Navigating Drought Challenges: A Resilience Framework for Bundelkhand, India

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ABSTRACT

The Bundelkhand region in India, with its semi-arid climate and agrarian economy, faces recurrent droughts. This study examines the spatiotemporal dynamics of droughts using the Standardized Precipitation Index (SPI) and Streamflow Drought Index (SDI). It reveals moderate droughts are more frequent, occurring every five years, with significant spatial variability during monsoons in northern districts. Utilizing GloFAS reanalysis discharge data, it identifies higher probabilities of hydrological droughts. Trend analysis indicates worsening drought conditions over the past decade despite policy interventions such as the National Action Plan on Climate Change and the Integrated Watershed Management Programme. The findings underscore the need for enhanced early warning systems, climate-resilient agriculture, and improved drought monitoring to inform policies, crucial for Bundelkhand and similar regions.

POLICY-RELEVANT ABSTRACT

•**Increased Drought Risk:** Rising probabilities of prolonged droughts necessitate enhanced early warning systems and proactive risk management policies.

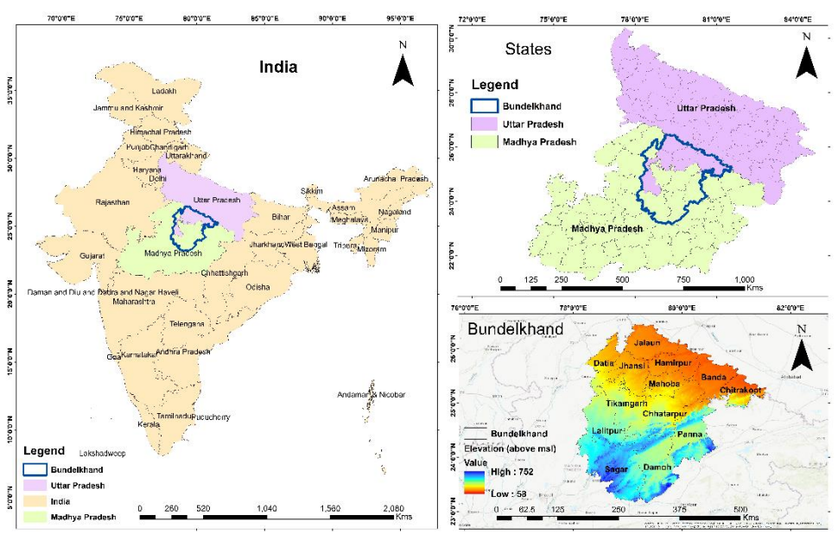
•**Targeted Interventions:** Northern districts, exhibiting significant trends towards increasing drought severity, require prioritized mitigation strategies for agriculture and water resources.

•**Hydrological Data Utilization:** The application of GloFAS data for hydrological drought in regions with limited gauge data offers a valuable tool for improving drought monitoring.

•**Climate Resilience:** Integrating climate-resilient agricultural practices and water conservation techniques is crucial to mitigate socio-economic impacts on vulnerable communities.

•**Local Context:** Bundelkhand's recurrent droughts have led to significant agricultural losses, water scarcity, and migration, underscoring the urgent need for effective drought resilience strategies.

STUDY AREA



DROUGHT MANAGEMENT ISSUES IN A CHANGING CLIMATE

Drought in agriculture is impacted by climate change in important ways, both in terms of frequency and severity. A few significant effects of climate change on agricultural drought include

Increased Frequency and Intensity: Drought episodes are becoming more common and extreme across many regions due to climate change. Changing evapotranspiration rates, changed precipitation patterns, and rising temperatures all lead to extended droughts that harm agriculture(Niranjan Kumar et al. 2013).

Modified Rainfall Patterns: As a result of climate change, there are modifications to the timing, intensity, and geographical distribution of precipitation. This may cause agricultural operations to be interrupted, impair crop growth phases, and result in water shortages during crucial times.

Increasing Temperatures: As a result of higher temperatures, evaporation rates rise, increasing water demand and hastening soil moisture loss. This worsens the effects of drought on crops, decreases the amount of water available for irrigation, and has an influence on agricultural output.

Changing Hydrological Regimes: Changes in river flows, groundwater recharge rates, and the availability of water resources are just a few examples of how climate change may affect the hydrological cycle. Such modifications may interfere with the water supply used for agriculture, worsening the drought situation.

Past droughts have taught us important lessons about how to handle drought in agriculture in a changing environment.

Technology and Advancements for Agricultural Drought Estimation

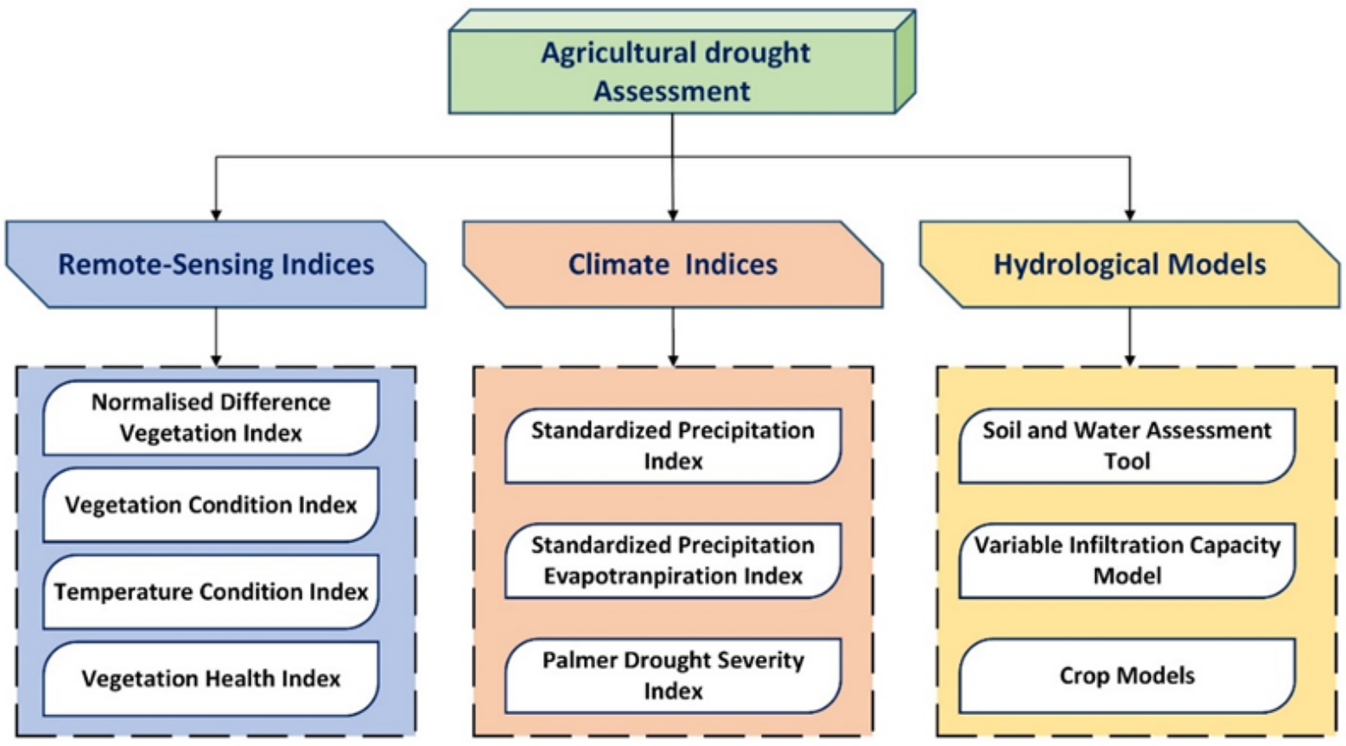


Figure 1 Flowchart of Agricultural Drought Assessment Methods

RECOMMENDATIONS

Remote Sensing and Earth Observation	Using high-resolution satellite imaging, drones, and sophisticated remote sensing techniques, we can collect real-time data on the health of the plants, the wetness of the soil, and the availability of water. These data sources allow for a more immediate and accurate evaluation of the state of the agricultural drought.
Data Analytics and Machine Learning	By using algorithms for data analytics and machine learning on sizable datasets, it is possible to better understand and anticipate the patterns of agricultural drought. These techniques may be used to anticipate drought episodes and identify drought risk regions by analyzing historical climate data, agricultural performance data, and other pertinent variables.
Internet of Things (IoT) and Sensor Technologies	Setting up IoT devices and sensor networks in farming areas can allow for continuous monitoring of crop health, weather, and soil moisture. These sensors' real-time data can help with early drought stress identification and decision-making for scheduling irrigation and water management.
Improved Climate Forecasting	Improved climate forecasting can deliver precise and timely information on rainfall patterns, temperature trends, and future drought events. This is accomplished by funding improved climate forecasting models and incorporating them into early warning systems. Farmers and other interested parties can use this information to decide on crop planning, water management, and mitigating strategies.
Integrated Drought Monitoring systems	The creation of thorough, user-friendly systems that include several data sources (such as climate data, remote sensing data, and on-the-ground observations) can make it easier to monitor agricultural drought conditions in real time. For farmers, extension agents, and policymakers, these platforms should offer user-friendly interfaces, visualization tools, and access to decision support systems (Shah and Mishra 2020).
Mobile Applications and Information Dissemination	Farmers' readiness for and ability to respond to agricultural drought may be greatly enhanced by utilizing mobile technology to offer timely information, warnings, and advisory services. Mobile applications may offer localized weather forecasts, suggestions for crops, and market data, arming farmers with the information they need for efficient drought management.
Climate-Smart Agriculture	: Promoting the use of climate-smart agricultural techniques such crop diversification, agroforestry, and precision farming. These techniques promote crop tolerance to drought circumstances while also enhancing soil health and water usage efficiency.
Water Harvesting and Management	Encouraging the use of water harvesting strategies can enhance the amount of water available for agriculture during dry spells. Examples include rooftop rainwater collection, small-scale ponds, and check dams. Aside from that, employing effective irrigation techniques like drip irrigation and micro-irrigation may maximize water efficiency and minimize water waste.
Agro-meteorological Services	Strengthening the agro-meteorological services that give farmers access to localized weather data, agro-advisories, and climate risk assessments. These services aid farmers in selecting crops, planning planting times, and managing water resources while taking current climatic conditions into account.

KEY MESSAGES

More work should be put into creating cutting-edge technology, enhancing early warning systems, and encouraging climate-resilient practices to better understand the effects of climate change on agricultural drought. To successfully assist drought management measures, policy frameworks must also be reinforced. This involves developing agricultural policies that are climate resilient, enhancing institutional capabilities, and encouraging community involvement. Finally, it should be noted that tackling the drought necessitates a proactive and cooperative strategy including governments, research organizations, farmers, and other stakeholders. The goal of enhancing drought assessment capabilities and improving drought management practices can be achieved by putting the study's recommendations into practice and encouraging further research and action. This will ensure the sustainability of farming communities and food security in areas where agriculture predominates.

Key References

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