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Review

A Review of Drought Disturbance on Socioeconomic Development

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Abstract: Climate-change-intensified drought carries great challenges for socioeconomic development. This article aims to provide a comprehensive review of research on the effects of drought disturbance on socioeconomic development within the context of climate change. According to the co-citation analysis of approximately 3000 literature sources, it should be emphasized that challenges resulting from drought carry significant socioeconomic implications, including agriculture losses, increased financial burdens on governments, and escalating insurance claims. Drought can also trigger humanitarian and social crises, especially in resource-limited areas, resulting in shortages of food and water, population displacement, and health risks. Therefore, effective policies, informed by robust research and data, are crucial for addressing the complex challenges of droughts in a changing climate. Proactive strategies, including improved water management, early warning systems, and sustainable agricultural practices, are essential for a comprehensive response. Addressing the socioeconomic impacts of climate-induced drought requires a holistic, interdisciplinary approach, emphasizing collaboration among governments, communities, researchers, and international organizations. Implementing adaptive measures and risk reduction strategies enhances resilience and mitigates the adverse effects of drought on society and the economy.

Keywords: drought impact; socioeconomic development; climate change; co-citation analysis

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1. Introduction

Numerous natural disasters are observed with notable frequency worldwide, encompassing phenomena, such as heat waves, excessive precipitation, wildfires, and drought. These events have profound effects on both societal productivity and the overall quality of life [1,2]. It is widely acknowledged that climate change is anticipated to heighten the risk and severity of drought events [3]. For instance, the rise in greenhouse gas concentrations in the atmosphere may alter the global water cycle, significantly affecting terrestrial hydrology [4]. An intensifying water cycle would promote regional water scarcity and increase drought occurrence with regional water scarcity. Drought generally exerts detrimental effects on various sectors of society, disrupting normal societal functions and potentially impeding sustainable socioeconomic development.

Drought, as a recurrent natural hazard, typically originates from abnormally reduced precipitation. This reduction leads to increased atmospheric water demand, subsequently resulting in above-normal evapotranspiration and below-normal soil moisture [5–7]. This leads to soil moisture deficits, reduced runoff, and other water shortages, further exacerbated by the drought prolongation [8]. Climate change has accelerated hydrological processes, making them faster and more intense, with various repercussions including an increased risk of wildfire [9–11]. Over the past few decades, drought events have frequently occurred worldwide, disrupting water balances and plant growth and, consequently, causing numerous indirect effects on ecosystems and various economic sectors, such as irrigation, drinking water supply, and electricity production. Drought stress triggers a series of morphological, biochemical, and physiological responses in plants, resulting in crop yield loss and tree mortality [12–15]. Tree mortality, a result of drought-induced wildfires and carbon starvation, significantly impacts the carbon cycle, potentially exacerbating global environmental changes and increasing the frequency of natural disasters. As a result, drought has captured the attention of environmentalists, ecologists, hydrologists, meteorologists, geologists, and agricultural scientists.

In recent decades, numerous studies and reviews have explored drought. These studies have focused on investigating the drivers, impacts, spatiotemporal variations, propagation, and future trends of drought. Consequently, there is a growing awareness of drought and related hazards, like heat waves and wildfires. However, most studies predominantly focus on the natural aspects of drought. Biologists are keenly interested in the genetic traits that confer resistance to drought conditions, while ecologists and environmentalists concentrate on the ecological consequences of drought, particularly in forests and croplands. Geographers and hydrologists emphasize the monitoring, attribution, and impact of drought events [5,16,17]. It is important to note that the definition of drought remains a subject of considerable debate, often formulated based on its impacts, taking into account local physical and social conditions [18]. Understanding the primary drivers of drought and finding improved methods to monitor them can facilitate quicker and more effective measures to mitigate their impacts, potentially reducing the associated economic losses. A comprehensive understanding of how vegetation growth and functional traits respond to drought on a macro scale can provide deeper insights into the impact on ecosystems and potential contribution to climate change. Furthermore, the examination of the drought resistance genes of vegetation on a microscopic scale holds promise for supporting agricultural productivity and safeguarding food supplies in drought conditions [13,19,20].

However, there has been limited research directly addressing the socioeconomic impacts of drought under climate change conditions. It is difficult to quantify the impact of drought on the social economy. The current drought indices are generally based on meteorological data, soil moisture, various vegetation indexes, and other related factors, whereas very few indices can be used to quantify the drought influence on the socioeconomic aspects of a region. Moreover, numerous factors influence social and economic development, such as population dynamics, local policies, social activities, and other natural disasters, making it difficult to isolate the socioeconomic effects of drought. Van Loon et al. contended that drought management remains inefficient due to an incomplete understanding of the feedback loops between drought and human activities. Therefore, in this era significantly shaped by human influences, it is imperative to reevaluate the concept of drought, considering the role of humans in both exacerbating and mitigating drought [8].

A comprehensive understanding of the potential impact of drought on various aspects of society is essential for the sustainable advancement of the socioeconomic landscape. It can also offer practical insights for future drought-related research, improving our living environment. To this end, we gathered a dataset of approximately 3000 articles from the Web of Science Core Collection, using search terms, such as climate change, society, socioeconomic drought, drought impact, and economic response. Subsequently, a screening process was conducted to select a subset of articles for in-depth analysis. We explored hotspots since the 21st century related to the socioeconomic impact of drought under climate change to gain a deeper understanding of the impact of drought on socioeconomic development. Afterwards, we provided a detailed discussion on the definition and identification of drought, the impacts of drought on society, and the response of socioeconomic development to drought.

2. Co-Citation Analysis of Literature Related to Socioeconomic Drought

A literature co-citation analysis was conducted using CiteSpace 6.1.R6. After choosing “Reference” from the “Node types” panel, high-citation studies were extracted from each slice (there were four years per slice during 2000–2023) based on a modified g-index. The

g-index denotes the maximum order (g) of a paper that accrues at least g^2 citations when sorted by citation count, and the modified g-index in CiteSpace is defined as:

$$g^2 \leq k\sum_{i \leq g} c_i \tag{1}$$

where the scaling factor (k) determines the number of nodes in the further analysis. In this study, we set k to 100, resulting in the selection of 1243 studies. Subsequently, the selected studies were clustered using the spectral clustering method based on keywords, and the top 15 clusters with the highest number of nodes in the co-citation network were extracted for presentation.

Cluster topics were analyzed by using CiteSpace built-in algorithms, which include latent semantic indexing (LSI), log-likelihood rate (LLR), and mutual information (MI). LSI is a natural language processing technique that aims to uncover hidden semantic relationships within textual data by reducing the dimensionality of the data and revealing the underlying structure of meaning. LLR is a statistical method that measures the likelihood of observing a particular term in a given context to assess the significance and relevance of terms or keywords in textual data. In addition, MI is a statistical measure used to evaluate how related two terms or topics are within a corpus. It is a useful tool for uncovering semantic connections in textual data by identifying the strength of relationships and co-occurrences between terms. After comparing the cluster topics provided by these three algorithms and gaining a thorough understanding of the primary content within each cluster, the labels of each cluster were summarized (Figure 1).

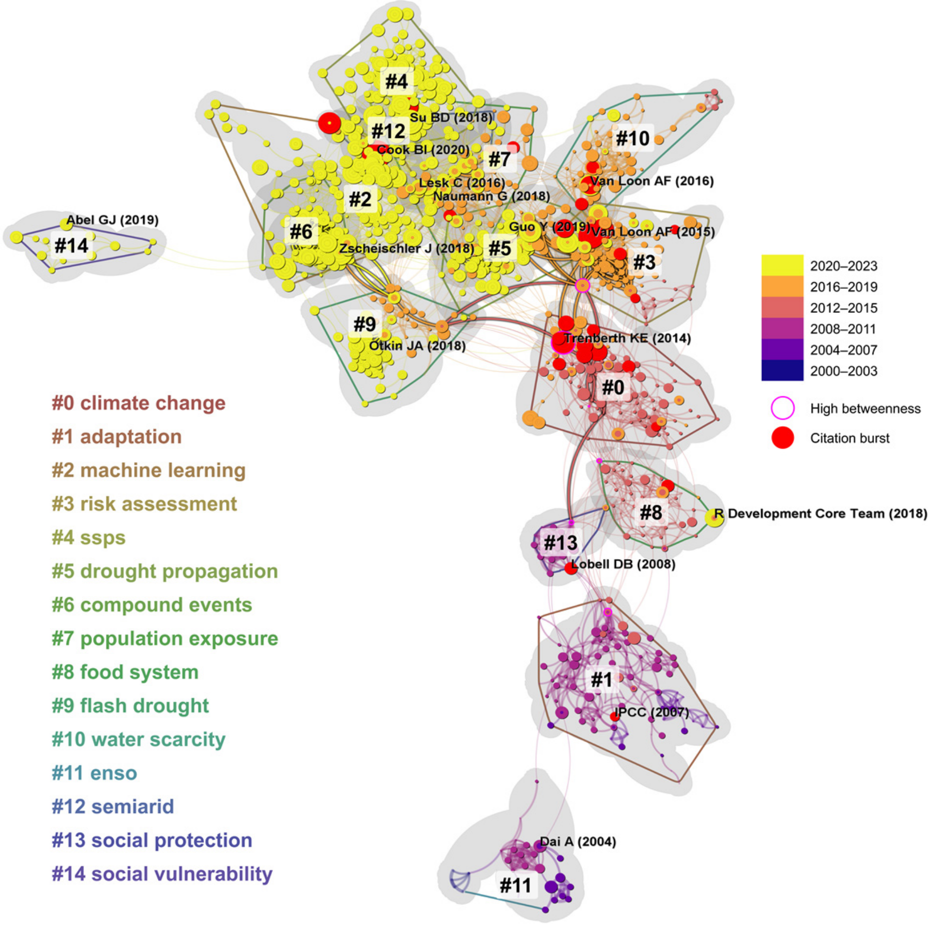

Figure 1. Co-citation network of drought and socioeconomic development literature published during 2000–2023. Color of cluster bubble represents age of the members. Sizes of each node are based on the citation tree rings, which are proportional to the number of citations in the corresponding event partition.

In Figure 1, each cluster is outlined with a border of the same color as the corresponding legend on the left, and the most cited study in each cluster is labeled. There are a total of 1243 nodes, representing all the selected literature. The node colors correspond to the publication period, as indicated on the right side of the legend. The size of each node is determined by the number of citations, with more citations resulting in a larger node radius. Additionally, we identified studies with relatively high betweenness centrality and significant citation bursts (Table 1), which have sustained attention for more than two years, and we marked them with purple rings and red circles, respectively. The Burst formula in CiteSpace is used to identify and detect "bursts" in the academic literature. A burst represents a significant increase in the citation rate of a specific keyword, topic, or term within a specific time frame. This information is valuable for identifying emerging trends or hot topics within a research field. The Burst Strength (BS) helps determine when a keyword or topic experiences a significant increase in citation rate compared to what would be expected. A positive BS value indicates a burst, suggesting a surge of interest in that keyword or topic within the research literature. The BS formula is calculated as follows:

$$BS = \left(C_{obs} - C_{exp}\right) / C_{exp} \tag{2}$$

where C_{obs} is the actual number of citations a particular keyword or topic receives during a specific time period, and C_{exp} represents the expected number of citations based on the average or random citation rate of the keyword or topic over the same time period.

Table 1. Top references with the strongest citation bursts.

Reference	Cluster	Begin	End	Topic
[21]	#15	2008	2015	South Asia and Southern Africa face significant crop-related climate risks without adaptation, requiring focused investment in these regions.
[22]	#0	2012	2019	The review discusses historical droughts, recent global aridity changes, and projections for increased aridity in various regions due to climate change.
[23]	#0	2012	2015	This review covers drought definitions, classification, indices, paleoclimatic studies, and links between droughts and climate indices, identifying research gaps.
[24]	#0	2012	2019	The increase in global droughts previously reported may be overestimated due to the simplified PDSI model not accounting for recent global warming effects.
[25]	#3	2012	2019	This paper reviews various methodologies used for drought modeling, including forecasting, probability-based modeling, and spatio-temporal analysis, emphasizing improvements and future research needs.
[26]	#0	2012	2019	CMIP5 is a significant global project providing climate modeling data for research, featuring long-term simulations, Earth system models, and decadal predictions.
[27]	#0	2012	2015	Global terrestrial net primary productivity (NPP) initially increased but has recently decreased due to large-scale droughts, potentially weakening the carbon sink.
[28]	#0	2013	2019	This analysis indicates that historical records and model predictions show increased aridity since 1950, with the models reproducing global aridity trends and linking aridity changes to sea surface temperatures. Future droughts are expected due to decreased precipitation and increased evaporation.
[29]	#8	2013	2019	Human-made greenhouse gases intensify the greenhouse effect with increasing radiative forcing. Aerosols partially counteract this effect, introducing uncertainty. Effective radiative forcing (ERF) is introduced alongside radiative forcing (RF) to assess temperature responses better, especially for aerosols impacting clouds and snow cover. ERF captures rapid cloud adjustments and better indicates temperature changes over the Industrial Era (1750–2011).

Table 1. *Cont.*

Reference	Cluster	Begin	End	Topic
[7]	#0	2014	2019	This assessment highlights issues with the Palmer Drought Severity Index (PDSI) and emphasizes the importance of accurate precipitation data and accounting for natural variability, such as El Niño/Southern Oscillation, in attributing drought causes.
[4]	#10	2014	2019	Global hydrological droughts are expected to intensify due to rising greenhouse gas concentrations, with regions like Southern Europe, the Middle East, Southeast US, Chile, and Southwest Australia emerging as potential hotspots.
[30]	#10	2014	2019	Climate change will significantly worsen global and regional water scarcity, especially if global warming exceeds 2 °C above preindustrial levels. Uncertainty in estimates emphasizes the need for improved hydrological models.
[8]	#3	2016	2023	This review focuses on hydrological drought, its definition, processes, climate influences, indicators, monitoring, predictions, impacts, management, and future research challenges.
[31]	#10	2016	2023	Rethinking drought to incorporate human influence for better management due to the incomplete understanding of drought-people feedback.
[32]	#3	2016	2019	This article discusses methods for computing the Standardized Precipitation Evapotranspiration Index (SPEI), including parameter estimation, reference evapotranspiration (ET0), and weighting kernels. It also provides software tools and a real-time drought monitoring system.
[33]	#7	2016	2023	The severe Syrian drought before the 2011 uprising resulted from natural variability and a long-term drying trend. Human-induced climate change made such droughts over twice as likely.
[34]	#1	2016	2019	California's record-setting drought is exacerbated by the increasing likelihood of warm and dry conditions influenced by human emissions.
[35]	#3	2016	2023	Droughts in the Anthropocene era resulted from complex interactions of meteorological anomalies, land processes, and human influences. We need new drought definitions, multi-driver analyses, and robust tools for drought research and management. Key questions focus on drivers, impacts, feedback, and adaptation. A holistic framework is essential for addressing drought challenges in the Anthropocene.
[36]	#0	2016	2023	Future climate change is expected to bring more severe and persistent droughts to the Southwest and Central Plains of Western North America, surpassing even the most extreme droughts of the past millennium. This severe drying trend is consistent across various models and metrics, indicating a robust response to warming.
[37]	#7	2016	2023	The Penman-Monteith-based Standardized Precipitation Evapotranspiration Index (SPEI_PM) is more effective for drought monitoring in China, especially in arid regions, than the Thornthwaite-based SPEI_TH. Droughts in China have increased since the late 1990s, with varying impacts from temperature and precipitation anomalies across different regions.
[18]	#3	2016	2019	Current drought management is reactive and crisis-based. A shift towards national drought policies focusing on risk reduction and preparedness is necessary due to increasing drought impacts and climate change.
[38]	#3	2016	2019	Droughts in Europe cause substantial losses. A new approach links climatological drought indices like SPI and SPEI to observed drought impacts to assess drought risk at the European scale, helping improve drought risk management.
[39]	#2	2020	2023	Climate change will increase drought risk, with drying evident in many regions. Drought responses are similar between CMIP5 and CMIP6 models, but uncertainties remain.
[40]	#4	2020	2023	CMIP, a cornerstone of climate science, is evolving to address diverse research needs with a federated structure, common standards, and specific MIPs in CMIP6.
[41]	#2	2020	2023	CRU TS v4, a widely used climate dataset, is updated to span 1901–2018, improving data quality and traceability.

Furthermore, it is noteworthy that with these clusters, six articles exhibit relatively high betweenness centrality, contributing to topics related to #0 climate change, #1 adaptation, #3 risk assessment, #8 the food system, and #13 social protection [7,42–46]. This suggests that the majority of the literature on socioeconomic drought is based on "climate change". It is worth noting that the alternation between El Niño and La Niña has been a significant source of interannual climate change on Earth, affecting global climate models, ecosystems, fisheries, and agriculture. For example, the extreme El Niño events in 1997–1998, followed by the extreme La Niña events in 1998–1999, led to severe droughts caused by an extreme El Niño event in Western Pacific countries, resulting in devastating floods. Conversely, the situation in the Southwestern United States was different. Since 2000, studies related to drought have increasingly focused on climate variability. As the impacts of drought have gained more significance in our lives, our understanding of the relationship between climate change, drought, and society has deepened. More research now concentrates on analyzing drought monitoring, characteristics, spread, and impact. Governments are also showing increased attention to climate disasters such as drought, leading to the implementation of more policies. Combined with local government policies on drought, research on the societal impact of drought has become a recent focal point.

In Sections 3–5, we will screen the literature primarily from the clusters that appear to have a high citation, high burstiness, and high betweenness centrality and provide a detailed description of the veins and frontiers of research related to drought, climate change, and human society. The selected clusters include climate change (#0), adaptation (#1), machine learning (#2), risk assessment (#3), shared socioeconomic pathways (SSPs, #4), population exposure (#7), the food system (#8), and water scarcity (#10).

3. Identification and Characterization of Drought

3.1. Drought Definition

The definition of drought can be categorized into conceptual and operational, with conceptual referring to those definitions formulated in general terms to identify the boundaries of the concept of drought [23]. For example, Tallaksen and Van Lanen defined drought as "a worldwide phenomenon characterized a sustained period of below-normal water availability with spatial and temporal characteristics varying significantly from one region to another [47]". Conceptual definitions provide little guidance to those who wish to apply them to current drought assessments. Operational definitions attempt to identify the onset, frequency, severity, termination, and duration of a given drought episode. Such definitions, therefore, require data on hourly, daily, monthly, or seasonal moisture deficiency or yield departures from "normal" (i.e., expected) to identify when drought occurred.

Considerable disagreement exists about the drought concept because the definition of drought is usually formulated based on the impacts, which requires consideration of local physical and social conditions [48]. For the purposes of discussion, studies generally classify droughts into four categories: meteorological drought, soil moisture drought (also called agricultural drought), hydrological drought, and socioeconomic drought. Meteorological drought is a lack of precipitation over a region for some time, possibly combined with increased potential evapotranspiration, extending over a large area and spanning an extensive period. Soil moisture is a deficit of soil moisture (mainly in the root zone), reducing the supply of moisture to vegetation. Several drought indices, based on a combination of precipitation, temperature, and soil moisture, have been derived to study soil moisture drought [49–52].

The operational definition of drought proposed by Dracup et al. is necessary for drought identification. It emphasizes the importance of clearly defining the subject of study, including precipitation for meteorological drought, streamflow for hydrologic drought, or soil moisture for agricultural drought, and then appropriate drought indices can be selected. It is also essential to specify the fundamental time scale of the study, whether it is on a monthly, quarterly, semi-annual, or annual basis. Furthermore, consideration should be given to how drought events are distinguished from other events within the same time series. For example, studies preferred to use threshold-based methods and select drought characteristics, like drought duration, magnitude (average water deficiency), and severity (cumulative water deficiency). Finally, it is emphasized that the selection of time scales and characteristic indicators should take the scope of the study area into account during the analysis process [53].

3.2. Drought Identification

Due to various requirements and purposes, numerous drought indices have been investigated to characterize different drought events accurately since the last century. For example, the commonly used indices for meteorological drought include precipitation, the Z index, the Standardized Precipitation Index (SPI), the Standardized Precipitation and Evapotranspiration Index (SPEI), the Reconnaissance Drought Index (RDI), and the Palmer Drought Severity Index (PDSI) [6,54–58]. In addition, the Standardized Soil-Moisture Anomalies (SMA), the Crop Moisture Index (CMI), and the Standardized Soil Wetness Index (SSWI) can be used to identify soil moisture drought events. Meanwhile, the Standardized Runoff Index (SRI), the Standardized Streamflow Index (SSI), the Surface Water Supply Index (SWSI), and the Palmer Hydrological Drought Index (PHDI) can be used to identify hydrological droughts [59–61]. However, using a single or simple index in drought identification may not lead to convincing conclusions. For example, Sheffield et al. argued that the PDSI calculation only used a simplified potential evaporation model and only responded to temperature changes. The PDSI did not consider the underlying physical principles of available energy, humidity, and wind speed changes, which would lead to an overestimation of the global drought reported in the past [7,24]. Consequently, composite drought indices, such as the Comprehensive Drought Index (CDI), Multivariate Standardized Drought Index (MSDI), Global Land Data Assimilation System (GLDAS), and United States Drought Monitoring (USDM), can be used to monitor complex drought conditions and aspects, and they have been constantly improved.

Most previous studies described drought based on large-scale meteorological and hydrological conditions. Currently, the amount of socioeconomic drought indices is significantly lower than that of other drought categories. However, the majority of these quantification methods predominantly take into account the adverse social impacts of drought on the economy and human life, albeit not fully addressing demand and local resilience to climate change [62,63]. Wang and Meng quantified the severity of drought from a social perspective and proposed the Society Drought Severity Index (SDSI) for drought identification in Yunnan Province of China, which is considered a valuable tool for drought disaster management and risk management [64]. Malek et al. developed a tightly coupled framework, VIC-CropSyst, which combines two widely used and mechanistic models (for crop phenology, growth, and management) to provide realistic and hydrologically consistent simulations of water resources for drylands and arid systems, including water demand for irrigated crops and agricultural productivity [65]. Mehran et al. proposed a Multivariate Standardized Reliability and Resilience Index (MSRRI) that can be used to measure socioeconomic drought [62]. MSRRI combines information about reservoir storage and demand to provide complementary information on the development and recovery of socioeconomic droughts.

Some studies directly used the time series of drought indices to represent the drought-changing time series. For example, Huang et al. used the SPI and SSI to characterize meteorological and hydrological droughts [5]. Additionally, some studies used threshold methods based on single or multiple drought indices for drought identification [28,32,55,66,67]. Regions are defined as facing drought when the drought indices are below the threshold level. In addition, some studies used more complex methods for drought identification. One of the clustering methods suitable for hydrological droughts is the algorithm developed by Andreadis et al. for droughts in soil moisture and runoff in the USA [66]. Following Andreadis et al., Lloyd-Hughes developed a spatiotemporal structure-based method for drought identification. This structure expands clustering from the 3 × 3 spatial domain to the general $R \times R \times R$ space–time domain [55]. Xu et al. summarized the area thresholds applicable in this space–time structural drought identification [67]. Blauhut et al. proposed a method to link meteorological drought indices with observing drought impacts in Europe and argued that the probability map of the occurrence of drought effects based on this method on an annual basis matches many known European drought events [38]. These maps may become an important part of drought risk management to promote resilience to this large-scale threat.

The methods mentioned above for drought identification are mainly effective for professional researchers. A more systematic and comprehensive approach to drought identification can offer additional insights for related research. Additionally, numerous studies focused on predicting future drought occurrences to improve our understanding of drought events and contribute to global transformation. However, for policymakers and government managers, timely and effective local drought monitoring is of vital importance. It is crucial to specify feasible policies that consider the economic and human conditions of the region through effective decision making as much as possible to minimize the risk of regional drought.

3.3. Drought Characterization

Drought duration, affected area, severity, intensity, and other characteristic indicators can be obtained according to the outputs of drought identification, and then drought frequency can be further analyzed. Following that, bivariate analyses (which involve the exploration of relationships between two characteristic variables or the analysis of characteristic indicator frequencies) and multivariate analyses (which explore relationships among multiple characteristic indicators) of drought characterization are feasible.

Duration is the persistent time of a drought event, calculated as the timespan between the initiation and termination times of a drought event. Severity is an expression of water shortage, indicating the total amount of water that is needed to recover to normal conditions. The affected area is the area swept by a drought event, which could be the projected area over the longitude–latitude surface in the three-dimensional space–time domain. In addition, some parameters are used to distinguish between droughts with large volumes arising from short-period deficits over a wide area and those accrued from sustained deficits over limited areas, such as the aspect ratio and intensity [55,67]. Furthermore, drought frequency refers to how often a specific type of drought event occurs within a certain period. It is generally calculated using empirical frequency and joint probability distribution analyses.

Bivariate feature analysis involves an exploration of the relationship between two drought feature indicators based on sequences of drought events. Generally, six sets of relationships should be considered: severity duration (S-D), severity area (S-A), duration area (D-A), severity frequency (S-F), duration frequency (D-F), and area frequency (A-F). The first three sets of relationships require an analysis of their correlation using various correlation measurement methods. These sets not only provide a foundation for constructing indicators to describe comprehensive drought characteristics but also serve as a reference for developing joint distribution functions in multivariate drought frequency distributions. For the latter three sets, priority should be given to using a parametric approach to fit the probability distributions of drought severity, duration, and area sequences. The goodness of fit can be assessed using chi-square distribution tests and Kolmogorov–Smirnov tests. Parametric methods for fitting can use common functional distribution forms, including the normal distribution, the gamma distribution, and the exponential distribution. Non-parametric methods, on the other hand, use kernel density functions [68].

Multivariate relationship analysis involves the examination of relationships between three or more feature indicators based on sequences of drought feature indicators. More specifically, it involves three feature indicators, which include severity–area–duration (S-A-D), severity–area–frequency (S-A-F), severity–duration–frequency (S-D-F), and duration–area–frequency (D-A-F). The S-A-D relationship can be visually represented through SAD relationship diagrams, while the latter three sets can be analyzed using joint probability distribution methods [66].

Both bivariate and multivariate analyses of drought characteristics aim to explore the connections between various indicators. These analyses provide a foundation for developing comprehensive drought descriptions. Understanding these relationships is crucial for assessing the likelihood of drought events with varying durations, severities, and affected areas. This information is valuable for policymakers and researchers striving to address the challenges posed by drought.

4. Socioeconomic Drought under Climate Change

4.1. Social and Economic Impacts of Drought under Climate Change

Drought exerts multifaceted impacts on human society across various domains, such as agriculture, water quality, and energy production, under climate change. For example, the food supply is intricately influenced by complex interplays among land, atmosphere, and human processes, encompassing both short-term and long-term stressors (e.g., drought and climate change). Drought can substantially diminish crop yields, potentially leading to severe socioeconomic losses and humanitarian crises (e.g., famine) [69,70]. Furthermore, drought often accompanies the emergence of water scarcity, with hydrological drought being the most impactful drought on water reservoirs, significantly affecting food security and economic prosperity in numerous nations [71–73]. Anticipated future demographic shifts are poised to exacerbate pressures on existing water resources within many countries and globally. In the examination of drought impacts related to water resources, it is imperative to consider other socioeconomic and demographic variables to comprehend the associations between drought and water deficit [30,74].

Drought will bring economic loss to the whole world. Over the past three decades, the repercussions of these droughts have inflicted losses exceeding EUR 100 billion on Europe [38]. The impacts of climate change, however, have far graver consequences for vulnerable communities in rural areas in developing countries [75]. For instance, with climate change, rainfall in South Africa is projected to become more uncertain and variable, subjecting a growing population to water insecurity. This situation may intertwine with disease prevalence, institutional capacity deficits, and limited livelihood opportunities, collectively constraining adaptive capacity [76]. Before the commencement of the Syrian uprising in 2011, the greater Fertile Crescent region experienced the most severe drought on record. For Syria, a nation characterized by poor governance and unsustainable agricultural and environmental policies, the drought served as a catalyst, culminating in political turmoil [33].

Furthermore, the widespread droughts induced by global warming have the potential to further weaken terrestrial carbon sinks [27]. In drought-prone regions, there may be a heightened occurrence of cyclones and severe hailstorms [72]. Notably, climate change represents a formidable risk management challenge for the insurance industry as the escalation of natural disasters is poised to lead to increased insurance payouts [77]. Additionally, water scarcity in drought increases the pressure on social water supplies and the economic burden on households. Droughts exacerbate affordable water access in many water-stressed regions by reducing water availability and increasing the cost of supplying water. Water providers must use expensive short-term mitigation measures such as curtailment or invest in additional water supplies to provide reliability, but these measures may increase water rates and cause unaffordable water bills for low-income households [78–80].

4.2. Response of Socioeconomic Development to Drought

Following drought occurrences, socioeconomic development responses influenced by market regulations and policies play a pivotal role in determining the resilience of drought-affected regions. In arid regions of Australia, grasslands have experienced multiple degradation events over the past century. Stafford Smith et al. revealed that these events involve interactions among climate, economics, and water factors, ultimately leading to environmental collapse and ecosystem instability [81]. An increase in local grazing rates during favorable climate and economic conditions is a precondition for the rapid environmental collapse following droughts in the region. Large-scale droughts and declining market conditions render destocking financially unattractive, thereby exerting pressure on the grassland environment. Subsequently, grazing productivity declines in response to local market and social conditions in subsequent seasons. To achieve sustainable management and effectively address these challenges, it is imperative to establish community learning systems that integrate local knowledge, research, and institutional support.

Extreme weather events related to climate change can disrupt drinking water supplies, thereby causing interruptions in the water supply. Using various vulnerability assessment models, Luh et al. summarized the relative vulnerability of different regions in the United States to losing their drinking water supply due to droughts, floods, and hurricanes. This information helps identify counties most susceptible to losing their drinking water supply due to droughts. These findings can support decision-making processes, such as resource allocation and the implementation of adaptation strategies [82].

Mandatory water conservation measures are commonly implemented in response to droughts in urban areas. The effectiveness of large-scale water resource conservation efforts is contingent upon the coordination among various water districts. A grasp of local conditions is pivotal for successfully reducing water usage [83]. For instance, the impact of drought in Mexico has prompted the water sector to develop a strategy aimed at cost reductions. Víctor Magaña emphasized the importance of considering vulnerability as a dynamic, multifactorial element in drought risk analysis. This approach entails cooperation among stakeholders from various sectors and regions to identify structural and non-structural measures for drought mitigation. These strategies encompass the implementation of early warning systems and go beyond monitoring and forecasting drought processes [84].

Furthermore, Van Loon et al. argued that a new definition of drought and a research framework are needed in the current human-modified world to provide a more rational approach to monitoring socioeconomic drought. It is imperative that this framework explicitly encompasses the human processes that drive and alter soil moisture and hydrological droughts. Several recommendations have been proposed, including the clarification of the temporal boundaries of drought, recognizing it as an episodic phenomenon, to avoid potential confusion with other interconnected phenomena, such as overexploitation and water scarcity, which signifies a long-term imbalance between water demand and water supply. The research and management of drought in the Anthropocene present various challenges that can be addressed by examining related fields, such as flood research, ecology, water resource management, and water resource studies. By drawing insights from these neighboring disciplines, valuable management strategies can be developed to mitigate drought severity and minimize future drought impacts [35].

After a deeper re-conceptualization of drought, the government also needs to adopt the necessary strategies to combat drought. For instance, climate-change-intensified drought could promote migration from the poorest region of Brazil. Furthermore, extended, more frequent, and severe droughts might trigger population movements across the nation. These extensive climate-induced migrations could exacerbate water scarcity, unemployment, and poverty in major Brazilian cities. Getirana et al. stated that, to tackle these challenges, it is imperative for the government to collaborate with social, political, and economic scientists to identify the driving factors behind climate-related migration and shape effective policy decisions, which should encompass the long-term health effects of drought, including issues like malnutrition and mental health [3].

5. Conclusions

In conclusion, the impact of drought under the influence of climate change on socioeconomic aspects is multifaceted, including agricultural impacts, water resource scarcity, economic vulnerabilities, policy and adaptation, and environmental degradation. Complex challenges from droughts demand proactive measures and strategies to mitigate their far-reaching consequences. In the face of these challenges, it is clear that a holistic and interdisciplinary approach is required to address the socioeconomic impacts of drought in a changing climate, and collaboration among governments, communities, researchers, and international organizations is vital. As climate change continues to reshape our world, understanding and mitigating drought impacts will remain a critical priority. Therefore, the development and implementation of adaptive measures and risk reduction strategies are essential to enhance resilience and minimize the adverse effects of drought on society and the economy. Through concerted efforts and sustainable practices and policies, we can build a more resilient and adaptive society capable of confronting the challenges that lie ahead.

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