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著者(和文)	KATNESHWARKARBageshree
Author(English)	Bageshree Katneshwarkar
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報告番号 For administrative use only	乙 第 号	氏 名 Name	Katneshwarkar Bageshree
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( 要 旨 )

(Summary)

The complex and multifaceted phenomenon of drought not only threatens food security by persistent agriculture failures but also affects the socioeconomic security of its key stakeholders i.e., farmers. For comprehensive drought analysis and mitigation, the knowledge of local influencing factors driving drought propagation is pertinent for effective drought categorization. Till now, the knowledge of vegetation response to the external influencing factors has either been carried out on a global scale that puts forward bulk estimates or precipitation is primarily discussed, where other regional driving factors may have a greater influence on the vegetation response. Given the socioeconomic sensitivity of India to precipitation and other factors, there is an urgent need for a quantitative assessment of the commonly anticipated factors (e.g., precipitation, groundwater, cropping intensity, crop productivity, and irrigation) and their complex interplay, especially in the regions highly vulnerable to droughts. Thus, in this thesis, the relation between greening-browning trends in vegetation (increase or decrease in leaf area), and their driving factors in drought-prone areas are discussed for the agrarian state of Maharashtra in central India. Using these confounding drivers, a multivariate joint drought index (JDI) is proposed for holistic drought quantification, reflecting the seasonal drought conditions. Furthermore, implications of these vegetation trends and novel drought index on farmers' socioeconomic security are also explored.

After discussing the framework of drought management in India and need of improvements in the current methods in chapter one, in chapter two, trends, and variability in the MODIS leaf area index (LAI) time series, along with spatiotemporal patterns in precipitation, groundwater storage, agriculture statistics, and irrigation infrastructure were analyzed to identify their influences on the vegetation response and to understand the dynamics of primary drivers. The study area of Maharashtra state showed greening attributed mainly to agricultural practices with a net gain of  $17.478 \times 10^3 \text{ km}^2$  of leaf area during 2003 to 2019. Maximum greening was observed in irrigated croplands, attributable to increased crop productivity, whereas inadequate irrigation facilities with erratic rainfall patterns and droughts were primarily responsible for cropland browning. Here, the dynamics and variability of vegetation response were discerned by incorporating a spectrum of synergistic feedback from multiple confounding drivers, where the quantitative distinction in leaf area change was governed by an uneven distribution of water availability across the administrative divisions. The results of chapter two will play a decisive role in establishing a framework for drought impact assessment and policymaking in Maharashtra state as well as for the multidimensional studies in other drought-prone regions of India and other developing

countries requiring serious attention to multiplex issues related to policy modifications and deteriorating status of key stakeholders of agriculture.

With the help of primary drivers of vegetation dynamics as analyzed in chapter two, chapter three deals with the development of a multivariate joint drought index (JDI) for better representation of drought severity assessment, enabling users to understand the integrated effect of multiple drought characteristics by assimilating the critical information from the constituent variables. The results of this analysis mainly discuss the JDI characteristics by two methods: Principal Component Analysis (PCA) and Copula along with the implications of JDI on drought monitoring and mitigation measures. The drought intensities captured by JDI are more realistic than the traditional ones corroborating well with the seasonal crop production. Moreover, the groundwater drought is effectively captured in JDI which is commonly neglected despite the dominant role of groundwater for irrigation in the study region. The chapter also gives insights into multiple characteristics of droughts including onset, duration, severity, and termination. The multidisciplinary approach of drought management as presented in this chapter is predominantly important in decision-making and government response to droughts, especially in socioeconomically sensitive regions of India.

Chapter four discusses the role of droughts, trends, and dynamics in hydroclimatic variables, irrigation infrastructure, agriculture related policies, and multivariate drought analysis in the socioeconomic security of the farmers, including economy of the state and various divisions. Despite the observed greening trends, the study region witnessed a high number of farmer suicides related to droughts and agriculture failures addressing the crucial need to reconfigure the irrigation infrastructure and comprehensive policy interventions for the abatement of farmer distress. Moreover, the decreasing share of agriculture in the state economy further highlights the stress on the sector, which gets echoed in the socioeconomic harmony of the farmers. Although it is difficult to point out a single driving factor for jeopardizing the security of farmers, indebtedness, agriculture failures, inadequate and insecure water availability for irrigation, and inefficient policy interventions are some of the key factors fueling the distress in farmers. Improved water management and timely and efficient state interventions in addition to modified agricultural techniques can help in dampening the harsh aftereffects of droughts and securing the farmers' social and economic status.

The quantitative assessment of vegetation dynamics and proposed framework for drought classification and management using multivariate drought index along with descriptive analysis of factors affecting the socioeconomic security of farmers by incorporating a spectrum of dynamic feedback from multiple confounding drivers as discussed in this thesis will be valuable in providing important insights to the policymakers for efficient and effective drought management and drought proofing of susceptible areas in India and worldwide.

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