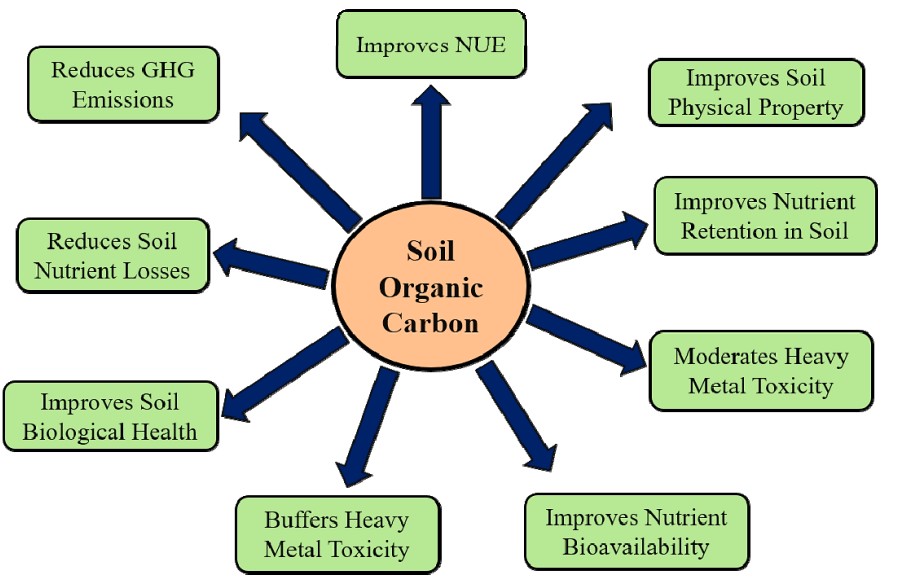

Figure 4: Benefits of SOC improvement in soil and plant system

its potential benefits, increasing soil carbon in Indian agriculture faces a variety of challenges, including the adoption of sustainable techniques, knowledge dissemination, and resource constraints. A few tactics that can promote soil carbon sequestration include utilizing cover crops, no-tillage farming, and managing crop leftovers. The improvement of soil fertility, water retention, and carbon sequestration are additional benefits of increasing soil carbon storage, which is an efficient way to combat climate change in Indian agriculture (Figure 4).

By adopting sustainable practices and providing sufficient support to farmers, India can address the difficulties brought on by climate change, boost agricultural productivity, and aid international efforts to mitigate climate change (Samra and Srinivasarao, 2021). Sustainable management of soil health would further help in contributing to Sustainable Development Goals (SDGs) [alleviating poverty (SDG-1), ending hunger (SDG-2), improving health (SDG-3), clean water (SDG-6), economic growth (SDG-8), and climate action (SDG-13)].

4.4 Agroforestry: Agroforestry was one of the key strategies for reducing CO2 emissions by boosting carbon sinks among others. It is a traditional approach to managing land use that combines agriculture and forestry and offers a special chance to combine the twin goals of mitigating and adapting to climate change. Perennial plants with deep roots are included, which improves soil carbon sequestration. Agroforestry covers 1,023 million ha (M ha) of land worldwide; in India, it covers 25.32 Mha (8.2% of the nation's total land area) (Toppo and Raj 2018). From this, cultivated lands make up 20.0 Mha and 5.32 Mha in additional areas, including shifting cultivation (2.28 Mha), 2.93 Mha from home gardens, and rehabilitation of troublesome soils.

One of the biggest issues Indian agriculture has is the shortage of water. Two advantages of agroforestry systems, particularly those with firmly rooted trees, are decreased soil erosion and improved water penetration. According to the National Research Centre for Agroforestry, well-designed agroforestry systems can reduce runoff and increase water recharge in aquifers, hence increasing crop water availability. Agroforestry systems can reduce both soil-based GHG emissions and store carbon in the soils as woody biomass. Agroforestry systems can increase soil organic carbon content by 20-40%, enhancing soil productivity and reducing the need for synthetic fertilizers, which are a significant source of greenhouse gas emissions. They indirectly replace fossil fuels and potentially stop the global discharge of 17Mt of carbon dioxide each year. The National Forest Policy's goal of 33% of the country's total geographic area being covered by trees can be achieved

with the help of Agroforestry systems. The biggest opportunity to absorb atmospheric CO_2 outside of direct advantages is through the conversion of grassland and wastelands into agroforestry (Dhyani *et al.,* 2016).

4.5 Methane pledge: Indian agriculture is at a crossroads because of the dual task of reducing its climate emissions and adjusting to a changing climate. Methane, a potent greenhouse gas, is a significant by-product of agricultural activity in the country. The significance of reducing methane emissions in Indian agriculture with a focus on sources, potential remedies, and their effects on climate change and sustainable agriculture. Enteric fermentation in animals, particularly in cattle and buffalo, is a substantial source of methane emissions in Indian agriculture. Ruminants generate methane (CH_4) during digestion, which contributes significantly to overall national emissions (Garg *et al.,* 2001). Rice farming techniques, such as flooding fields, provide anaerobic environments that are suitable for bacteria that make methane (CH_4). As a result, paddy fields contribute significantly to methane emissions in Indian agriculture. Manure management, notably the anaerobic digestion of animal waste in pits and lagoons, is another source of methane emissions in Indian agriculture (Kumari *et al.,* 2014). With efficient waste management practices and biogas production, these emissions can be reduced.

At COP26 in 2021, the Global Methane Pledge was introduced to spur efforts to cut methane emissions. 111 nations have joined the Pledge, led by the United States and the European Union, and they collectively account for 45% of the world's methane emissions. Countries who sign up for the Pledge promise to cooperate in order to reduce global methane emissions by at least 30% below 2020 levels by 2030. The Global Methane Pledge does not define any extra measures or procedures that signatories are required to follow, although the United States and the European Union have requested that all participants draft or revise a national methane reduction action plan by COP27.

5. Climate policies

Climate change threatens biodiversity loss and food security by exposing vulnerable groups to risks such disasters, epidemics, loss of livelihoods, crop failures, poverty, and relocation. Due to its diverse ecosystems, geography, and temperature zones, India is vulnerable to threats associated with large-scale climate change. India is ranked as the seventh most climate change-affected country in the world by the Global Climate Risk Index 2021. According to the State of India's Environment 2022, during the dates of March 11 and May 18, 2022, there were 280 heatwave days, which are highest in the past 12 years. The key strategy to combat the effects of global warming is to sequester atmospheric CO2 through bioenergy production, afforestation,

carbon capture and storage, direct air capture, and increased SOC content. As part of the Global Climate Action Plan (GCAA) adopted by the United Nations Framework Convention on Climate Change (UNFCCC), France launched the "4 per 1000/ 4 per mille" initiative in 2015 at COP22. This initiative aims to increase SOC sequestration through a variety of technological approaches, including agro-forestry, conservation agriculture system intensification (CASI), and landscape management. As our honourable Prime Minister, Shri Narendra Modi, acknowledges the contribution to the field of environmental protection, India is also dedicated to UNFCCC and the Paris Climate Change Agreement. Several Indian institutions are also active in the assessment and monitoring of SOC stocks in different kinds of land. With these steps in consideration, the United Nations Environment Programme (UNEP)'s 2014 Emission Gap Report recognizes India as making progress toward meeting its voluntary climate change mitigation goals.

The Indian government launched the National Action Plan on Climate Change (NAPCC), which consists of eight missions to address climate change on a sector-by-sector basis. It may be possible to reduce GHG emissions by 7.6% year from 2020 to 2030 in order to reduce the world temperature. One of the eight missions within NAPCC, the National Mission for Sustainable Agriculture (NMSA), was launched in 2010 to encourage the wise management of resources. Additionally, the Government of India (GOI) launched the Green India Mission (GIM) in 2014 under the auspices of NAPCC with the primary goal of protecting, restoring, and upgrading India's dwindling forest covers in order to lessen the negative consequences of climate change. In order to safeguard the health of the soil, the Government of India (GOI) created the Soil Health Card (SHC) program and Neem-Coated Urea (NCU) to reduce the overuse of urea fertilizers. Programs like the National Project on Organic Farming (NPOF) and National Agroforestry Policy (NAP) were implemented in 2004 and 2014, respectively, to provide farmers with greater economic benefits and environmental protection. These regulations had as their main goals the provision of plant nutrients in the form of organic amendments and the capture of carbon (C) through leaf fall from tree plantations along bunds.

India set goals under the Kyoto Protocol to reduce its GHG emissions by 10–15% by 2020 and its economic emission intensity by 33–35% over 2005 by 2030. India estimates the three main strategies required to fulfil the 1.50 C pledge made via the Paris Climate Accord are climate finance, technological transfer, and capacity building. To build a cumulative carbon sink of 2,500–3,000 MtCO2e by 2030, almost equal to current annual emissions, India has outlined a plan to enhance forest cover. India announced a National Green Hydrogen Policy in 2022 with the goal of encouraging the generation of

green hydrogen and green ammonia in order to fulfil its climate pledges while lowering its import costs for fossil fuels. By 2030, India intends to produce a total of five million tons of green hydrogen, opening up significant investment potential. In reality, a number of governmental and private actors have declared their dedication to the creation of green hydrogen. For instance, Reliance recently declared its intention to invest USD 75 billion in infrastructure for renewable energy sources, with a focus on green hydrogen, including generation facilities, solar panels, and electrolysers.

6. Conclusion

By 2030, it is anticipated that India's food production will need to increase by 50-100% above current levels in order to meet demand. This can be done by employing greener energy sources and lowering GHG emissions. The majority of the Sustainable Development Goals (SDGs) are projected to be met by the agriculture sector, which employs about 70% of India's population directly or indirectly. In the current situation, issues related to climate change are dealt with by increasing the productivity of pulses, adhering to effective nutrient and water management practices, changing cropping patterns, supporting species that are tolerant to abiotic stress, introducing substitute legume crops into cropping systems, and promoting watershed management and micro irrigation practices. Adopting recommended management methods helps agriculture become more climate resilient by conserving water and soil, increasing the quantity of soil organic carbon, and reducing greenhouse gas emissions from agricultural fields. Efficient technologies for soil, water, and nutrients are practical ways to improve productivity, farmer net profits, and soil health in India while lowering GHG emissions and environmental degradation.

7. Way forward

- It is necessary to promote resource conservation techniques like conservation agriculture (CA) methods, SRI cultivation, diversified cropping systems, proper crop residue management to reduce infield burning, inclusion of legume and oilseed crops in cropping systems, effective irrigation techniques like drip and sprinkler irrigation for water conservation, and slow-release fertilizers to improve nutrient use efficiency and minimize losses from volatilization and leaching.
- Policy Reforms should focus on GHG emission reduction technologies, which are essential for sensible nutrient resource management, boosting SOC build-up, and preventing residue burning.
- Farmers should get comprehensive education regarding proper fertilizer dosages based on soil tests and be closely watched to ensure that both

organic and inorganic nutrient sources should applied in an integrated and balanced manner.

- In order to educate farmers about GHG emissions from agricultural fields and their detrimental effects on the food productivity system and human health, training and awareness campaigns should be organized.

- There is a holistic management approach is required to minimizing GHG emissions and addressing climatic vulnerabilities impact on agrarian community of the country.

References

1. Abdalla, M., Osborne, B., Lanigan, G., Forristal, D., Williams, M., Smith, P. and Jones, M.B. 2013. Conservation tillage systems: a review of its consequences for greenhouse gas emissions. Soil Use and Management, 29(2), 199-209.
2. Auffhammer, M., Ramanathan, V., Vincent, J.R., 2012. Climate change, the monsoon, and rice yield in India. Climate Change. 111(2), 411-424.
3. Bhat, A. H., Kumar, A. and Dubey, R. 2017. Wind energy for irrigation and power generation in remote areas. In R. Kumar, A. V. Shanmugam, A. K. Singh, & R. Bhattacharya (*Eds*.), Renewable Energy in India: Policies, Trends, and Prospects (pp. 155-166). Springer.
4. Chen, J., Zhao, Y., Li, S. and Dai, S. 2017. The current status of organic farming in China and the potential for greening of Chinese agriculture. Sustainability, 9(7), 1263.
5. Cheng, M., Wang, H., Fan, J., Wang, X., Sun, X., Yang, L. and Zhang, F. 2021. Crop yield and water productivity under salty water irrigation: A global meta-analysis. Agricultural Water Management, 256, 107105.
6. Cummings, R.W. 2019. RS Paroda: reorienting Indian agriculture: challenges and opportunities. CABI, Oxfordshire, UK, 2018, 314 pp, ISBN 978-1-78639-517-7.
7. DARE/ICAR Annual Report, 2008-09. Department of agricultural research and education. Ministry of Agriculture, Government of India.
8. Das, A., Layek, J., Babu, S., Krishnappa, R., Thoithoi Devi, M.T., Kumar, A., Patel, D.P., Ramkrushna G.I., Yadav, G.S., Sarika, K., Tripathi, A.K., Ghosh, P.K. and Prakash, N. 2019. Intercropping for Climate Resilient Agriculture in NEH Region of India. Technical bulletin No 1 (Online). ICAR Research Complex for NEH Region, Umiam – 793 103, Meghalaya.
9. Dash, S., Chakravarty, A.K., Singh, A., Upadhyay, A., Singh, M. and Yousuf, S. 2016. Effect of heat stress on reproductive performances of dairy cattle and buffaloes: A review. Veterinary World. 9(3): 235-244.
10. Dhar, O.N. and Nandargi, S. 2000. A study of floods in the Brahmaputra basin in India. International Journal of Climatology, 20:771–781.
11. Dhar, O.N. and Nandargi, S. 2003. Hydrometeorological aspects of floods in India. Natural Hazards.

12. Dhyani, S.K., Ram, A. and Dev, I. 2016. Potential of agroforestry systems in carbon sequestration in India. Indian Journal of Agricultural Sciences, 86(9), 1103-1112.
13. Drew, M.C. 1979. Plant responses to anaerobic conditions in soil and solution culture. Current Advances in Plant Science. 36: 1-14.
14. Dunn, R.J.H., Mead, N.E., Willett, K.M. and Parker, D.E. 2014. Analysis of heat stress in UK dairy cattle and impact on milk yields. Environmental Research Letters 9:064006 (11 pp).
15. EnviStats-India 2023: Vol.I: Environment Statistics, National Statistical Office (NSO), Ministry of Statistics & Programme Implementation, Government of India, New Delhi.
16. Gadgil, D. 1995. Climate change and agriculture: An Indian perspective. Current Science 69(8): 649–659.
17. Garg, A., Pathak, H., Kalra, N. and Sahu, A. 2001. Methane emission from Indian livestock. Indian Journal of Animal Sciences, 71(4), 290-295.
18. Geraert, P.A., Padilha, J.C. and Guillaumin, S. 1996. Metabolic and endocrine changes induced by chronic heat exposure in broiler chickens: growth performance, body composition and energy retention. British Journal of Nutrition. 75:195–204.
19. Gupta, D.K., Gajbhiye, N.A., Pradhan, N. and Kumar, A. 2018. Soil organic carbon and soil physical properties as affected by different land uses in Bundelkhand region of Central India. Journal of Soil Science and Plant Nutrition, 18(3), 693-706.
20. INCCA, 2010. Indian Network for Climate Change Assessment, India: Greenhouse Gas Emissions 2007. Ministry of Environment & Forests, India.
21. Jaybhaye, P. 2022. Mitigation and Adaptation Strategies of Plants against Hailstorm under Changing Climate. Plant Defense Mechanisms, 123.
22. Johnson, H.D. 1987. Part II, chapter 3: Bioclimate effects on growth, reproduction and milk production. In: Bioclimatology and the adaptation of livestock. Elsevier, Amsterdam.
23. Jordan, A., Zavala, L.M. and Gil, J. 2010. Effects of mulching on soil physical properties and runoff under semi-arid conditions in southern Spain. Catena, 81(1), 77-85.
24. Kumar, A., Brahmanand, P.S. and Nayak, A.K. 2014. Management of cyclone disaster in agriculture sector in coastal areas. Directorate of Water Management, NRM Division (ICAR), Chandrasekharpur, Bhubaneswar. P108.
25. Kumar, K.N., Reddy, M.J., Reddy, K.V., Paramesha, V., Balasubramanian, M., Kumar, T.K., Kumar, R.M. and Reddy, D.D., 2023. Determinants of climate change adaptation strategies in South India: Empirical evidence. Frontiers in Sustainable Food Systems, 7, p.1010527.
26. Kumar, R. and Kumar, K.K. 2007. Managing physiological disorders in litchi. Indian Horticulture 52 (1): 22-24.

27. Kumari, A., Singh, P. and Mittal, A.K. 2014. Methane production potential of dairy cattle dung and poultry litter. Bioresource Technology, 162, 408-414.
28. Ladha, J.K., Rao, A.N., Raman, A., Padre, A.T., Dobermann, A., Gathala, M., Kumar, V. and Saha, D. 2016. Agronomic improvements can reduce methane emissions from rice fields. PNAS, 113(39), 8923-8930.
29. Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science, 304(5677), 1623-1627.
30. Lemke, R.L., Zhong, Z., Campbell, C.A. and Zentner, R. 2007. Can pulse crops play a role in mitigating greenhouse gases from North American agriculture? Agronomy Journal. 99: 1719–1725.
31. Lin, H., Jiao, H.C., Buyse, J. and Decuypere, E. 2006. Strategies for preventing heat stress in poultry. World's Poultry Science Journal. 62:71–85.
32. Matson, P.A., Naylor, R. and Ortiz-Monasterio, I. 1998. Integration of Environmental, Agronomic, and Economic Aspects of Fertilizer Management. Science (80-) 280:112–115.
33. Meera, A.V., John, J., Sudha, B., Sajeena, A., Jacob, D. and Bindhu, J.S., 2019. Greenhouse gas emission from integrated farming system models: a comparative study. Green Farming, 10(6), 696-701.
34. NAAS, 2021. Strategies for Enhancing Soil Organic Carbon for Food Security and Climate Action. Policy Paper No. 100, National Academy of Agricultural Sciences, New Delhi, pp16.
35. NRAA, 2013, Contingency and Compensatory Agriculture Plans for Droughts and Floods in India- 2012. Position paper No.6. National Rainfed Area Authority, NASC Complex, DPS Marg, New Delhi-110012, 87P
36. Padua, J.T., Dasilva, R.G., Bottcher, R.W. and Hoff, S.J. 1997. Effect of high environmental temperature on weight gain and food intake of Suffolk lambs reared in a tropical environment. In: Proceedings of 5th international symposium, Bloomington, Minnesota, USA, pp 809–815.
37. Pathak, H. 2015. Greenhouse gas emission from Indian agriculture: trends, drivers and mitigation strategies. Proceedings of the Indian National Science Academy, 81(5), 1133-1149.
38. Pathak, H., Bhatia, A. and Jain, N. 2014. Greenhouse Gas Emission from Indian Agriculture: Trends, Mitigation and Policy Needs. Indian Agricultural Research Institute, New Delhi, xvi p39.
39. Pathak, H., Bhatia, A. and Jain, N. 2014. Greenhouse Gas Emission from Indian Agriculture: Trends, Mitigation and PolicyNeeds. Indian Agricultural Research Institute, New Delhi, xvi.39.
40. Perdona, M.J. and Soratto, R.P. 2020. Arabica coffee–macadamia intercropping: yield and profitability with mechanized coffee harvesting. Agron. J. 112: 429–440.
41. Raj, N. 2009. Air pollution-A threat in vegetable production. In: Sulladmath, U. V. and Swamy, K.R.M. International Conference on Horticulture (ICH-2009) Horticulture for Livelihood Society and Economic Growth. 158-159.

42. Ramarao, I.V.Y. 2011. Estimation of efficiency, sustainability and constraints of SRI (System 1377 of Rice Intensification) vis-a-vis traditional methods in north coastal zone of Andhra 1378 Pradesh. Agricultural Economics Research Review 24: 325-331.
43. Ray, L.K., Goel, N.K. and Arora, M. 2019. Trend analysis and change point detection of temperature over parts of India. Theoretical and Applied Climatology.138 (1–2), 153–167.
44. Samra, J.S. and Srinivasarao, Ch. 2021. Circular Carbon Economy in India: Efficient Crop Residue Management for harnessing Carbon, Energy and Manure with Co-benefits of Greenhouse Gases (GHGs) Emissions Mitigation. Policy Paper, ICAR-National Academy of Agricultural Research Management, Hyderabad, India, p20.
45. Sapkota, T.B., Vetter, S.H., Jat, M.L., Sirohi, S., Shirsath, P.B., Singh, R., Jat, H.S., Smith, P., Hillier, J. and Stirling, C.M. 2019. Cost-effective opportunities for climate change mitigation in Indian agriculture. Science of the Total Environment, 655, pp.1342-1354.
46. Shah, T. 2009 Taming the Anarchy: Groundwater Governance in South Asia. Resources for the Future, Washington, DC, and International Water Management Institute, Colombo, Sri Lanka, https://hdl.handle.net/10568/36566.
47. Sharma, A., Wasko, C. and Lettenmaier, D.P. 2018. If precipitation extremes are increasing, why aren't floods? Water Resources Research, 54:8545–8551.
48. Siegel, B.R. 2018. Hungry nation: Food, famine, and the making of modern India. Cambridge University Press.
49. Singh, C., Rio, C.R.D., Soundarajan, V., Nath, N. and Shivaranjani, V. 2019. Assessing India's mounting climate losses to Financial Institutions, http://www.indiaenvironmentportal.org.in accessed on 28th February 2020.
50. Singh, H.C.P. 2013. Adaptation and Mitigation Strategies for Climate-Resilient Horticulture. eds., Singh, H.C.P., Rao, N.K.S. and Shivashankar, K.S. Climate-resilient horticulture: adaptation and mitigation strategies, Springer India. pp 81-88.
51. Singh, S.K., Meena, H.R., Kolekar, D.V. and Singh, Y.P. 2012. Climate change impacts on livestock and adaptation strategies to sustain livestock Production. Journal of Veterinary Advances. 2(7): 407-412.
52. Srinivasarao, Ch., Prasad, R.S. and Mohapatra, T. 2019. Climate Change and Indian Agriculture: Impacts, Coping Strategies, Programmes and Policy. Technical Bulletin/Policy Document. Indian Council of Agricultural Research, Ministry of Agriculture and Farmers' Welfare and Ministry of Environment, Forestry and Climate Change, Government of India, New Delhi. p25.
53. Srinivasarao, Ch, Prasad, J.V.N.S., Choudhari, S.K. and Singh, A.K. 2020. Mainstreaming climate resilient villages in national programmes towards sustainability of agriculture and environment in India. Climate Change and

Environmental Sustainability, 8(2), 116-133.

54. Srinivasarao, Ch., Gopinath, K.A., Venkatesh, G., Dubey, A.K., Harsha, W., Purakayastha, T.J., Pathak, H., Pramod, J., Lakaria, B.L., Rajkhowa, D.J., Sandip, M., Jeyaraman, S., Venkateswarlu, B. and Sikka, A.K. 2013. Use of biochar for soil health management and greenhouse gas mitigation in India: Potential and constraints, Central Research Institute for Dryland Agriculture, Hyderabad, Andhra Pradesh. 51.
55. Srinivasarao, Ch., Prasad, J.V.N.S., Choudhari, S.K. and Singh, A.K., 2020. Mainstreaming climate resilient villages in national programmes towards sustainability of agriculture and environment in India. Climate Change and Environmental Sustainability, 8(2), 116-133.
56. Srinivasarao, Ch., Subha Lakshmi, C., Kundu, S., Ranjith Kumar, G., Manasa, R. and Rakesh, S. 2020. Integrated nutrient management strategies for rainfed agro-ecosystems of India. Indian Journal of Fertilisers 16(4), 344-361.
57. Stagnari, F., Maggio, A., Galieni, A. and Pisante, M. 2017. Multiple benefits of legumes for agriculture sustainability: an overview. Chemical and Biological Technologies in Agriculture, 4(1), 1-13.
58. Tanveer, S.K., Lu, X., Hussain, I. and Sohail, M. 2019. Soil carbon sequestration through agronomic management practices. In CO_2 sequestration. IntechOpen.
59. Tesfai, M., Moed, I. and Greipsland, I. 2016. Integrated soil management practices: adaptation and mitigation to climate change. In Climate Change and Agricultural Development. Routledge. 177-200.
60. Thakur, A.K. and Uphoff, N.T. 2017. How the system of rice intensification can contribute to climatesmart agriculture. Agronomy Journal 109(4): 1163- 1182.
61. Thornton, P.K. and Herrero, M. 2014. Climate change adaptation in mixed crop-livestock systems in developing countries. Global Food Security 3:99–107.
62. Toppo, P. and Raj, A. 2018. Role of agroforestry in climate change mitigation. Journal of Pharmacognosy and Phytochemistry, 7(2), 241-243.
63. Venkatesh, G., Srinivasarao, Ch., Gopinath, K.A. and Sammi Reddy, K. 2015. Low-cost portable kiln for biochar production from on-farm crop residue. Indian farming. 64(12): 9-12, 18.
64. Venkateswarlu, B and Singh, A.K. 2015. Climate change adaptation and mitigation strategies in rainfed agriculture. In: Climate Change modelling, Planning and Policy for Agriculture. Springer, New Delhi, pp. 1–11.
65. West, J.W. 2003. Effect of heat stress on production in dairy cattle. Journal of Dairy Science. 86: 2131- 2144.
66. WMO Greenhouse Gas Bulletin, No.17, 25th October, 2021.

Responding to Disaster Health Needs with Homoeopathy

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Abstract

Reducing the health impacts of disasters is an urgent need to minimise the physical and mental suffering of the affected population. Homeopathy has delivered documented results in different disaster situations. This article discusses about contributions of Homeopathy in varied disaster situations since its discovery. Results are replicated in daily practice on a small scale and enough evidence(s) are there for results produced on a large scale in disasters. Some conditions where results have been found have been produced here. In conclusion, this can be stated that - the use of homoeopathy in the health needs of disaster situations can significantly reduce the suffering of the affected population.

Key words: *Burn, Communicable diseases, Disaster, Epidemic diseases, Homoeopathy, Injury.*

1. What are the health impacts of disasters?

Health impacts in disasters are varied. They often present a common pattern in different types of disasters. Principally, immediately after the disaster strikes; the affected population become overwhelmed by the sudden striking and life-changing phenomenon they are in. This leads to denial and after a while, they succumb to the grave nature of the disaster[1, 2].

The health impacts of disasters may be summarised as follows:

The immediate public health impacts of natural disasters are obvious; these events also spark several other longer-term problems[1, 2, and 3]. (Correll, 2022; Randolph R, et al., 2019; Watson JT, et al., 2007)

1. **Injuries:** Just following a natural disaster, the most common health impact is injuries/wounds that need immediate attention. Triage is a pressing need during the early phase while addressing injuries. The largest number of casualties occurs in earthquakes in comparison to all other disasters. Injuries can be bruises, abrasions, cuts, fractures, and muscle injuries like sprains and strains.

2. **Care of sufferers of pre-existing diseases:** Patients suffering from chronic diseases need special attention due to the disruption of the local structures, power cuts and breakdown of the healthcare services. Chronic diseases can range across the different organic conditions e.g., heart, lung, liver, kidney, brain conditions hypertension, diabetes etc. Continuing care for these populations is an urgency to handle during the crisis.

3. **Communicable diseases:** Public health aims to control the outbreak of certain diseases after a disaster. Waterborne diseases (cholera, typhoid etc.) and vector-borne diseases (dengue, malaria etc.) evolved after disaster. These diseases are communicable and infectious which needs to be addressed and medical care is required. Hence there is a need for quick restoration of structural infrastructure including sanitation, supply of safe drinking water and surveillance of the health status of the affected population.

4. **Grief, shock, and psychological impacts:** Victims in disasters suffer loss of property, relatives and friends. The sudden striking of the devastating experience shakes their world of emotions, feelings and aspirations. Acute issues can be disorders of cognition, behavioural problems, etc. All suffer immediate grief, go into shock, and face anxiety, phobia, depression, insomnia and short-term and long of post-traumatic stress disorder. These may lead to substance use disorder in due course.

5. **Burn:** Burns in disasters may range from minor to major. In disasters involving fires usually, the victims suffer severe burns; also associated with other previous illnesses which multiply the suffering. Depending upon the type of disaster burns may accompany electrocution, different types of wounds like abrasions, wounds, fractures etc. Hypovolemic shock is a severe consequence and can lead to death.

6. **Epidemic or endemic diseases after disaster:** Epidemics themselves are disasters and disasters can lead to different types of epidemics. Disruption of public health utilities following disasters and prevailing unhygienic environments like enhanced breeding of vectors like flies and mosquitoes coupled with crowding in a temporary shelter help spread communicable diseases.

Homoeopathy is a system of therapeutics that postulates that medicinal agents that are tested on healthy human beings when prescribed to patients upon the presentation of a set of symptoms that simulate the findings upon healthy humans can alleviate the sufferings of the patient. This phenomenon in Homoeopathy is termed "Similia Similibus Curenter"[4].

2. Scope of Homoeopathy to address these impacts

Homoeopathy can help the victims – Homoeopathic treatment can help the victims in most of the above-discussed sufferings. Here is a summary of the all-possible help Homoeopathy can offer in such conditions:

2.1 Physical Injuries (Bruises and wounds): Homoeopathic medicines can relieve pain in injuries besides healing the wounds. Arnica Montana is the prime medicine in acute injuries and inflammation arising from trauma conditions, it can heal open (albeit following closure/suture of wounds) as well as closed injuries and can help sufferers of cuts, bruises, and fractures to relieve pain and promote fast recovery, it can arrest haemorrhages internal as well as external - very quickly. Besides depending upon injury to the part involved - medicines like Rhus tox can help torn, sprained and strained muscles; Ruta can heal trauma to bones, Symphytum in trauma to the eyes and any fracture, Bryonia in trauma to the joints, Calendula in clean and sharp cuts, Ledum in punctured injuries, Staphysagria in sharp-cut wounds, Bellis Perennis in injury to deeper and soft tissue structures like testes and scrotum, Hypericum in injuries to nerves - for sharp as well as blunt injuries to nerves, Echinacea can be used in dressing of infected wounds. Natrum sulph is another useful medicine which helps in old head injuries i.e. especially after a head injury, people suffer from confusion, memory loss or seizures.

Calcarea phosphorica can be used when there is injury to bones, also fractures that refuse to heal or tenderness in bones following any kind of injury. Calendula ointment is useful in cuts, inflammation and burns. Ipecac is a medicine for gushing blood from the site of injury when coupled with a sense of nausea; it can arrest bleeding very fast. Phosphorous, Millefollium can also be useful in bleeding of any kind[5, 6, 7, and 8]. The list of medicines in homoeopathy is quite long. Medicines given here are minimal and only suggestive. Depending upon specific presentations lots of medicine can be used with very decisive effect[5, 6, and 7].

One study has suggested homoeopathy can be an intervention in injury, the study was conducted in Israel where many labourers engaged in construction became severely injured, where homoeopathic treatment was administered to injured patients to supplement conventional orthopaedic treatment. Fifteen orthopaedic patients were included. Arnica Montana in 200 potencies was administered to all victims to start with. 9 patients were given Aconite in 200 potency for Anxiety, other medicines for Anxiety were Opium (three patients) two patients were given Ignatia in 200 potency and one victim received Arsenicum Album in 200 potency upon matched symptoms. One day later 58% felt improvement in pain, 89% of patients

reported improvement in their level of anxiety, and amongst all patients, and 61% reported benefit from homoeopathic treatment. During further follow-up treatment after 48 hours of injury, the patients were administered medicines following standard homoeopathic principles. It was found to be useful in 67% of victims[8].

2.2 Care of sufferers of pre-existing diseases: Chronic diseases of different organs like heart, liver, kidney, lungs, brain, joints etc. can be treated by homoeopathic medicines as per the presentations in individual sufferers. Hypertension and diabetes mellitus are common sufferings which can be managed with homoeopathic medicines. Some of the medicines used in daily practice for these above-mentioned organic diseases are Adonis vernalis, Aurum metallicum, Cactus Grandiflorus, Digitalis purpurea, Kalmia latifolia, Naja tripudians, Tabacum, Nux vomica, Phosphorus etc are few among many more for diseases of the heart. For respiratory illnesses, medicines can be prescribed ranging from the common cold, acute viral fevers, bronchitis, bronchial asthma, pneumonia, and COVID-19 to pulmonary oedema and respiratory failure.

A wide array of medicines is available for all these illnesses. Arsenicum Album, Bryonia Alba, Chelidonium, Cinchona, Dioscorea, Lycopodium, Nux vomica, Pulsatilla are only very few of a whole lot of medicines for liver diseases. For brain conditions like an organic brain injury in disasters Nat. sulph is a medicine par excellence for pre-existing diseases like Epilepsy, Migraine, Neuralgia, Stroke etc. many homoeopathic medicines are available; Aconitum napellus, Agaricus muscarius, Bryonia, Belladonna, Hyoscyamus niger, Nux vomica, Stramonium, Veratrum Album, Veratrum viride are few medicines. For joint diseases, a few important medicines are Abrotanum, Arnica montana, Aurum met., Belladonna, Bryonia, Calcarea carb., Calcarea fluor., Formica rufa, Ipecac., Kali carb., Kali iod., Kalmia lat., Ledum Palustre, Phytolacca, Rhustox, Satphysagria etc. For diseases of the kidney Acetic acid, Apis mel., Arsenic album, Digitalis, Kali carb., Ferrum met., Many studies are in support of many systemic diseases showing the usefulness of homoeopathy [7, 9, 10, 11, 12 and 13].

2.3 Communicable diseases: Communicable diseases that affect any population in a disaster-hit area may be of various types ranging from diarrhoea, cholera, typhoid, malaria, respiratory infections like common cold, influenza, chicken-pox, measles, fungal diseases, tuberculosis etc. A long list of homoeopathic medicines is available for these conditions. Homoeopathic doctors are regularly treating these patients to the satisfaction of the patients. Medicines for the common cold are Aconitum Napellus, Arsenic Album, Arsenic Iodatum, Allium Cepa, Eupatorium Perfoliatum,

Gelsemium, Hepar sulph, Natrum mur., Sanguinaria canadensis, Senega, Tuberculinum are few among many more. For diarrhoea and cholera, we can use Aloe Socotrina, Bryonia, Croton Tig, Camphor, Podophyllum, Veratrum alb, Jatropa, Phosphoric Acid, Mercurius, Nat. Sulph, Sulphur, Nitric Acid, Phosphorus etc. Malaria can be treated with Arsenic Album, Cinchona, Ferrum Met, Nat. Mur., Ipecacuanha, Chininum sulph, Apis mel, Sulphur, Rhus tox and many more depending upon the presentation of the individual case in hand. Typhoid can be treated with Arsenic Album, Baptisia, Gelsemium, Muriatic Acid, Rhus tox., Phosphoric Acid etc. Measles can spread during late winter/ at the transition of winter-spring - and can be treated by Arsenic Album, Allium Cepa, Apis mel, Gelsemium, Pulsatilla, Rhustox, Sarracenia, Morbilinum, Variolinum[7, 10, 14, 15, 16 and 17].

2.4 Post-Traumatic Stress Disorder: Grief, shock and other psychological issues: Immediately after being struck by a sudden-onset disaster people become overwhelmed by the suddenness and devastating nature of the disaster. People go into shock at the incident and that is when the homoeopathic medicine Aconitum napellus helps to soothe the nerves and relieve the tension/stress immediately. Also medicines like Ignatia, Opium, Staphysagria, Nat. Mur, Causticum, Phosphoric Acid, Aurum Metallicum, Lachesis, Natrum sulph etc. can be used effectively to address the immediate grief. As arnica is a very well-known medicine for trauma/injury, it is very useful to know that it is also an excellent medicine to address the immediate and long-term effects of mental trauma7, 10. One Bach flower medicine namely rescue remedy helps a lot to overcome the anxiety and stress out of the sudden nature of suffering[18].

2.5 Burns: The principal medicine for burns in homoeopathy is cantharides or cantharis. The indications are burns and scald that presents with blister formation and much burning when touched and much redness etc. Cantharis can be used as ointments, lotions, aqueous solutions and globules for licking. Many other medicines with indications like Anthracinum, Tarentula, Urtica urens, Apis mel, Causticum, Fluoric Acid, Hamamelis, and Graphites can also be used depending on the presenting symptoms. The charred tissue in the burn can be helped to regenerate fast with Calendula, and Echinacea when the burn site starts getting infection[7, 10].

2.6 Epidemic or endemic diseases after disaster: Epidemic diseases that erupt in any geographical area are in themselves disasters; also disasters can give rise to epidemic diseases following 2- 4 weeks after disasters. They can be of different types – principally of respiratory and gastrointestinal origin. Respiratory origin epidemics are influenza, severe acute respiratory syndrome, Middle East respiratory syndrome, acute respiratory syndrome,

COVID-19 etc. Gastrointestinal epidemics are mainly gastroenteritis. Other disasters that may strike are dengue, chikungunya, malaria, leptospirosis, and typhoid etc[2, 3].

3. Health Problems Common to All Natural Disasters

Disasters normally don't give rise to large-scale infectious disease incidence, albeit in some situations the possibility of disease transmission increases. The immediate threat of transmission of diseases is by contaminated food and also sources of water. So, mainly gastric and intestinal infections are of the biggest concern among infectious diseases. The possibility of an epidemic depends upon the volume of the crowd and their movement. So, the main challenge is to address the public health infrastructure and treatment and prevention of the spread of diseases. Later effects are vector-borne diseases following flooding. Also, increases are dangers of animal-to-human transmission when mass movement brings both of them closer, 3. Over 200 years ago, Dr. Samuel Hahnemann (Father of Homoeopathy) provided very clear instructions on dealing with epidemic diseases and in the last few centuries, homoeopathic approaches have been proven successful during the greatest disease outbreaks of epidemics. Underneath are a few case examples where homoeopathy has proved its usefulness in cases of disasters -

a) Case study- 1: Homeopathic treatment in emergency medicine[8]

In an incident in Israel during May, 2001 fourth floor of a community hall gave in and collapsed which may be due to some civil/construction works fault. Around 600 people were attending a ceremony there, 23 died on the spot and more than 300 people got injured. 152 injured victims were rushed to the Shaare Zedek Medical Centre. Centre of Integrated Complementary Medicine was called upon to be involved in the homoeopathic treatment of casualties along with the Orthopaedic Department to administer add-on therapy besides the allopathic treatment. The administration of homoeopathic medicines was split into two parts. Firstly, pain and anxiety were treated, and treatment of other complaints was followed after pain and anxiety treatment. Follow-up visits were done every day, jointly by a team of two or three homoeopathic doctors; medicines were selected with the help of homoeopathic repertory software RADAR.

At the first leg of treatment, patients were examined around 24 hours after the mishap, all victims were administered Arnica Montana in 200 potency only one dose, they were also prescribed other appropriately selected/indicated medicines for anxiety after Arnica Montana. Nine

patients received Aconite, three got Opium, two patients were given Ignatia and one of them received Arsenicum Album. There was an improvement of different grades in 58% of patients, 42% of victims reported no results and also an increase in pain. Amongst a whole lot of patients followed, 89% could find reduced anxiety levels, and 61% of the treatment group found homoeopathic treatment useful. The subsequent treatment of other symptoms/complaints with the help of software and as per homoeopathic principles was found to be useful in 67% of patients.

b) Case study -2: Study on Epidemic of Leptospirosis in Cuba with ultra-dilution of bacteria conducted in 2010[19]

Leptospirosis is an endemic and epidemic disease mainly in tropical and subtropical regions, Cuba is one of the affected countries. The disease incidence in Cuba rose from 2004 to 2007. In the year 2007, the incidence in Cuba attained epidemic levels following huge rainfall, inundations and severe impact on the environment. The incidence and chance of infection in exposed individuals left the existing control measures incapable of taking control of the situation.

The country was divided into two regions for the study namely IR (Intervention region) and RC (Rest of the Country). The intervention was termed as Homoeoprophylaxis (HP). The preventive treatment was started in the 45th week of 2007 in the Intervention Region and not in the rest of the country. The subjects were followed up for any incidence of Leptospirosis and it came to the observation that the natural incidence of the disease majorly altered from the end of 2007 till into 2008. The lowering of the disease occurrence started just two weeks following the administration of the intervention medicine and the preventive capacities of the intervention medicine continued till the end of 2008. During the years 2007-2008, the yearly incidence was reduced to 84% in the intervention region, while the incidence in the rest of the country was found to increase by 21.7%.

The scale of vaccination and homeo-prophylaxis in the intervention region differed. 96% population received homoeopathic preventive medicine whereas vaccination covered only 0.6% of the public. The low vaccination rate was due to the shortage of stock. Both the intervention region and the rest of the country were equally affected by hurricanes and rainfall was equivalent in these two study-specific regions. The intervention region reported less no. of cases which is concurrent to 70% population getting homeoprophylaxis intervention. Hence

the homeo-prophylaxis treatment may have played a crucial role in reducing the incidence of leptospirosis in the intervention region.

c) Case study -3: Homoeopathic Genus Epidemicus 'Bryonia alba' as a prophylactic during an outbreak of Chikungunya in India[20]

In another double-blinded, placebo-controlled study in two districts of Kerala upon Chikungunya in 2007 from August into September, wherein no other preventive medicines were administered either by any govt. or private agency the following observations were made. Willing participants (19750 subjects) received three doses of Bryonia in 30 potency successively three days, and another 18479 healthy subjects got a placebo on an empty stomach per mouth. All participants were divided into 167 clusters.

Analysis was done for 158 clusters. Participants were followed for five weeks to observe rates of infection in both the study groups, namely the medicine/preventive group and the placebo group. After calculation of the study results it was found that the risk of chikungunya could be reduced up to 19.76% when compared to the placebo group. This study could demonstrate an edge of homoeopathic medicine Bryonia Alba 30 over placebo in control of chikungunya in Kerala.

d) Case study - 4: Study of Homoeopathy in Epidemic Viral Conjunctivitis (1981) at Udaipur[21]

A single-blind study was conducted to evaluate the efficacy of Homoeopathy in epidemic acute viral conjunctivitis in the year 2010 in a government dispensary in Udaipur, Rajasthan. 92 patients were included who were split into four groups – A, B, C and D. Homoeopathic medicine and Euphrasia eye drops were given to group A, placebo and Euphrasia were given to group B patients, group C patients received homoeopathic medicines and Normal saline eye drops; while group D patients received placebo and normal saline eye drops. Most of the study subjects found relief in a span of three to five days in the treatment group; patients in group B found relief after 7 days, and group D patients went on declining. The results pointed towards the positive effects of homoeopathic medicines over the placebo group in the treatment of the epidemic viral conjunctivitis group.

In another study in July to December 1981 upon epidemic conjunctivitis - 3376 patients were treated across various units of the Central Council for Research in Homoeopathy. Study patients were picked by randomisation in two stages. 25% of patients from every unit and a total of 469 subjects were included in the analysis. Follow-up care was taken by 54.37% of patients while the rest of the patients left after

the first visit. Nearly 80% of study subjects received medicine within 3 days of onset of symptoms. 96% of patients showed different grades of improvement to the point of complete recovery, out of which 74.89% were relieved within 1-3 days. Belladonna was the most frequent prescription, Euphrasia, Argentum nitricum and Apis mellifica are other medicines in decreasing order. Inference drawn may be summarised as although in varying grades there is a definite effect of homoeopathic medicines in the treatment of epidemics of conjunctivitis.

e) Case study - 5: Effect of adjuvant homoeopathy with usual care in the management of thrombocytopenia due to dengue[22]

Adjuvant homeopathy with usual care was given to 138 patients in a hospital in New Delhi, India in a severe outbreak of dengue for the treatment of thrombocytopenia from September through December 2015. Patients were given homoeopathy medicine besides routine treatment, 145 patients got regular treatment only. The outcome of the study was measured by platelet count (below 1, 00,000/cu.mm). The results were analysed by the Kaplan-Meier method of survival analysis, computing the time taken to achieve a platelet count of 1, 00,000/cu.mm. The results showed a significant in statistical analysis in the rise of count after one day of treatment in the regular treatment plus homoeopathy group over the regular treatment group (p-value – 0.001). The observations continued in favour till the 5th day (p – 0.02). It took 2 days for the platelet count to reach 1,00,000/cu.mm in the homoeopathy plus regular treatment group which was quicker when compared to regular treatment ($p < 0.001$). The findings in this study show a definite role of homoeopathy when combined with regular treatment for thrombocytopenia from dengue.

f) Case study - 6: 2018 study on acute encephalitis syndrome conducted by standard protocol treatment plus homoeopathic medicines[23]

A randomized placebo-controlled trial was conducted at a paediatric unit from 2013 to 2015 to observe whether homoeopathy when coupled with standard treatment protocol adopted by the hospital for treatment of acute encephalitis in paediatric group aged from 6 months to below 18 years, patients were randomised and given usual care plus homoeopathy (325 children) and usual care plus placebo (323 children).

Glasgow outcome scale was followed for analysing the effectiveness in the first place. Morbidity status was measured by the Liverpool Outcome Score. Intention to treat was followed for analysing the data. 612 children

were treated and analysed – the homoeopathy group 304 children and the placebo group 308 children. The results showed variable significance in homoeopathy and placebo groups in favour of homoeopathy. The homoeopathic group showed less no. of fatality/brain-dead i.e., 14.8%, while in the placebo group, it was 29.8%. Absolute risk was reduced to 15.05 in the homoeopathy group and relative risk was computed to be 0.49. Medicines came out as most frequent are in the following order – Belladonna – 116 patients, Stramonium – 33 patients, Arsenicum Album – 25 patients, Sulphur – 18 patients, Opium – 17 patients and Nux Vomica – 10 patients. The results of the study point towards the fact that homoeopathy can help bring favourable outcomes in encephalitis.

g) Case study - 7: Homoeopathy for COVID-19 in primary care: A randomized, double-blind, placebo-controlled trial (COVID-Simile study)[24]

In a study in Brazil from June 2020 to April 2021 on RTPCR-diagnosed SARSCOV-2 patients above the age of 18 years, the patients were grouped into placebo and medicine groups, the was double-blinded and randomisation done. The first group was given Natrum mur in 0/2 potency, the other arm got placebo and they were isolated at home.

In the study, the primary end-point was kept as a cure for influenza, and the secondary criteria were analysing the survival and severity of the presenting symptoms. Observations from 86 patients were scrutinized – 42 in homoeopathy and 44 in the placebo group. The time taken for recovery was equal (p – 0.56). Secondary improvement criteria were found to be 50% less in symptom scores in the medicine group (p – 0.04). The average survival time calculated points to the fact that symptom score might have reduced up to 0.9 days quicker in the homoeopathic medicine group in the first 5 days of follow-up(p – 0.022). Patients who got hospitalised were 2.4% in the homoeopathy group and 6.8% in the phytum group (p – 0.62). Severe consequences reported were six in the placebo arm, while it was three in the medicine arm. Findings revealed that the statistical significance is not notable in Natrum mur 0/2 and placebo group in the treatment of COVID disease.

h) Case study-8: Homoeopathy as an Adjuvant to Standard Care in Moderate and Severe Cases of COVID"[25]

In a study which was randomized, inert-controlled and followed up prospectively upon COVID-19 patients of moderate to grave severity of both sexes in a super-speciality hospital the following observations were made. 150 adults above 18 years of age were included in the study and were software-randomised in two batches of homoeopathic medicine

group and placebo group, patients were administered homoeopathy and placebo in addition to protocol treatment of COVID-19 in force.

In the study, the RT-PCR negative condition which denotes the non-existence of the virus was considered the primary outcome. MYMOP2 scale, the clinical ordinal scale of WHO besides other biochemical markers were applied for secondary outcome measurement.

The primary outcome was the time taken to achieve RT-PCR-confirmed virus clearance for COVID-19. Secondary outcomes were changes in the MYMOP2 scale, Clinical Ordinal Outcomes Scale (COOS) of the World Health Organization and several biochemical parameters. Non-linear data were evaluated by applying an unpaired t-test. Semi-parametric data was tested by Wilcoxon signed rank test.

72 candidates in aggregate of the add-on homoeopathic medicine group took a shorter time in a change of RT-PCR positive state to negative, when tallied with the add-on placebo group (p-0.001). The average COOS score reduced to 3.64 ± 1.50 from 4.26 ± 0.44 in the add-on Homoeopathy group, whereas the reduction in the score in the add-on placebo group was from 4.3 ± 0.46 to 4.07 ± 1.8 which is not valid statistically. Differences in-between groups concerning variables like platelet count, C-reactive protein, total WBC count, fibrinogen and alkaline phosphatase came out as meaningful in the homoeopathic medicine group($p<0.05$). Some other biochemical markers showed no significant difference in both groups. Large-scale, meticulous studies are necessary to accept or refuse these findings.

All these studies give the proof of usefulness and effectiveness of homoeopathy in various disaster situations. The approach of homoeopathy to disasters may be of the following methods. In cases of injury, fracture etc. disaster situations can be treated homoeopathically by symptom similarity. In epidemic situations, homoeopathy can be given after closely monitoring the presenting features of at least 15-30 depending upon the no.s of the affected population and reaching a minimum through genus epidemics as per homoeopathic principles, as a final resort homoeopathy can be used as an adjunct to standard treatment protocol existing in allopathy.

As per the reports of the World Health Organization, the commonest causes of death in disaster situations are summarized as diarrhoea, acute respiratory infections, malaria, measles and malnutrition. The following approach of Homoeopathic treatment can be used in sudden outbreaks of water-borne, vector-borne diseases and direct contact diseases, as in disaster situations:

a. Water-borne diseases:

Disease/symptoms	Homoeopathic treatment
Cholera - copious rice-watery stool	Carbo veg., Nux vomica, Cuprum met., Camphora, Arsenicum Album, Aloes, Podophyllum, Veratrum Album, Croton Tig., Jatropha, Bryonia, Merc. Sol., Phosphorus, Nitric Acid etc[26].
Leptospirosis - sudden onset fever, bleeding from orifices, aches and pains, low urine output etc.	Crotalus horridus, Arsenicum Album, Bryonia, Rhus tox., Sulphur, Nit. Ac., Phosphorus, Nux vom., etc[19].
Hepatitis – nausea, anorexia, vomiting, fever, malaise, weakness, yellow color skin, urine etc.,	Bryonia alba, Chelidonium, Hydrastis can, Phosphorus, Nux vom., Carduus Marianus, Ceanothus, Mercurius, Crotalus, Chelone etc[27].
Bacillary Dysentery - frequent bloody, mucoid stool, malaise, feverishness, pain abdomen, severe weakness etc.,	Nux vom., Mercurius sol., Aloes, Trombidium, Ipecacuanha, Cantharis, Colchicum etc[28].
Typhoid - Continuous fever, aches and pains, pain abdomen, constipation early and late diarrhoea etc.	Arsenicum Album, Bryonia, Gelsemium, Rhus tox., Mur. Ac., Nit. Ac., Baptisia etc[2, 3, 29].

b. Vector-borne diseases

Disease/symptoms	Homoeopathic treatment
Dengue - high fever, break-bone pains, flu-like illness, pain behind eyes, severe head pain, rashes may be there	Bryonia Alba, Rhus Tox., Gelsemium, Eupatorium Perf.[30], Nux vom, Cinchona off [2,3,30].
Malaria - fever, chills, sweats, head and body aches, nausea and vomiting	Natrum mur., Arsenic Album, Gelsemium, Nux vom., Cinchona, Chininum Sulphuricum, Chininum Arsenicum, Cedron, Digitalis, Eupatorium Perfoliatum, Ferrum Metallicum[2,3]
Japanese encephalitis – high rise of temperature, severe headache, neck rigidity, altered sensation, sometimes convulsion and coma	Belladonna, Bryonia, Gelsemium, Natrum sulph., Helleborus, Phosphorus, Nux vom. etc.
Yellow fever - fever, aches and pains, yellow discoloration of eyes, skin and mucous membranes, liver and kidney failure, nausea and vomiting	Crotalus horridus, Lachesis, Cinchona, Phosphorus, Digitalis purpurea etc.

4. Conclusion

Disasters are striking at a more frequent rate across the globe, epidemic infectious diseases are also disasters since this outbreak suddenly, affected a huge no. of people to start with, and spread at a very fast pace. Rapid, organised and effective plan execution can play a pivotal role in controlling the situation within a fixed time frame. Homoeopathy when coupled with a conventional system of medicine has delivered better outcomes. It would be prudent to incorporate homoeopathy besides the conventional system in the planning of disaster management which can yield better results than when treated with allopathy alone.

References

1. Randolph R, Chacko S, Morsch G. Disaster Medicine: Public Health Threats Associated With Disasters. FP Essent. 2019 Dec; 487:11-16. PMID: 31799815. Available from: https://pubmed.ncbi.nlm.nih.gov/31799815/#:~:text=After%20a%20disaster%2C%20immediate%20public,increased%20risk%20of%20human%20trafficking.

2. Very well health [Homepage on the internet]. Correll R. Available at https://www.verywellhealth.com/health-threats-and-epidemics-after-natural-disasters-4149848. Accessed on 8.11.23

3. Watson JT, Gayer M, Connolly MA. Epidemics after natural disasters. Emerg Infect Dis. 2007 Jan; 13(1):1-5. Available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2725828/. Accessed on 8.11.23

4. The North Eastern Institute of Ayurveda & Homoeopathy (NEIAH) [Homepage on the internet]. Available from: https://neiah.nic.in/homoeopathy.html#:~:text=Homoeopathy%20simply%20means%20treating%20diseases,likes%20are%20cured%20by%20likes%E2%80%9D. Accessed on 8.11.23

5. Boericke William. New Manual of Homoeopathic Materia Medica. New Delhi: B. Jain Publishers(P)Ltd; 2014

6. Kent JT. Lectures on Homoeopathic Materia Medica. New Delhi: B. Jain Publishers (P) Ltd; 2010.

7. Clarke JH. A Dictionary of Practical. New Delhi: B. Jain Publishers (P) Ltd.; 2014.

8. Oberbaum M, Schreiber R, Rosenthal C, Itzchaki M. Homeopathic treatment in emergency medicine: a case series. Homeopathy, 2003, 92 (1): 44-47.

9. Allen TF. Hand Book of Materia Medica and Homoeopathic Therapeutics. B. Jain Publishers (P) Limited, 2023.

10. Dewey WA. Essentials of Homoeopathic Therapeutics. B. Jain Publishers (P) Limited, 2016.

11. Singh S, Varanasi R, Garg K, Sehrawat N, Bhatti J, Chakma A. Homoeopathy in the management of chronic kidney disease – A narrative review. Indian Journal of Research in Homoeopathy. 2022, 16. 10.53945/2320-7094.1099.

12. To KLA, Fok YYY, Chong KCM, Lee YCJ, Yiu LSS. Individualized homeopathic treatment in addition to conventional treatment in type II diabetic patients in Hong Kong - a retrospective cohort study. Homeopathy. 2017 May; 106(2):79-86. doi: 10.1016/j.homp.2017.02.002. Epub 2017 Mar 17. PMID: 28552177; PMCID: PMC6376626.

13. Bhalerao RD, Manchanda RK, Roja V. Homoeopathy in the management of Dyslipidemia: A short review. Indian J Res Homoeopathy 2015; 9:258-66.

14. Varanasi R, Nayak D. Homoeopathy in the management of infectious diseases: Different facets of its use and implications for the future. Indian J Res Homoeopathy 2020; 14:110-21.

15. Chaudhary A, Khurana A. A review on the role of Homoeopathy in epidemics with some reflections on COVID-19 (SARS-CoV-2). Indian J Res Homoeopathy 2020; 14:100-9.

16. Jacobs J. Homeopathic Prevention and Management of Epidemic Diseases. Homeopathy. 2018; 107:157-160. doi: 10.1055/s-0038-1649487. Epub 2018 May 12.

17. Teixeira MZ. Homoeopathy: a preventive approach to medicine. International Journal of High Dilution Research, 2009; 8(29):155-172.

18. Thaler K, Kaminski A, Chapman A, Langley T, Gartlehner G. Bach Flower Remedies for psychological problems and pain: a systematic review. BMC Complement Altern Med. 2009 May 26; 9:16. doi: 10.1186/1472-6882-9-16. PMID: 19470153; PMCID: PMC2695424.

19. Bracho G, Varela E, Fernandez R, Ordaz B, Marzoa N, Menendez J et al. Large scale application of highly diluted bacteria for Leptospirosis epidemic control. Homeopathy. 2010: 99(3): 156-166.

20. Janardan Nair K, Gopinadhan S, Sreedhara Kurup T et al. Homoeopathic genus epidemicus 'Bryonia Alba' as a prophylactic during an outbreak of Chikungunia in India: A cluster randomized, double blind, placebo controlled trial. IJRH 2015; 4(3): 160-165.

21. Verma DK, Verma SK, Atray JP, Atray M. Homoeopathy and Epidemic Viral Conjunctivitis. Homoeopathic Links. 2013; 26 (1): 58-62.

22. Nayak D, Chadha V, Jain S, et al. Effect of adjuvant homeopathy with usual care in management of thrombocytopenia due to dengue: a comparative cohort study. Homeopathy 2019; 108 (03):150–157.

23. Oberai P, Varanasi R, Padmanabhan M, et al. Effectiveness of homeopathic medicines as add-on to institutional management protocol for acute encephalitis syndrome in children: an open-label randomized placebo-controlled trial. Homeopathy 2018; 107(03):161–171.

24. Adler UC, Adler MS, Padula AEM, Hotta LM, de Toledo Cesar A, Diniz JNM, de Freitas Santos H, Martinez EZ. Homeopathy for COVID-19 in primary care: A randomized, double-blind, placebo-controlled trial (COVID-Simile study). J Integr Med. 2022 May; 20(3):221-229. doi: 10.1016/j.joim.2022.03.003. Epub 2022 Mar 12. PMID: 35339397; PMCID: PMC8917006. Access on 08.11.23

25. Kaur H, Kaushik S, Singh G et al. Homeopathy as an Adjuvant to Standard Care in Moderate and Severe Cases of COVID-19: A Single-Blind, Randomized, Placebo-Controlled Study. Homeopathy. 2023; 112(3):184-197. doi: 10.1055/s-0042-1755365. Epub 2022 Nov 28. PMID: 36442593. Access on 08.11.23

26. Hahnemann S. Cause and prevention of the Asiatic cholera. In: Dudgeon RE. The lesser writings of Samuel Hahnemann. New Delhi: B. Jain Publishers; 1995 (Reprint edition). p. 753-756.

27. Sarter B, Banerji P, Banerji P. Successful Treatment of Chronic Viral Hepatitis with High-dilution Medicine. Glob Adv Health Med. 2012 Mar; 1(1):26-9. doi: 10.7453/gahmj.2012.1.1.007. PMID: 24278798; PMCID: PMC3833483.

28. Singh PK. To Study The Efficacy Of Homoeopathic Medicine In Treatment Of Amoebic And Bacillary Dysentery. 2019; 2(1): 1-8.

29. Umashankar C, Kunchirman BN, Shinde C. Homeopathic interventions against Salmonella typhi: A narrative review. Asia Pacific Journal of Molecular Biology and Biotechnology. 2023; 31(2):119-128.

30. Rath P, Arya B, Vichitra A, Singh U. Case Series of Dengue Treated with Homoeopathic Intervention. Homoeopathic Links. 2019, 32: 31 - 35.

31. Hawke K, van Driel ML, Buffington BJ, McGuire TM, King D. Homeopathic medicinal products for preventing and treating acute respiratory tract infections in children. Cochrane Database Syst Rev. 2018 Apr 9;4(4)

Warehousing Pre-Positioned Relief Material for Effective Disaster Response

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Abstract

Humanitarian agencies (HAAs) provide comfort to victims of natural and man-made disasters, preparing for millions of victims each year. Their main program is to collect money and goods from donors around the world and provide comfort to poor people around the world. Therefore, logistics is very valuable in terms of tactics for their movements and objectives. However, our research shows that the environment, perceptions and characteristics of the products have a significant impact on the economic performance of the sector, due to unskilled personnel, inconsistent technology, poorly explained procedures and lack of access to the organisation. I just know. Therefore, the status and importance of transportation in HAAs in general or through donations that provide financial services to consoles is not always well understood or cared for. Approximately 500 natural disasters occur every 12 months, killing approximately 70,000 people worldwide and affecting more than 200 million people. As such situations arise, various devices are needed to provide comfort to people. There is a humanitarian industry that provides comfort to survivors of natural and man-made disasters. The most important problem in solving such problems is the ease of preparation of the equipment and the ease of operation of the distributed equipment. Focusing on these goals, this article continues to develop product plans and disaster plans advancement plans to provide relief to people affected by disasters due to the crisis and subsequent failures.

Keywords : *Disaster management, Warehousing, Logistics, Relief*

1. Introduction

During a disaster (World Health Organization, 2021), lack of resources or slow action can render immediate response ineffective, leaving people struggling and dying. Humanitarian logistics play a key role in planning, responding to, and recovering from emergency disasters, as well as solving long-term development problems (Swann, 2014). Business practices are unknown in many areas, but certain practices of global companies or, in many cases, diverse groups of people are no longer affected. It is ironic that a business

with stringent requirements on time, cost, and management does not make sense. It is this fragility that creates what we see as the potential for economic growth and human activity. In the context of disaster risk reduction, it is clear that humanitarian organizations use the mission statement to create organization-specific strategic plans for chain metals (Leeuw, 2010). Smart humanitarian organizations can help analyze disasters, development, and healthcare and identify future research opportunities (Arunachalam Nayaranan, 2021). One way the human community can improve emergency response and disaster preparedness capacity and have better access to mitigation resources is through prepositioning or storage. By relocating or storing data transmissions, the system can effectively respond to disasters at any time and reduce the loss to zero (Jason Acimovica, 2016). In particular, long-term pre-positioned communities will be most effective in responding to unexpected disasters (such as earthquakes) without modification by maintaining response products to residential areas. However, creating a pre-deployment community to help deal with an unplanned emergency is not a smooth sailing as the severity, time and location of the situation can be unpredictable. There are many international aid and humanitarian programs that provide assistance to survivors of natural and man-made disasters.

2. Literature Review

Information on storage mechanisms in humanitarian organizations generally falls into three areas: geographic location, inventory management, and community water. Regional research specializes in the study of spatial aspects of business and investigates the impact of geographic location on factors such as cost, service, and response time from human comfort. To determine the best class before target community setup, it is important to remember the following:

Pre-financial support (preliminary inventory and warehouse setup) and warehouse walking price) (Ross, 2015). Specifically, we are trying to answer the following question: What is the community structure that reduces the minimum response time, given the initial amount? At the moment we forget about operating costs, because it is not possible to obtain approximate data for the answer (materials and transportation costs) to estimate operating costs and then check operating costs in the first place.

But the general idea is that in addition to savings in purchasing and shipping, there are additional expenses that include the cost of stocking capital, which is nicely used in inventory, and the cost of walking through warehouses. A disaster. We think that travel products are not that big anymore, thanks to donations from the authorities and collaborations with UNHRD and different humanitarian organizations. Since the goal of the pretargeting community

is to increase the ability to deal with rapid onset delays, this release takes into account the international demand for a comfort high dose due to the sudden onset of natural delays. In particular, we consider the extent to which people are exposed to earthquakes, storms (cyclones, tornadoes, tornadoes, and tornadoes), ocean waves (tsunamis and tides), and floods. We eliminate slow-moving diseases, including malnutrition, because comfort companies can come together to address these errors and provide comprehensive answers without using the community first.

Inventory management and product management are difficult in disaster situations and are often associated with other operations or supply chain management. For example:

1) Providing raw materials for post-disaster production planning,
2) Production of finished products is limited to production,
3) Product requirements for emergency services determined by intermediate production planning (Shevishak, 1993),
4) Location and distribution capability of warehouses during and after the disaster,
5) Types of transportation used for internal and external transportation (James Higginson, 2015),
6) The impact of pricing, approvals and other business decisions; and
7) Vendor selection.

A method of supply chain management and the importance of supporting information and education has been studied for use in supply chain management in various engineering schools and graduate schools (M. Eric Johnson, 2009).

Table 1: Important parameters of Warehouse Management in disaster cases

Prepared-ness	Assessment/ Appeals	Resource Mobiliza-tion	Transportation	Procurement Execution
Tracking & Tracing	Stock/Asset Management	Extended Point of Delivery	Performance	Evaluation

3. Determining the Criteria

In today's disaster response practice, many organizations maintain supply chains to guide emergency response after a disaster begins. Some of the

important organizations include identifying potential suppliers (local and/or international), conducting the purchasing process, identifying production facilities, and renting and improving warehouses. It is offered by the seller. For example, because the need for assistance is time-sensitive, international freight forwarders often transport goods by air to ports in affected areas and then use their assistance to move resources from the ports to warehouses or distribution centers.

Distribution: The community can also use many private things, but a private thing is the biggest activity the public organization has in warehouses and traffic due to the loss of infrastructure. The loss of a reliable transportation community and level of planning is not uncommon due to the different types of investments each organization receives.

Financial assistance for warehouse management during a disaster is provided by obtaining immediate response and emergency insurance after the disaster, but financing for infrastructure and planning will be more difficult to obtain. First of all, in the understanding of damage management and transportation of people, existing solutions are quite common in the management of products where damage is difficult and ineffective (Serhan Duran, 2012). They play an important role in field studies (Douglas Paton, 1999). Humanitarian organizations (HOs) often decide on stockpiles based on personal preferences and information rather than judgment. Many HOs employ separate dispatchers for emergency response and regular operations. Based on input from the human resources planning community and intensive data monitoring by the Office of the United Nations High Commissioner for Refugees (UNHCR) (UNHCR), this document presents a model of community repositories for integration with political and security contexts. Although accessibility, proximity, security, and human resources are essential for the implementation of human resources management, these key elements are currently missing from previous social optimization models (Peter Berling, 2016).

The usual method is to ship directly from nearby and/or international distributors. Among these options, organizations committed to the twin dreams of increasing social value and reducing costs often choose community service providers. Local and regional food assistance (LRP) is often viewed as a faster, more cost-effective intervention (B. Barrett, 2013). The benefits of local delivery include rapid transportation of national goods and strengthening the local economy, allowing affected communities to recover faster.

Management of international trade integration in the business market requires the integration and integration of business resources, balance

precision and connection of logistics processes in production, purchasing, storage, transportation and business areas (Pitel Nina, 2019). However, when supplying products to the region, doubts will arise about best-in-class products, availability and efficiency in the aftermath of the disaster. There is also a risk that prices will increase due to shortage. Organizations can obtain global data when data is not available locally. Shipping from major and legitimate suppliers around the world ensures higher quality, higher quality products.

4. Methodology

Medical teams can utilize their electronics and achieve lower costs by purchasing in bulk from smaller international suppliers. The danger is that unexpected events require long distances, increasing transportation costs and delaying response times. Sustainability is an important value for many companies, but they find it difficult to operate in the current business environment, especially when they manage tasks such as warehousing and distribution in their product chains (Barjis, 2009). To improve emergency response times, we found that a third of the options were pre-positioned before deciding on non-disruptive equipment. In this way, rescue equipment can be stored in warehouses in three different locations and used after the disaster. The success of pre-deployment communities has been achieved as the United Nations Humanitarian Emergency Depot (UNHRD) and some governments now provide loose or convenient storage stations and provide transportation services for international groups (Sabine F. Shu Ertz, 2010).). The first method can complete the daily practice of sending accurate information from suppliers, completing the purchase with few responses and reducing the burden on other vendors. Additionally, medical records can be targeted to potential locations and prepared in advance for transportation, resulting in faster response times and less downtime (Staudt, 2015).

a) **Demand:** After collecting facts about people affected by the failure, we estimate the actual demand for different products by optimizing the demand for various products used and the value of the property required by the affected parties. We collected facts from the region to understand the geographic area where the content was collected. The final step in planning the implementation program is grouping to calculate the risk of responding to events that occur in different locations. This is necessary because the failure that occurs during the transfer of goods needs to be handled by the existing inventory of the entire warehouse (Yousefi-Zenouz, 2018).

b) **Delivery:** International suppliers can provide delivery solutions and add warehouses in advance. Provide adequate assistance in a limited time frame and provide shelter and assistance to the victims (Beresford, 2015).

As mentioned earlier, emergency responses are often temporary and humanitarian organizations often do not fully address the effectiveness of service providers. As a result, there are no accurate estimates of the geographic area and delivery times of various service providers. To overcome this problem, this version assumes that all repair products have suppliers who can deliver everything they need to do, including the time required for purchasing and shipping to the affected countries, in the middle of two weeks. After the inspection, seven emergency supplies are stored in the pre-determined warehouse: food, water and hygiene supplies, warm weather tent, bloodless tent, household goods, people and hygiene products. We do not forget that each warehouse has inventory first, and the inventory is replenished after each response. The warehouses are added by international suppliers, and there is no change in the product.

c) **Response Time:** Response time is the time it takes for the shipment to reach the port of entry of the relevant country. Therefore, the response time for shipments sent by courier is two weeks, while for domestic warehouses it depends on the location and location of the goods between warehouses. The time required to fly such a large arc distance, especially at the speed of an ordinary transport aircraft used in humanitarian aid, is far from sufficient. Other factors such as customs clearance, protest levels, damage to highways, local customs and shipping distances may affect response times. But we focus on global distribution and forget about these factors because their consequences are the same regardless of how the community was first established.

For a given decision, response time will normally decrease as the number of open items increases. Considering that the basic response time without using prepositioning is two weeks (or 336 hours), the response time starts to decrease significantly when we move from one warehouse to two warehouses. After three to four warehouses, minimum profit will be achieved and the daily response time will decrease at a lower rate as the product will increase (Mary M. Nelan, 2018).

Program Company Logistics can make the voice of humanitarian logistics heard. Therefore, humanitarian logistics needs to focus on the following five important areas:

1. Creating a collaborative practice will allow people in the supply chain to share their understanding and knowledge on common issues and work together with donors and peers to create a common voice.
2. Legal perception management can, to some extent, address the lack of understanding of the organization by overworked staff through perception capturing and reporting.

3. Creating flexible responses will increase credibility by providing insight into the installation and making people and processes more efficient.
4. The best analytical models will also provide a framework for understanding management, overall performance, and intelligence.

6. Conclusion

In addition to the regular direct delivery process, pre-order express delivery will have many advantages. These include increasing green purchasing, creating responsive designs and reducing shipping costs. The final result depends solely on the configuration of the university prepositioning community. The results show how to spend money very early to achieve the best results and also support the implementation of slow expansion in the community. The decision is based solely on outdated statistics to estimate the frequency, location and cost of demand and to optimize warehouse space and distribution of goods according to the number of jobs opened and the price of goods sold for early money. . Determine the most popular configuration in the community and provide a way to achieve different prices at the end. By understanding the performance and traditional patterns of the community, companies can now narrow down their startup options and consider the different methods of each planning area, including managing location, customs, warehouse costs, workforce level, labor cost, and accessibility and construction time. Collaborate with different businesses to make final decisions.

Humanitarian logistics can increase its support for disasters and justify its strategies by addressing the poverty issues outlined above. This can be done through activities in information management, technology, measurement, communications and voice. When transporting rescue equipment to the disaster area will still be the key to transportation, sending accurate information in a timely manner should be the goal of the business, along with internal research and others, to research the facts to get an idea about the way to improve the business. Creating a network that simultaneously sells products and invests in the production of that content can have many effects on each customer's efforts. Rather than limiting itself to immediate impact, humanitarian logistics can find its own voice and create its own future through the realities and methods of the website.

References

1. ArunchalamNayaranan, North America (2021). There is a lot of humanitarian aid. Ann OperRes.
2. B.Barrett, E. C. (2013).

3. Timeliness and cost-effectiveness of regional and sub-regional food services. World Development Science Guide, 9-18.
4. Sustainable warehouse management. EOMAS '09: Proceedings of the International Conference on Industrial and Organizational Modeling and Simulation.
5. Prepositioning of warehouses at regional and local levels for humanitarian organizations. International Journal of Production Economics, 616-628.
6. Traumatic stress: Emergency care. Disaster prevention and control. H. (2015).
7. The law approves freight consolidation programs. Journal of Business Logistics, 14th. (2016). Standards and indicators for assessing humanitarian response capacity.
8. Journal of Operations Management, 45, 11–29. (2010).
9. Create a work report to evaluate human performance. A virtual work conference. Springer connection. Eric Johnson, D.F. (2009).
10. Supply chain management framework guide. Production and operations management. (2018). Agility in problem solving: A social engineering approach. Risk Hazards and Crises in Public Policy, 132-150.
11. Integration of UNHCR's emergency and ongoing operations. Science Direct, 57-72. Managing the business logistics system in the context of international business TEM Magazine, 6.
12. Ross, D. F. (2015). Product management. In D.F. Ross, Distribution Planning and Control (p. XXV, 915). New York: Springer, NY. (2010).
13. Horizontal collaboration in disaster logistics: benefits and barriers. International Journal of Physical Distribution and Logistics Management. E. (2012).
14. Humanitarian logistics: pre-purchase and pre-positioning of aid supplies. Journal of Global Logistics, 447-662. Shevishak, O.B. (1993).
15. Deterministic approach to service center inventory management. IB Transactions, 98-104. Product performance measurement: A literature review.
16. International Journal of Production Research, 5524-5544. (2014).
17. Humanitarian logistics. The latest trends in information technology, optimization, delivery and production. (2021).
18. World Health Organization research methods for health emergencies and disaster risk management. Kobe, Japan: World Health Organization Health Promotion Center (WKC). (2018). Integrating the location-inventory-route humanitarian supply chain network takes into account pre- and post-disaster management. Socioeconomic Planning Sciences, 21-37.
19. Transportation for the preparation of equipment that will support the soldier during the summer program. Military Logistics, 105-119.

Emergent Responsive Disaster Management at Workplaces for Employees with Respiratory-Distresses

Mohd. Faisal Nawaz

Abstract

This article explores the critical importance of enhancing workplace disaster preparedness for employees with respiratory conditions. It advocates for inclusive policies, proactive planning, and robust support systems to ensure the safety and well-being of all employees. Drawing from global guidelines and real-world case studies, this article serves as a comprehensive guide for stakeholders in bolstering workplace resilience.

Keywords : *RPWD Act, Disaster Management, Medical Emergency, Inclusive Workplace, Human Rights*

1. Introduction

In today's dynamic workplace landscape, disasters, whether natural or man-made, pose significant threats to individuals and communities worldwide. Among the most vulnerable groups disproportionately affected by these adversities are individuals with disabilities, particularly those grappling with respiratory conditions. Despite notable advancements in disaster management practices, there remains a glaring gap in adequately addressing the unique needs of these individuals. This article embarks on an exhaustive exploration of the multifaceted dimensions of disaster preparedness in workplaces, shedding light on the urgent imperative to mitigate risks and enhance support mechanisms for employees with respiratory distress.

2. The Importance of Inclusive Disaster Management

At the core of effective disaster management lies the principle of inclusivity. International frameworks, such as the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD), underscore the significance of inclusive disaster risk reduction strategies. Similarly, India's Rights of Persons with Disabilities Act (2016) reinforces the call for the rights and inclusion of persons with disabilities in all spheres of life, including disaster

management. However, translating these principles into actionable strategies necessitates concerted efforts to dismantle barriers and ensure meaningful participation and protection for individuals with respiratory distress.

2. Building a Resilient Workforce

The foundation of workplace resilience rests upon proactive measures designed to safeguard the safety and well-being of employees during emergencies. This encompasses the development of comprehensive emergency response plans, the implementation of regular drills and training exercises, and the cultivation of a culture of preparedness among employees. Central to these endeavors is the recognition of diverse needs, including those of employees with respiratory conditions, and the provision of tailored support and accommodations to ensure their inclusion and safety.

3. Mitigating Risks and Ensuring Timely Intervention

During disasters, respiratory distress presents a critical threat to health and safety. Rapid identification, access to medical support, and effective communication are paramount for risk mitigation and timely intervention. Adequate preparedness, including tailored emergency response plans, is essential to safeguard vulnerable individuals and minimize the impact of disasters on respiratory health. Developing a strategy requires assessing various elements, such as the administrator's authority level. Key inquiries include:

- What resources are available?
- Whom should we contact?
- How extensive should our actions be?
- What risks must we mitigate?
- And what weaknesses does our organization face?

4. Leveraging CCTV Technology for Workplace Health Emergencies, Particularly for Vulnerable Employees

CCTV technology stands as a cornerstone in managing workplace health crises, notably for employees with respiratory vulnerabilities. These cameras provide real-time surveillance, swiftly detecting any signs of distress or medical emergencies among staff. By triggering automated alert systems, they ensure immediate notification of management and emergency responders, crucial for prompt intervention in cases of respiratory distress. Moreover, CCTV footage serves as invaluable documentation, aiding post-incident analysis and regulatory compliance. Its presence fosters heightened

situational awareness among employees, encouraging adherence to safety protocols and facilitating swift responses. Integrated into emergency response protocols, CCTV surveillance strengthens workplace preparedness, ensuring effective management of health emergencies and the safeguarding of all employees, including those with respiratory conditions.

5. Creating an Inclusive Workplace Environment

An inclusive workplace environment serves as the cornerstone for supporting employees with respiratory conditions. This entails ensuring physical accessibility, providing assistive technologies, and fostering awareness and understanding among colleagues. Employers should prioritize the health and well-being of all employees, cultivating an environment characterized by mutual respect, empathy, and support.

6. Supporting Remote Work Options

In response to the evolving nature of work, employers must embrace alternative options to accommodate employees with respiratory distress. Flexible work-from-home policies offer a viable solution, providing a safe and accessible environment for these individuals while ensuring business continuity. Employers should invest in robust technology infrastructure, establish clear communication channels, and provide unwavering support to facilitate effective remote work arrangements.

7. Addressing Emotional and Financial Needs

Beyond medical support, addressing the emotional and financial needs of employees with respiratory distress is paramount. Employers should proactively offer counseling services, mental health resources, and financial assistance programs to alleviate stress and financial burdens. By fostering a supportive and inclusive workplace culture, employers can boost employee morale, enhance productivity, and promote overall well-being.

8. Case Studies and Practical Insights

Real-world examples and best practices serve as guiding beacons, offering invaluable insights into effective disaster management strategies for employees with respiratory distress. Case studies spotlighting successful interventions, collaborative initiatives, and lessons learned provide practical guidance for employers and policymakers striving to bolster workplace preparedness and resilience. In this case study, we encounter a scenario where an employee with a locomotor disability experiences a medical emergency, highlighting the critical importance of effective disaster management protocols in the workplace, especially for individuals with pre-

existing health conditions. Let's delve deeper into each stage of the disaster and the key learnings derived from it:

Stage 1: Immediate Response:

- **Target Areas include:**
  - *What is your plan of action?*
  - *What is your communication plan?*

As the Head of the Department, upon receiving the distressing message, your primary concern is the well-being of your colleague. Your prompt action involves rushing to the location to assess the situation first-hand. This demonstrates the crucial role of leadership in emergency situations, emphasizing the need for swift and decisive action to ensure the safety of employees.

Stage 2: Assessment and Resource Mobilization

- **Target Areas include:**
  - What type of resources will you need at this point in the rescue process?
  - What is your communication plan?

Upon arrival at the scene, it becomes apparent that urgent medical attention is required. However, the workplace dispensary lacks the necessary resources, such as oxygen cylinders and masks / nasal canula, oximeters etc. to address the severity of the situation. This underscores the importance of having comprehensive medical facilities within the workplace, equipped with essential medical equipment and supplies to handle medical emergencies effectively.

In response to the resource constraints at the dispensary, you initiate immediate transportation to a hospital with adequate medical facilities. This highlights the significance of having well-defined protocols for escalating emergencies beyond the workplace capabilities, ensuring that employees receive timely and appropriate medical care. Family members would also be informed to provide moral support to the employee, and regular updates would be provided until the employee's family arrives

9. Key Learnings

1. ***Comprehensive Medical Facilities:*** Workplace medical facilities should be equipped with a wide range of medical equipment and supplies to cater to the diverse needs of employees. This includes ensuring the

availability of oxygen cylinders, BiPAP machines, nebulizers, oximeters, and other essential supplies to address various medical emergencies.

2. ***Equipment Maintenance:*** Regular maintenance and calibration of medical instruments are essential to ensure their functionality during emergencies. Employers should prioritize the upkeep of medical equipment to minimize the risk of equipment failure and ensure timely medical assistance for employees in need.

3. ***Medical Records Accessibility:*** Access to employee health records, including medical history and relevant health information, is crucial for informed medical interventions during emergencies. Employers should ensure that employee health records are readily available in workplace medical facilities to facilitate prompt and tailored medical care.

4. ***Emergency Response Protocols:*** Clear communication channels and established protocols are essential for effective emergency response. Employers should have robust protocols in place for escalating emergencies beyond the workplace's capabilities, including arrangements for transporting employees to suitable medical facilities.

5. ***Role of CCTV:*** CCTV surveillance systems play a crucial role in monitoring workplace safety and security, including during medical emergencies. By strategically placing CCTV cameras in key areas, employers can enhance situational awareness, facilitate rapid response, and ensure employee safety.

6. ***Employee Support Networks:*** In emergencies, involving family members or designated caregivers can provide crucial emotional support to affected employees. Employers should prioritize regular updates and communication with both the employee and their family to ensure transparency and alleviate concerns during challenging situations.

7. ***Work from Home Options:*** Flexible work-from-home policies can provide a safe and accessible environment for employees with respiratory distress or other medical conditions. Employers should consider implementing such policies to ensure business continuity while prioritizing employee well-being.

8. ***Financial Support:*** Beyond medical assistance, providing financial support such as covering medical expenses or offering paid leave can alleviate stress and financial burdens for employees facing medical

emergencies. Employers should explore options for providing financial support to employees in need, demonstrating a commitment to their well-being.

10. Conclusion

Effective disaster management in workplaces necessitates a holistic and inclusive approach that meticulously addresses the specific needs of employees with respiratory distress. By prioritizing proactive planning, supportive policies, and robust support systems, employers can fortify workplace resilience and ensure the safety and well-being of all employees. Through collaborative efforts and steadfast commitment to continuous improvement, we can forge a more inclusive and resilient workforce adept at navigating emergencies and crises with unwavering resolve.

References

1. United Nations. "Disability-Inclusive Disaster Risk Reduction and Emergency Situations."
2. United Nations General Assembly. "Convention on the Rights of Persons with Disabilities; Sixty-first session of the General Assembly by resolution A/RES/61/106."
3. Government of India. "National Policy for Person with Disabilities 2022."
4. Government of India. "Rights for Person with Disabilities Act 2016."
5. Thompson Reuters. "Emergency Preparedness."
6. Valcik, Nicolas A., and Paul E. Tracy. "Case Studies in Disaster Response and Emergency Management."
7. Rodríguez, Havidán, Enrico L. Quarantelli, and Russell R. Dynes. "Handbook of Disaster Research."
8. Sorensen, John H. "Hazard warning systems: review of 20 years of progress." Natural Hazards Review, May 2000.

Flood Preparedness Scorecard: An Initiative to Tackle and Minimise the Vulnerability of Flood in Bihar

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Abstract

Since time immemorial, floods have been one of the most devastating and recurring natural disasters in Bihar. The Bihar Disaster Risk Reduction Roadmap indicates that 29 of the total 38 districts in the state are prone to floods. The catastrophic floods endanger lives and cause human tragedy as well as heavy economic losses. The changing scenario – both familiar and unfamiliar risks – requires an integrated and innovative approach to reduce flood risk, build resilience and achieve sustainable development in Bihar. This article aims to analyse an applied action research implemented by the Disaster Management Department, Government of Bihar, to tackle the vulnerability of flood. Though floods are natural phenomena, their severity and impacts could be reduced and limited through adequate preparedness and risk management approaches. The paper examines the process of formulating the Flood Preparedness Scorecard (FPS) for multi-stakeholder innovative planning and coordination. Finally, the article offers a distinct opportunity and practical approach to share and transfer the knowledge to enhance the capability to deal with floods and their cascading impact on lives and livelihood for sustainable development.

Keywords: *Flood Preparedness Scorecard, Risk Management, Planning and Coordination, Innovation Platform, Sustainable Development.*

1. Introduction

Flood is one of the most devastating and recurring natural disasters, irrespective of the state of human development and natural conditions (Novita Sari et al., 2013) in Bihar (DMD, 2014) (CoEDM, 2021) (Singh et al., 2023). It impacts the physical, economic, social, geographical, psychological, and cultural spheres of human endeavour in society (Agbola et al., 2013). The Bihar Disaster Management Plan (DMD, 2014) indicates that 29 of the total 38 districts in the state are prone to floods, and areas in south Bihar that were historically not flood-prone have also started experiencing flooding

in recent years due to various natural and human factors. The catastrophic floods endanger lives and cause human tragedy as well as heavy economic losses in north Bihar (DMD, 2014). In addition to economic and social damage, floods can have severe environmental consequences as well. In the changing scenario – both familiar and unfamiliar risks – requires integrated and innovative ways to reduce disaster risk, build resilience and achieve sustainable development.

Prior to the disaster, preparedness planning and coordination for community-level disaster risk resilience have become a significant policy objective for many governments (Adekola et al., 2020) (Chandler, 2014) (Ntontis et al., 2019) for several reasons. First, there is a paradigm shift towards "prevention is better than cure", and community-based disaster risk management is also gaining ground, which follows from recognising the need to empower members of local communities in the disaster risk assessment process to extend support and increase local ownership of risk (Maskrey, 2011). Second, the international agreements to prevent or reduce disaster risks at various level has increasingly shaped national and regional guidance and principles. The Sendai Framework for Disaster Risk Reduction 2015–2030, adopted in March 2015 by the United Nations, also emphasises the preparedness to tackle natural and man-made disasters. The Sendai Framework aims to reduce the consequences of disaster risks, including their impact on lives, livelihoods and infrastructure. Bihar Disaster Risk Reduction Roadmap (2005) also considers that the disaster management cycle must focus on preparedness and multi-stakeholder planning.

After implementing the Bihar Disaster Risk Reduction Roadmap, the Disaster Management Department, Bihar shifted attention from managing ''disaster'' to managing ''risk'' and emphasised learning from the effects of past hazardous events. According to the UNDRR, this represents a fundamental step in disaster risk prevention. Furthermore, factors such as climate change, increased urbanisation, poverty, conflict, and globalisation continue to expose a significant number of people to disaster-prone areas (Kelman, 2019). The costs of disasters to governments and citizens have the potential to multiply and grow, which ultimately have cascading and ripple impacts on lives and livelihoods.

Though floods are natural phenomena, however, their severity and impacts could be reduced and limited through adequate preparedness and risk management approaches. The Disaster Management Department, Government of Bihar, considers that a business-as-usual approach will not lead to change. Recognising the importance of flood preparedness, the department has launched a web portal to provide a holistic overview of

flood preparedness at the district and block levels. Considering flood as a frequent flyer and its multi-pronged impact on the lives of affected people, animals, and the resources of surrounding peripheral areas in Bihar, the Disaster Management Department decided to prepare a flood calendar and Flood Preparedness Scorecard (FPS) to understand better the preparedness level of flood affected districts and blocks prior to the flood.

The Flood Preparedness Scorecard (FPS) is a web portal intended to provide a holistic overview of the preparedness level of flood-prone districts and blocks in Bihar. The objective of this Flood Preparedness Scorecard (FPS) is to establish and standardise minimum preparedness standards (MPS) and actions for flood governance and management in Bihar. It will develop an online simplified system of scoring the preparedness level of districts and blocks to track flood preparedness status prior to the flood. Furthermore, it will enable an ecosystem to analyse and understand areas of improvement and support required for flood-affected districts and blocks for progressively improving flood preparedness at the grassroots level. The stakeholders (policymakers, planners, implementation authorities, researchers, academicians and CBOs) can build perspective to manage extreme flood events and their adverse impacts on people, properties and livelihood.

The article examines the entire process of formulation of the Flood Preparedness Scorecard by the Disaster Management Department, Government of Bihar. Further, it will create an ecosystem to develop a multi-stakeholder innovative planning and coordination approach and provide a platform to bring together all concerned departments who have a tryst with the flood. Finally, the article offers a distinct opportunity and practical approach to share and transfer the knowledge to enhance the capability to deal with floods and their cascading impact on lives and livelihood.

2. Methodology

The current article is based on applied research implemented by the Disaster Management Department, Government of Bihar. A rigorous process has been followed to prepare the flood Preparedness Scorecard (FPS). The conceptual framework was initiated with a workshop implemented by the Centre of Excellence in Disaster Management (CoEDM), Patna. To capture the rich and diverse expertise of stakeholders, an experience-sharing workshop was planned on April 15 2021 in Patna, Bihar. However, due to the COVID outbreak and under the preventive protocols issued by the Government of Bihar, the workshop couldn't be organised in physical mode. Hence, on June 29, 2021, the Centre of Excellence in Disaster Management (CoEDM) at the Development Management Institute (DMI) organised a workshop on "Experience Sharing for Flood Risk Reduction in Bihar" online mode.

On the basis of experiences and learning gained from the workshop, in June 2022, at an inception meeting with senior officials of DMD, CoEDM, UNICEF and NIC, the Secretary of the Disaster Management Department decided to develop a web-based portal to have a holistic overview of flood-affected districts and blocks and their preparedness level at the grassroots level to better manage the shocks and reduce the vulnerability of flood in Bihar.

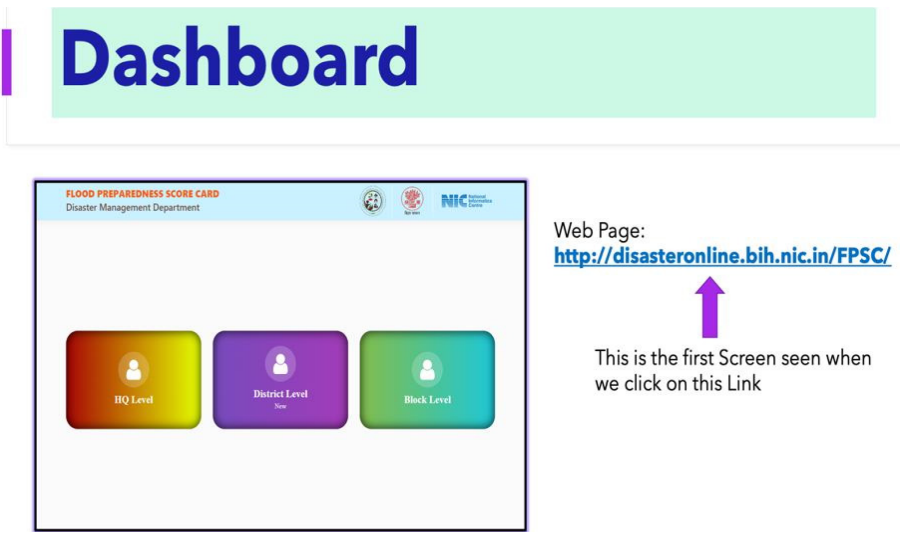


Figure 1: Flood Preparedness Scorecard Dashboard

The current paper is based on three strategies: desk study, preparation of a web-based FPS portal and gathering the required data from flood-affected districts and blocks. The desk study helped in reviewing theories, views of different authors, information on the subject matter and key concepts related to the flood. Furthermore, the desk study provided insight to identify the indicators and variables which is highly correlated with flood intensity and its negative impact. After a rigorous review of the literature on flood and its impact on society, the team members decided to identify the indicators and variables for the study. In the initial phase of the study, overall, 16 indicators and 76 variables were identified to capture the district-level flood preparedness measures being adopted to tackle the emergency during the flood period. However, after the trial of the web-based portal, it was decided that district, as well as block level preparedness level scorecards, would be more convenient to identify the preparedness level at the grassroots level. In this case, district (7) and block (13) level indicators have been separately selected for the study. Finally, 32 district-level variables and 53 block-level variables have been identified for the flood preparedness web portal, and each variable carries one point. On the basis of the score obtained by

the districts and blocks, the system separately generates a preparedness scorecard for flood-affected districts and blocks.

After the inception meeting and initial discussions, literature reviews, finalisation of indicators and variables, and several round discussions with team members, the National Informatic Centre (NIC) prepared a web-based, user-friendly portal. To gather the information from the district and Block, the responsible officials invited web-based training, and finally, the user name and password were shared for each.

3. Result and Discussion

3.1 Vulnerability Context: Flood Situation in Bihar: Bihar is a land-locked state demarcated by the river Ganges into north and south and further divided into regional blocks by rivers flowing down from the Himalayas and the Chhotanagpur Plateau to find repose in the Gange (DMD, 2014). The Northern Gangetic plain of Bihar is the courtyard of rivers flowing from the Himalayas, like the Ghaghara, the Gandak, the Burhi Gandak, the Bagmati, the Kamla, the Kosi and the Mahananda. The Southern Gangetic plain is the backyard to the rivers that descend the Chotangapur Plateau, like the Karmansa, the Sone, the Punpun, the Phalgu, the Kiul and the Sakri. Altogether, more than a dozen major rivers flow through the state, dividing it into seven "geo-cultural zones" (Table 1).

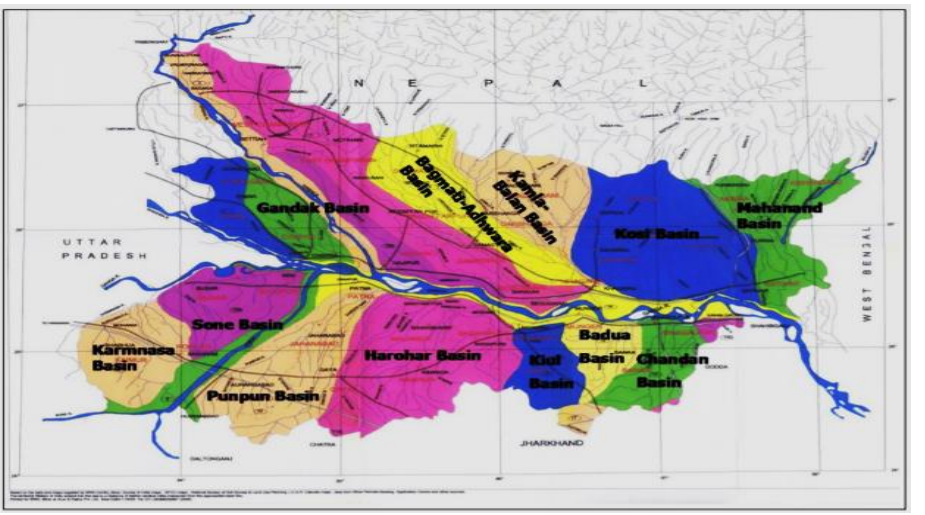
The rivers like Ghaghra, Gandak, Burhi Gandak, Bagmati, Kamla, Adhwara group of rivers, Kosi and Mahanada originate from the Himalayas, and a considerable portion of their catchment falls in the glacial regions in Nepal and Tibet.

Among the flood-affected districts - Sitamarhi, Supaul and Kishanganj are 90% affected; five districts- Bhagalpur, Darbhanga, Khagaria, Madhepura, and Saharsa, get around 70% affected, and the rest of the districts vary from 55% to 25%. These floods destroy thousands of human lives apart from assets and livestock worth millions on an annual basis.

Table 1: Seven River Zones in Bihar

Sl. No	River Zones	Districts
1.	Ghaghara-Gandak	East and West Champarans, Gopalganj, Siwan and Saran
2.	Gandak-Bagmati	Sheohar, Sitamarhi, Muzaffarpur, Vaishali, Samastipur & Begusarai
3.	Bagmati-Kosi	Darbhanga, Madhubani Supaul, Saharsa & Khagaria

Sl. No	River Zones	Districts
4.	Kosi-Mahananda	Madhepura, Araria, Purnia, Kishanganj and Katihar
5.	Karmnasa—Sone	Buxar, Kaimur, Bhojpur and Rohtas
6.	Sone—Punpun	Patna,Jehanabad,Arwal,Gaya,Nalanda,Aurangabad and Nawada
7.	Punpun-Sakri	Sheikpura, Lakhisarai, Jamui, Banka, Munger and Bhagalpur



Source: Bihar Disaster Management Plan 2014.

Figure 2: River basins in Bihar

For nearly five months, the state suffered through the ravages of flood. Along with Ganga and Kosi, other major rivers, like Son, Saryu, Gandak, Budhi Gandak, Bagmati, etc., get flooded during the monsoon months and affect the surrounding areas.

Most of the rivers mentioned above are snow-fed and perennial in flow, and positioned to receive very copious rainfall during monsoon when the discharge of these rivers is 50 to 90 times larger than fair weather flow in the region (Sinha et al., 2012). This causes frequent and large-scale flooding in North Bihar. As such, 73.63 per cent of the geographical area of North Bihar is considered to be prone to floods.

The empirical evidence indicates that the geographical location and

topography of the state, along with other socio-economic factors, create an ecosystem which is highly vulnerable for lives and livelihood in the state. Trend analysis also indicates that, more or less every year, floods create shocks in the state, particularly in the rainy season. In addition to economic and social damage, floods can have severe environmental consequences as well. Due to the impact of climate change, the coming years are likely to see higher flood risks and greater economic damages in the state. Furthermore, in recent years, the emerging trends in floods and their cascading impact have aggravated the community-level vulnerabilities and associated challenges. In the changing scenario – both familiar and unfamiliar risks – requires integrated and innovative ways to reduce disaster risk, build resilience and achieve sustainable development.

3.2 Indicators for Flood Preparedness Scorecard: Flood preparedness planning is about putting in place a set of appropriate arrangements in advance for an effective response to floods (Alam & Muzzammil, 2011). Some of the commonly identified flood preparedness activities are Public awareness raising on flood preparedness, response and mitigation measures; Stockpiling of emergency relief materials, i.e., food, fodder for livestock, emergency medicines, materials for temporary shelter etc; Installation of community-based early warning system for issuance of timely and effective flood warnings; Management of safe areas for temporary removal of people and property from a threatened location; transportation to safe areas/ evacuation centre; Ensuring access to health and sanitation facilities;

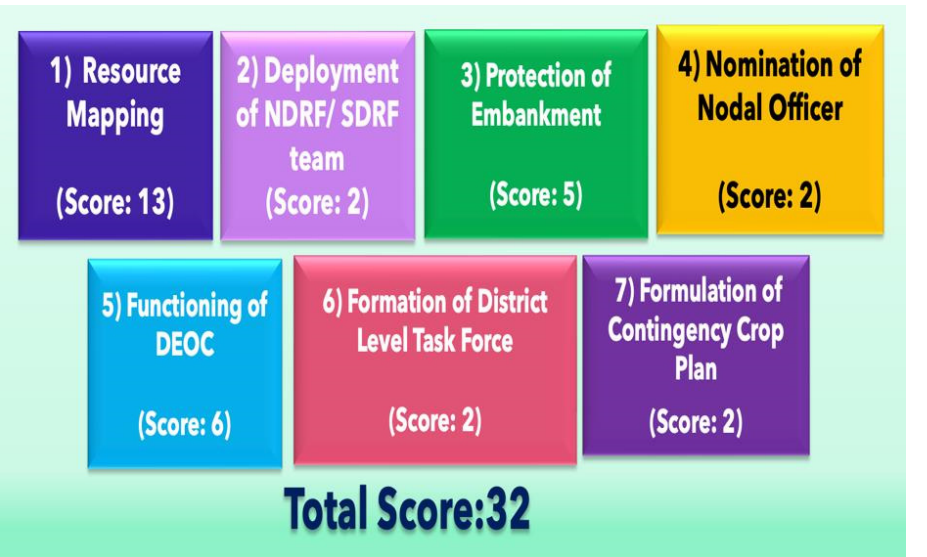


Figure 3: FPS District Level Indicators and Variables

Conducting drills and rehearsals (Alam & Muzzammil, 2011) (Asian Disaster Preparedness Center, 2009).

In Bihar, several stakeholders are responsible for managing flood risks and improving community resilience. They include government authorities, private and non-governmental organisations, and at-risk communities. Such multi-stakeholder approaches, enshrined in international frameworks, recognise that only some agencies have all the necessary power, expertise, resources, and structure to address the challenge of reducing new or existing disaster risks (Hickman, 2018).

In the initial phase, overall, 16 indicators were identified; however, considering the differences in priorities and requirements of districts and blocks, seven district-level indicators (Figure 2) and 13 block-level indicators were finally selected for the scorecard. The selected district-level indicators are:

a) Resource mapping
b) Deployment of NDRF/ SDRF,
c) Protection of embankment
d) Nomination of nodal officer
e) Functioning of DEOC
f) Formulation of district-level task force, and
g) Formulation of contingency crop plan.

As an administrative unit, the Block is crucial in managing the flood at the grassroots level. In the process of capturing entire facets of block-level flood preparedness, the following indicators have been selected:

1. Functionality and use of rain gauge machines,
2. Identification and mapping of vulnerable groups and the areas likely to be affected by floods Resource mapping
3. Formulation of search, rescue and relief operation teams
4. Identification of flood relief centres/community kitchens
5. Deputation of regional supervisors
6. Repair of roads
7. Nomination of nodal officer
8. Functioning of control room
9. Contingency plan for deploying boats/life jackets/motor boats
10. Formulation of Block level task force

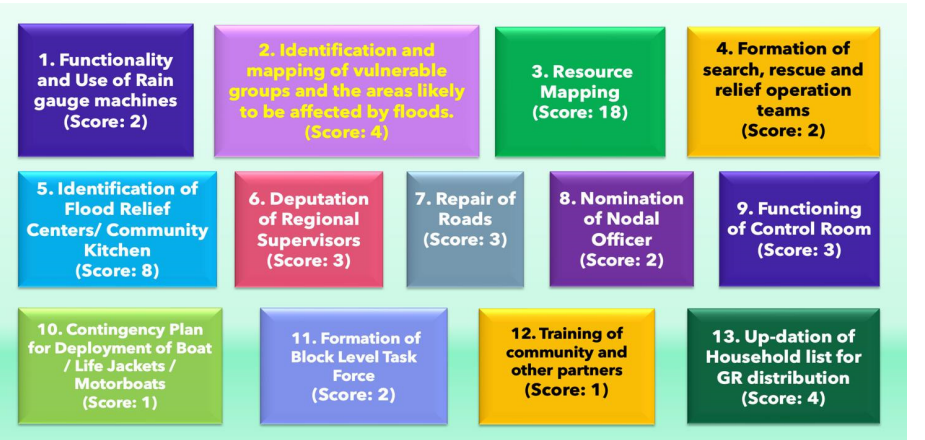


Figure 4: *FPS Block Level Indicators*

11. Training of community and other partners; and
12. Updation of the household list for GR distribution.

3.3 Flood Preparedness Score Count: Flood Preparedness Scorecard enables the find and examine district and block level data and monitor data quality over time. A scorecard tool would allow automated scoring and weighting of flood preparedness-related elements. The process will showcase district and block-level flood preparedness data, define the weighting, enter the measure values, and watch the scorecard "colour-up." Scorecards provide calculated scores and graphic displays that represent the quality of your source data. A scorecard consists of the calculated scores for the district and block-level variables.

District-level 32 variables have been adopted for this study. The indicators variables[7] are:

1. Resource mapping (13)
2. Deployment of NDRF / SDRF (2),
3. Protection of embankment (5),
4. Nomination of nodal officer (2),
5. Functioning of DEOC (6),
6. Formulation of district-level task force (2) and
7. Formulation of contingency crop plan (2) (Figure 2).

Similarly, block level indicators, the following variables have been selected:

1. Functionality and use of rain gauge machines [(2)],
2. Identification and mapping of vulnerable groups and the areas likely to be affected by floods [(4)],
3. Resource mapping [(18)],
4. Formulation of search, rescue and relief operation teams [(2),]
5. Identification of flood relief centres/community kitchen [(8)],
6. Deputation of regional supervisors [(3)],
7. Repair of roads [(3),]
8. Nomination of nodal officer [(2)],
9. Functioning of the control room [(3)],
10. Contingency plan for deploying boats/life jackets/motor boats [(1)],
11. Formulation of Block level task force [(2)],
12. Training of community and other partners [(1)], and
13. Updation of the household list for GR distribution [(4)] (Figure 3).

Table 2: FPS Categorisation and Colour

Range	Category	Colour
0 -35 %	Below Average	Red
35-70%	Average	Orange
70 – 90%	Good	Yellow
Above 90%	Excellent	Green

The number in parenthesis indicates variables for the particular indicators[7]

Further, each variable has been formulated into the question form and contains an equal weightage of 1.00 points. The state-level responsible officials share the login and password with the district and level nodal/ authorised officials to fill in the questions and the data. After filling up the questions, the system will auto-calculate the score and categorise the districts and blocks into four groups – excellent, good, and average and below average.

The first group of districts/blocks who scored above 90 percent will fall into the "Excellent" category and reflect with green colour. The second group of districts/blocks who scored between 70-90 percent will fall under the "Good " category and reflect with yellow colour. Similarly, the third group of the districts/blocks who scored between 35-70 percent will fall under the "Average" category and reflect with orange colour. Finally, the fourth group of the districts/blocks who scored below 35 percent are considered "Below Average" and represented with Red colour (Table 2).

4. Conclusion

As a concluding remark, it can be said that floods are natural phenomena. However, their severity and impacts could be reduced and limited through adequate preparedness and risk management approaches. This applied action-based research implemented by the Disaster Management Department, Government of Bihar, provides an innovative tool to senior officials who are involved in policy-level decisions in the state. Additionally, easy access to the web portal offers a holistic overview of the preparedness level of flood-prone districts and blocks in Bihar. Further, the Flood Preparedness Scorecard (FPS) standardises minimum preparedness standards (MPS) and actions for flood governance and management. It can motivate and energise the officials who are responsible for the implementation of policy-level decisions in flood-affected regions. It develops an online simplified system of scoring the preparedness level of districts and blocks to track flood preparedness status prior to the flood.

Finally, it will enable an ecosystem to analyse and understand areas of improvement and support required for flood-affected districts and blocks for progressively improving flood governance and management at the grassroots level. In addition, the other stakeholders - planners, implementation authorities, researchers, academicians and CBOs) - can build perspective to manage extreme flood events and their adverse cascading impacts on people, properties and livelihood for sustainable and inclusive development.

References

1. Alam
1. Adekola, J., Fischabcher-Smith, D., & Fischabcher-Smith, M. (2020). Inherent Complexities of a Multi-stakeholder Approach to Building Community Resilience. *International Journal of Disaster Risk Science*, *11*(1), 32–45. https://doi.org/10.1007/s13753-020-00246-1
2. Agbola, B. S., Ajayi, O., Taiwo, O. J., & Wahab, B. W. (2013). *The August 2011 Flood in Ibadan , Nigeria : Anthropogenic Causes and Consequences. August 2011*. https://doi.org/10.1007/s13753-012-0021-3
3. Alam, J., & Muzzammil, M. (2011). Flood Disaster Preparedness in Indian Scenario. *International Journal on Recent Trends in Engineering & Technology*, *April 2011*, 33–38. https://www.researchgate.net/publication/280082664_Flood_Disaster_Preparedness_in_Indian_Scenario
4. Asian Disaster Preparedness Center. (2009). *Manual on Flood Preparedness Program for Provincial and District Level Authorities in the Lower Mekong Basin Countries*. 104.

5. Bosher, L., Dainty, A., Carrillo, P., Glass, J., & Price, A. (2009). Attaining improved resilience to floods: A proactive multi-stakeholder approach. *Disaster Prevention and Management: An International Journal*, *18*(1), 9–22. https://doi.org/10.1108/09653560910938501
6. Chandler, D. (2014). Beyond neoliberalism: Resilience, the new art of governing complexity. *Resilience*, *2*(1), 47–63.
7. CoEDM. (2021). *Multi Stakeholder, Action Oriented Report on Flood Risk Reduction (FRR) in Bihar*. Centre of Excellence in Disaster Management, Patna, Bihar
8. DMD. (2014). *Government of Bihar Disaster Management Plan*. Disaster Management Department. Government of Bihar.
9. Hickman, P. (2018). A Flawed Construct? Understanding and Unpicking the Concept of Resilience in the Context of Economic Hardship. *Social Policy and Society*, *17*(3), 409–424. https://doi.org/https://doi.org/10.1017/S1474746417000227
10. Kelman, I. (2019). Axioms and actions for preventing disasters. *Progress in Disaster Science*, *2*, 4–6. https://doi.org/10.1016/j.pdisas.2019.100008
11. Maskrey, A. (2011). Revisiting community-based disaster risk management. *Environmental Hazards*, *10*(1), 42–52. https://doi.org/10.3763/ehaz.2011.0005
12. Novita Sari, A., Susilo, A., & Susilo, E. (2013). The role of stakeholders in flood management: study at Ponorogo, Indonesia. *The International Journal of Engineering And Science*, *2*(10), 1–10. www.theijes.com
13. Ntontis, E., Drury, J., Amlôt, R., Rubin, G. J., & Williams, R. (2019). Community resilience and flooding in UK guidance: A critical review of concepts, definitions, and implications. *Journal of Contingencies and Crisis Management*, *27*(1), 2–13. https://doi.org/10.1111/1468-5973.12223
14. Singh, Vivek Kumar, Geetanjali Kumari, Amrita Dhiman, and Amritanjali Kumari (2022), *Multi-Stakeholder Planning and Coordination for Flood Risk Reduction in Bihar*, Book Chapter 6, in Babu, S.A. (Ed.). 5th World Congress on Disaster Management: Volume II (1st ed.). Routledge. https://doi.org/10.4324/9781003341932
15. Sinha, R., Burton, M., & Tiwari, G. (2012). *Strengthening the institutional framework for flood and water resources management in Bihar: Developing a strategy for reform (Phase I). September*, 51. http://www.waterwoes.iitk.ac.in/Pdf/Sinha et al 2012_PhaseI.pdf

Centre for Disaster Management

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