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Agromet Advisories to Mitigate the Effects of Aberrant Weather in Himachal Pradesh

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Abstract:- Weather is a pivotal factor in agricultural production, influencing crop growth, disease and pest occurrences, water and fertilizer needs, and the effectiveness of cultural and preventive measures. Extreme weather events can cause physiological stress, physical damage, soil erosion, and crop quality degradation. In India, agriculture's vulnerability to adverse weather is a significant concern, with natural disasters like floods, droughts, and cyclones leading to crop failure, food insecurity, and economic impacts. To mitigate these challenges, Agrometeorological Advisory Services (AAS) play a crucial role in providing farmers with weather-based advisories to manage agricultural risks. The Integrated Agro-Meteorological Advisory Service (IAAS), run by the Indian Ministry of Earth Sciences and the India Meteorological Department (IMD), offers district-level weather forecasts and agromet advisories to support farmers in adapting to weather fluctuations. These advisories cover various weather-related risks, including cold injury and frost, high temperatures, wind damage, hailstorms, and floods. Sample advisories suggest measures like irrigation for frost protection, mulching to reduce heat stress, and shelter belts to mitigate wind damage. Effective dissemination of advisories involves communication through electronic media, Krishi Vigyan Kendras (Agriculture Science Centres), and Kisan (Farmer) Call Centres. Thrust areas for enhancing AAS include improved scientific understanding, advanced monitoring and prediction of severe weather events, satellite-based communication technologies, and real-time forecasting. By integrating these strategies, farmers can better prepare for extreme weather and mitigate its impact on agriculture.

Keywords:- *Agrometeorology, Weather Extremes, Crop Protection, Agrometeorological Advisory Services, Early Warning System, Climate-Resilient Agriculture.*

I. INTRODUCTION

Weather plays a crucial role in agricultural production systems through its influence on the growth, development and productivity of a crop, it also affects the occurrence of diseases and pests, along with the water and fertilizer needs of crops, especially concerning nutrient mobilization during water stresses, as well as the promptness and efficiency of cultural and preventive measures on crops (Singh et al., 2015). Weather aberrations lead to (i) physiological under-performance of crop plants, (ii) physical damage to the crops, (iii) soil erosion and (iv) may render the agricultural inputs ineffective. Weather affects crop quality during their transport from field to market. Unfavorable conditions also affect the quality of crop produce when it remains indoors and is transported, and laying in the fields also affects the viability and vigor of seeds and planting material (Singh et al., 2021). In India, where agriculture holds paramount importance for its economy, growth is heavily contingent on the whims of weather, especially extreme conditions (Dube and Rao, 2015). Insufficient rainfall and the incidence of natural disasters like floods and droughts can lead to crop failure, food insecurity, famines, loss of life and property, mass migrations, and adverse effects on national economic prosperity (Sivakumar and Hansen, 2007). Agriculture is significantly impacted by extreme weather conditions and climatic abnormalities. Every year, weather phenomena such as heavy rains, cyclones, hailstorms, dry spells, drought, heat waves, cold waves, and frost cause significant crop yield losses (Sivakumar et al., 2005). Extreme occurrences can have both direct and indirect repercussions. People, their animals, and their possessions are directly impacted when events come into direct physical contact with them. Severe agrometeorological occurrences can have indirect effects or effects that are caused by them. When a severe event occurs, indirect repercussions frequently happen elsewhere or later on. The act of evacuating individuals in the case of a cyclone landfall, interrupting daily routines and recreational activities, stress-related illnesses, and anticipating and feeling anxious about potential severe occurrences like bushfires and floods are considered indirect impacts (Sivakumar et al., 2005). The appropriate use of available climatic resources, in addition to soil and water resources, reduces the negative impact of extreme weather while maximizing the benefits of favorable weather. Early warning systems for climate extremes give individuals and communities enough time to mitigate agricultural damage (Chandol et al., 2021). Early warning consists of two phases: prevention and readiness. Providing timely predictions and warnings of severe weather, excessive temperatures, floods, and droughts helps to prepare people (Ambenje 2000). Using improved meteorological and climatic data and forecasts, together with efficient early warning systems, contributes to the preparedness for extreme weather occurrences.

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➢ *Aberrant Weather Events in Agriculture in Himachal Pradesh:*

The most important of these weather events from the perspective of agriculture and livestock are (IPCC 2007):

- Floods, heavy rains during monsoons, water logging and landslides.
- Severe thunderstorms and hail storms.
- Heat waves and drought.
- Frost, low temperature, snow and cold spells.
- Weather-related fires (the lightning).

➢ *Occurrence of Aberrant Weather in Different Seasons:*

The majority of natural harms that are caused by weather

- Winter (Jan-Feb): Mist, a cool wave, frost and snow.
- Pre-Monsoon (Mar-May): Heat wave, Thunder storms and Hail storm
- Monsoon (Jun-Sep): Southwest monsoon Circulation, Torrential rains and floods
- Post-Monsoon (Oct-Dec): Western disturbances

The main responsibility of Advisory Services Agromet in mitigating the adverse effects of anomalous weather is to devise strategies and tactics for modifying crop cultivation plans and practices following the timing of those events (Chattopadhyay and Chandras, 2018). In India, the Ministry of Earth Sciences (MoES) and the India Meteorological Department (IMD) are working on the Integrated Agro-Meteorological Advisory Service (IAAS) at the district level, which represents a modest step towards managing agriculture according to the cycles of weather and climate fluctuations that are suitable for agricultural output. In order to reduce the negative impact of bad weather. Integrated Agromet Advisories scheme offers farmer a unique type of inputs in the shape of advisories which can greatly impact farm productivity (Chaubey et al., 2018).

➢ *Medium range Weather Forecast under AAS:*

As part of IAAS, IMD began providing quantitative district-level weather forecasts for up to five days on June 1, 2008. Rainfall, maximum and minimum temperatures, wind direction and speed, relative humidity, and cloudiness are the seven meterological parameters that have quantitative forecasts (Rathore et al., 2011 and Chaubey et al., 2018).

II. NATURE OF IMPACTS OF ABERRANT WEATHER AND ITS MITIGATION THROUGH AGROMET ADVISORY SERVICES

A. Cold Injury and Frost:

Consistent air temperatures and snow cover throughout the winter are critical in protecting crops from cold harm. Thaws, which contribute to the compaction and loss of snow cover, worsen dormancy conditions, and reduce or remove the protective characteristics of snow cover (Bedekar et al., 1974). To mitigate the stress that was caused by frost is that breaking up the inversion that accompanies intense nighttime radiation. This can be achieved through placing the oil burners near an agricultural farm to heat the air. Other methods to protect crops from frost include watering, brushing (putting a protective cover over the plant), and the use of windbreaks or shelterbelts (Sivakumar and Motha, 2008). Frost injury over long periods leads to losses in cool season crops and fruit crops. Also, frost injury is caused in the depth of plant roots and low soil temperature. Such a decrease in soil temperature occurs with strong frosts in the absence of snow cover when the soil is deeply frozen. Damage to a part of a plant does not always result in damage to the whole plant. Frost damage during the tillering node is a decisive factor; if it is serious, the whole plant will die. The most frequent damage caused by frost occurs in cool season crops grown on uplands, where there is less snow cover and the depth of soil freezing is more (Chattopadhyay and Lal, 2007). Low soil temperature at the tillering node depth is the primary agrometeorological factor causing frost damage in winter crops (Ji et al., 2021). The crops will be completely destroyed if they face intensive cooling and chilling for longer periods. During cold waves, it leads to slow growth, destruction of cell structure, desiccation, slow growth, and heavy snowfall that also causes damage to woody plants. Plant reproductive organs are also damaged by unseasonal frost (White and Haas, 1975).

➢ *Sample Advisory for Frost Injury*

- Apply irrigation to safeguard the crops, viz., apples, pear, and early-sown wheat from cold/frost injury.
- Arrange for smoking near the field to protect the crops.
- Farmers are advised to spray sulphuric acid or thiourea @ 0.1% or carbendazim at 0.05% on frost-sensitive crops (Anonymous, 2010).
- To protect the small fruit plants in the nursery from frost and cold winds cover the basin of plants with a polythene sheet (Anonymous, 2023).

B. High Temperature:

High temperature leads to a rise in evapotranspiration, induced sterility in some crops, poor vernalization, and the frequency of pests during the winter (Seneviratne et al.,2014). High temperatures at night lead to an increase in the loss of respiration. “Heat waves”, Long-term periods of unusually high temperatures are particularly dangerous.

➢ *Sample Advisory for Heat Injury*

- Since there hasn't been much rain for the past few weeks, farmers are recommended to irrigate their fields frequently to lower the canopy temperature. Dry weather is expected for the upcoming five days. The elevated temperatures may hinder plant growth and wheat yield (Chattopadhyay, 2013).
- Mulching is attainable between two rows of vegetable crops in the field to maintain moisture and reduce heat losses from the surface.

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C. Winds:

In dry climate zones, wind affects plant growth physiologically and mechanically. Plant tissues are damaged by the dust and sand particles that was carried by the wind. Emerging seedlings may be completely covered by strong winds. Winds also lead to lodging, breaking of stalks, shedding of grains, and ultimately a decrease in the yield. Physical damage occurs in plant parts or the whole plant (e.g. defoliation, particularly of shrubs and trees) because of soil erosion and high evaporation. Wind is the contributing factor in the event of bush or forest fires. Damage that happens during high winds is controlled with the use of shelter belts (windbreaks). To protect animals and crops there are man-made (e.g. walls, fences) and natural resources (e.g. trees, shrubs, or hedges). Strategically placed and well-designed shelterbelts play a very important role in stabilizing agriculture in areas where strong winds can lead to mechanical damage and severe moisture stress on crops. Windbreaks prevent the soil from eroding and improve the soil's moisture content.

➢ *Sample Advisory for Winds*

- Wind speed is greater than 20 knots and further will be greater than 34 knots, avoid applying fertilizer to the crop in particular districts (Ghosh, 2023).
- Apply the necessary fertilizer in the remaining state districts as the wind is calm.

D. Hailstorm:

Though hail impact is usually confined, the resulting damage to crops—especially during critical growth stages—and infrastructure can be remarkably major. Pest and disease incidence is followed when light hail happens. It is not possible for annual crops on large fields, but it is possible for perennials and cash crops such as orchards; a hail net may be used. (Bal et al.,2017).

➢ *Sample Advisory for Hailstorm*

- Cover the orchards with hail nets in Kangra, Chamba, Una, Hamirpur, Bilaspur, Solan, Mandi, and Shimla districts, as there is a higher chance of hailstorms in these districts (Prasad et al.,2018).
- Anti-hail mechanism should be introduced to diffuse hailstorms in all major fruit-growing areas of the State (Anonymous 2017).

E. Flood:

Prior to conditioning of a space is crucial to figure out how significant damage a flood can cause. Components pertaining to soil, vegetation, and water availability should be taken into account (Tomar, 2012). Compared to comparatively dry soils, saturated soils have a higher chance of producing a destructive flood before a catastrophic weather event. Soil erosion is considerably more likely to occur in fields that were just plowed and lack vegetation. The intensity and consequences of flooding can be lessened by vegetation that can absorb large amounts of water and that can function as a hindrance to moving water. Flood damage can be decreased using water storage devices that can collect and keep the majority of the incoming water. When using rain-fed agriculture, managers usually plan for enough rainfall to occur during the season of growth to irrigate crops either naturally or artificially. Retaining sufficient water for crop production typically requires striking a balance with environmental health (Sen and Chander, 2003). Crops like maize can adjust to such conditions, but rice is adaptable (Chattopadhyay, 2013).

➢ *Sample Advisory for Flood (Anonymous 2017)*

- Prepare, update, and implement flood management plans for susceptible municipalities in the state.
- Enforce flood management laws, rules, regulations, guidelines, manuals, and procedures.
- Implementing watershed management strategies, such as catchment area remediation and afforestation, can greatly reduce flood hazards.
- Early flood warnings can save lives by allowing for prompt escape from submergence areas.

III. DISSEMINATION OF AGROMETEOROLOGICAL ADVISORIES

Crucial components for successful dissemination are weather- and climate-sensitive agricultural decision-making, with effective outreach. The task of AAS is to provide beneficial information to farmers so they can make the best use of weather and climate. Establishing good working connections and communication with the agricultural extension, Krishi Vigyan Kendra (Agriculture Science Centres), Kisan (Farmer) Call Centre, etc. to encourage farming connections through participative approaches. Care must be given to the message's substance, which must be pertinent to the farmer's decision-making based on the weather. In order to create weather-based advisories and technological action, this entails identifying weather and climate-sensitive decisions and interacting between weather forecasters from meteorological centers and agriculture scientists from agriculture universities and/or Institutes of the Indian Council of Agriculture Research (Rathore et al., 2011). Under the IAAS system, information is distributed through various methods, such as electronic and mass media. Electronic communication via email and the internet (Web Pages), as well as interpersonal and group interactions via phone calls, emails, etc. (Rathore et al., 2011).

➢ *Thrust Areas*

For the management of extreme events through the Agromet Advisory Service includes:

- Advancement in scientific understanding,
- Enhancing the monitoring and prediction of severe weather-related incidents like heavy rain or snowfall in the data-deficient Himalayan region through the utilization of land, ocean, and space-based technologies.
- Improving the real-time forecasting of mesoscale catastrophic events like thunderstorms and hailstorms.

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- Developments of satellite-based communication technologies and
- Active initiation of Forecast Demonstration Projects on
- Cyclone,
- Thunderstorm,
- Fog a
- The Continental Tropical Convergence Zone (CTCZ) caused heavy rains in the monsoon season.
- Development of appropriate adaptation and mitigation measures to minimize the effect of severe weather on farming (Chattopadhyay et al., 2016)

IV. CONCLUSION

In summary, weather plays a critical role in agricultural systems, influencing crop growth, productivity, and quality. Extreme weather events such as floods, heatwaves, and frost can significantly impact agricultural production, leading to crop damage, food insecurity, and economic losses. To mitigate these impacts, the implementation of effective early warning systems and agrometeorological advisory services is crucial. These services help farmers adapt their practices to weather conditions and make informed decisions to protect their crops. In India, where agriculture is a key component of the economy, the India Meteorological Department (IMD) has established the Integrated Agro-Meteorological Advisory Service (IAAS) at the district level to provide weather forecasts and guidance to farmers. The IAAS plays a vital role in helping farmers plan for extreme weather events and adopt appropriate mitigation measures. Sample advisories for various weather-related threats offer practical solutions for farmers to protect their crops from frost, high temperatures, winds, hailstorms, and floods. These advisories recommend measures such as irrigation, mulching, shelterbelts, and early warning systems to minimize damage and maximize productivity. Going forward, there is a need for continued advancements in weather forecasting, real-time monitoring of extreme events, and improved communication with farmers to ensure effective dissemination of advisories. By enhancing our understanding of weather patterns and adopting innovative mitigation strategies, we can strengthen the resilience of agricultural systems in the face of climate change and extreme weather events.

REFERENCES

[1]. Agarwal PK, Sinha SK. 1993. Effect of probable increase in carbon dioxide and temperature on productivity of wheat in India. *Journal of Agricultural Meteorology* 48: 811814.

[2]. Agarwal PK. 2002. Climate Change and Agriculture: Information Needs and Research Priorities. *International Conference on Capacity Building for Climate Change*

[3]. Agro-met Advisory Bulletin for the State of Himachal Pradesh. 2023. Government of India Ministry of Earth Sciences, Meteorological Centre Shimla.

[4]. Ambenje P. 2000. Regional Drought Monitoring Centres - The Case of Eastern and Southern Africa.

[5]. Annie M, Pal RK and Konwar K. 2023. Enhancing agricultural risk management through weather forecasting and agro-meteorological advisory services. *The Pharma Innovation Journal* 12: 2045-2049

[6]. Bal SK, Saha S, Fand BB, Singh NP, Rane J, Minhas PS. 2014. Hailstorms: causes, damage and post-hail management in agriculture. *NIASM Technical Bulletin No. 5. ICAR-National Institute of Abiotic Stress Management* 44

[7]. Bal SK, Minhas PS, Singh Y, Kumar M, Patel DP, Rane J, Kumar PS, Ratnakumar P, Choudhury BU, Singh NP. 2017. Coping with hailstorm in vulnerable Deccan plateau region of India: technological interventions for crop recovery. *Current Science* 113

[8]. Bal SK, Minhas PS. 2017. Atmospheric stressors: challenges and coping strategies. *Springer Singapore* 9–50

[9]. Bhardwaj J, Singh S, Singh D. 2007. Hailstorm induced crop losses in India: some case studies. *Fourth European Conference on Severe Storms* 10–14

[10]. Bhattacharya S. 2006. Climate Change and India. *International Workshop on Future International Climate Policy*. University of Sao Paulo, Brazil.

[11]. Bedekar VC, Dekate MV, Banerjee AK. 1974. Heat and cold waves in India. *India Meteorological Department Forecasting Manual* 63

[12]. Carlson JD. 1989. The Importance of Agricultural Weather Information – A Michigan Survey. *Bulletin of American Meteorological Society* 70: 366-380

[13]. Chandol T, Gupta AK, Amin F, Bindal MK. 2021. Training Manual on Climate Change and Extreme Events Risk Reduction. *National Institute of Disaster Management* 199

[14]. Chattopadhyay N, Chandras S. 2018. Agrometeorological advisory services for sustainable development in Indian agriculture. *Biodiversity Int J* 2:13-18

[15]. Chattopadhyay N, Hulme M. 1997. Evaporation and Potential evapotranspiration in India under conditions of recent and future climate change. *Agricultural and Forest Meteorology* 87:55-73

[16]. Chattopadhyay N and Lal B. 2007. Agrometeorological Risk and Coping Strategies-Perspective from Indian Subcontinent. *Managing Weather and Climate Risks in Agriculture* 83-98

[17]. Chattopadhyay N. 2013. Agromet advisories for minimizing the impact of extreme weather events in India. *Agrometeorological Aspects of Extreme Weather Events* 215-220

[18]. Chattopadhyay N, Ghosh K and Chandras SV. 2016. Agrometeorological Advisory to assist the farmers in meeting the challenges of extreme weather events. *Mausam* 67: 277-288

[19]. Chaubey D, Prakash V, Patel AB and Yadav TC. 2018. Role of Agro-Meteological Advisory Services on Risk Mitigation in Agriculture. *International Journal of Pure and Applied Bioscience* 6: 27-32

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24APR1973

[20]. Das SK, Hunt JCR. 2007. Variability of climate change in India. *Current Science* 93
[21]. Das J, Umamahesh NV. 2021. Heat wave magnitude over India under changing climate: Projections from CMIP5 and CMIP6 experiments. *International Journal of Climatology* 1–21
[22]. Dash SK, Mamgain A, 2011. Changes in the frequency of different categories of temperature extremes in India. *Journal of Applied Meteorology and Climatology* 50:1842–1858
[23]. De US, Joshi KS. 1995. Genesis of cyclonic disturbances over the North Indian Ocean. 1891-1990. *India Meteorological Department Pre-Published Scientific Report* 47
[24]. De US, Joshi KS. 1999. Interannual and interdecadal variability of tropical cyclones over the Indian seas. *The Deccan Geographer* 37:5-21
[25]. De US, Sinha Ray KC. 2000. Weather & climate related impacts on health in Megacities. *WMO Bulletin* 44:340-348
[26]. De US, Dube RK, Prakasa Rao GS. 2005. Extreme Weather Events over India in the last 100 years. *Indian Geophysical Union* 9:173-187
[27]. Dube R and Rao G. 2005. Extreme Weather Events over India in the last 100 years. *Journal of Indian Geophysical Union* 9: 173-188
[28]. Gautam RC. 2012. Impacts of drought on crops and ways to mitigate it. *Indian Farming* 62:13–19.
[29]. Ghosh k. 2023. Agromet advisory services for management of climate risks in agriculture. *Climate smart viticultural technologies for sustainable quality grape production* 36-53
[30]. Govinda Rao P. 1993. Climate changes and trends over major river basins in India. *Climate Research* 2: 215-223
[31]. Govinda Rao P, Kelly PM, Hulme M. 1996. Climate Change, greenhouse gas emissions, Future climate and response strategies: the implications for India. *Theoretical and Applied Climatology* 55:41-64
[32]. Himachal Pradesh State Disaster Management Plan. 2017
[33]. Hughes P, Wood R. 1993. Hail: the white plague. *Weatherwise* 46:16–21.
[34]. Ji R, Yu W, Feng R, Wu J, Zhang Y. 2021. Identification and characteristics of combined agrometeorological disasters caused by low temperature in a rice growing region in Liaoning Province, China. *Scientific Report*.
[35]. Joyce LA. 2003. Improving the flow of scientific information across the interface of forest science and policy. *Forest Policy & Economics* 5: 339-347
[36]. Kotawale DR and Kumar RK. 2005. On the recent changes .in surface temperature trend over India. *Geophysical Research Letters* 32
[37]. Kothawale DR, Revadekar JV, Kumar KR. 2010. Recent trends in pre-monsoon daily temperature extremes over India. *Journal of Earth System Science* 119:51–65.
[38]. Lal M. 2001. Future climate change: Implications for Indian summer monsoon and its variability. *Current Science* 81:1205
[39]. Morey DK and Sadaphal M.N. 1981. Effect of weather elements on yield of wheat at Delhi. *Punjabrao Krishi Vidyapeeth Research Journal* 1: 81-83
[40]. *Nagarajan R. 2003. Drought: Assessment, Monitoring, Management and Resource Conservation. Capital Publishing Company 312*
[41]. Nagarajan R. 2010. Drought assessment. *Springer Netherlands* 121–159
[42]. National Agromet Advisory Bulletin. 2010
[43]. Pai DS, Thapliyal V, Kokate PD. 2004. Decadal variation in the heat and cold waves over India during 1971–2000. *Mausam* 55: 281–292
[44]. Pai DS, Smitha A, Ramanathan AN. 2013. Long term climatology and trends of heat waves over India during the recent 50 years (1961–2010). *Mausam* 64: 585–604
[45]. Parry M, Canziani O, Palutikof J, Linden PVD and Hanson C. IPCC, 2007*: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* 967
[46]. Pathak H, Aggarwal PK, Singh SD. 2012. Climate Change Impact, Adaptation and Mitigation in *Agriculture: Methodology for Assessment and Applications* 7
[47]. Prasad R, Sharma A and Negi MK. 2018. Extreme weather events – impact on agro-horticultural sector in Himachal Pradesh. *Himachal Journal of Agricultural Research* 44: 25-35
[48]. Rao GD and Sinha SK. 1994. Impacts of climate change on simulated wheat production in India. *Implications of climate change for international agriculture: Crop Modeling Study*. Rosenzweig, C and Iglesias,I (Eds). EPA, USA 1-10
[49]. Raper SCB, Wigley TeainfalML, & Warrick RA.1996. Global sea-level rise: past and future. Sea-level rise and coastal subsidence: causes, consequences, and strategies. *Kluwer Academic Publishers* 11-45.
[50]. Rathore LS and Maini P. 2008. Economic Impact Assessment of Agro-Meteorological Advisory Service of NCMRWF. Report no. NMRF/PR/01/2008, 104pp, Published by NCMRWF, Ministry of Earth Sciences, Government of India, A-50 Institutional Area, Sector- 62, NOIDA, UP, INDIA 201 307
[51]. Rathore LS, Bhowmik SKR and Chattopadhyay N. 2011. Integrated Agrometeorological Advisory Services in India. *Challenges and Opportunities in Agrometeorology* 195-205
[52]. Rohini P, Rajeevan M, Srivastava AK. 2016. On the variability and increasing trends of heat waves over India. *Scientific Reports* 6:1–9
[53]. Sen A, Chander M. 2003. Disaster management in India: the case of livestock and poultry. *Revue Scientifique et Technique Office International* of *Epizootics* 22:915–930

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24APR1973

[54]. Seneviratne SI, Donat MG, Mueller B, Alexander LV. 2014. No pause in the increase of hot temperature extremes. Nature Climate Change 4:161–163
[55]. Sikka AK, Bapuji RB, Rao VUM. 2016. Agricultural disaster management and contingency planning to meet the challenges of extreme weather events. *Mausam* 67:155–168
[56]. Singh K, Kumar A and Singh RKP. 2015. Role of Information and Communication Technologies in Indian Agriculture: An Overview. *SSRN Electronic Journal*.
[57]. Singh AK, Singh N, Sindh H and Kushwaha HS. 2021. Role and Importance of Weather Forecasts in Modern Agriculture. *International Journal of Current Microbiology and Applied Sciences* 10: 2646-2662
[58]. Sinha A. 2002. Minutes of the Brain Storming Session on Management of Drought, 2002 on 13th September 2002. National Centre for Disaster Management, New Delhi.
[59]. Sivakumar MVK, Motha RP and Das HP. 2005. Natural disasters and extreme events in Agriculture. *Springer Publication* 93-117
[60]. Sivakumar MVK and Motha RP. 2008. Managing Weather and Climate Risks in Agriculture. *Springer Publication* 83-97
[61]. Sivakumar MVK and Hansen JW. 2007. Climate Prediction and Agriculture: Summary and the Way Forward. *Climate Prediction and Agriculture: Advances and Challenges* 1-13
[62]. Tomar MS. 2012. An insight into the severe floods in India during 2005, 2006 & 2007. *Mausam* 63:65–70
[63]. White, GF, Haas JE. 1975. Assessment of Research on Natural Hazards. *The MIT Press, Cambridge* 487