Received: 28 September 2021 | Revised: 16 December 2021 | Accepted: 22 December 2021

DOI: 10.1002/wcc.761

ADVANCED REVIEW

WIREs CLIMATE CHANGE WILEY

Drought and society: Scientific progress, blind spots, and future prospects

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Funding information
This research has received funding by the European Research Council (ERC) within the project "HydroSocialExtremes: Uncovering the Mutual Shaping of Hydrological Extremes and Society," ERC Consolidator Grant No. 771678.

Edited by: Matthias Heymann, Domain Editor and Mike Hulme, Editor-in-Chief

Abstract

Human activities have increasingly intensified the severity, frequency, and negative impacts of droughts in several regions across the world. This trend has led to broader scientific conceptualizations of drought risk that account for human actions and their interplays with natural systems. This review focuses on physical and engineering sciences to examine the way and extent to which these disciplines account for social processes in relation to the production and distribution of drought risk. We conclude that this research has significantly progressed in terms of recognizing the role of humans in reshaping drought risk and its socioenvironmental impacts. We note an increasing engagement with and contribution to understanding vulnerability, resilience, and adaptation patterns. Moreover, by advancing (socio)hydrological models, developing numerical indexes, and enhancing data processing, physical and engineering scientists have determined the extent of human influences in the propagation of drought hazard. However, these studies do not fully capture the complexities of anthropogenic transformations. Very often, they portray society as homogeneous, and decision-making processes as apolitical, thereby concealing the power relations underlying the production of drought and the uneven distribution of its impacts. The resistance in engaging explicitly with politics and social power—despite their major role in producing anthropogenic drought—can be attributed to the strong influence of positivist epistemologies in engineering and physical sciences. We suggest that an active engagement with critical social sciences can further theorizations of drought risk by shedding light on the structural and historical systems of power that engender every socioenvironmental transformation.

This article is categorized under:

Climate, History, Society, Culture > Disciplinary Perspectives

KEYWORDS

anthropogenic drought, climate change, resilience and adaptation, risk, hazard, and vulnerability, society

"People have been living with drought for 5,000 years, but what we are seeing now is very different."
Mami Mizutori, UN Secretary General's Special Representative for Disaster Risk Reduction

1 | INTRODUCTION: DROUGHT AS SOCIOENVIRONMENTAL PHENOMENA

Drought is an extreme hydro-climatological phenomenon that has occurred in varying degrees of magnitude and duration over the course of history. Since early human civilizations, drought has contributed to the world's most severe famines (Meza et al., 2020; Schiermeier, 2019; UNDRR, 2021) and has been associated with some of the largest population movements and displacements in human history (Lucero et al., 2017; McLeman et al., 2010; Sear et al., 2020). Societal collapses, conflicts, and instabilities have often unfolded together with droughts (Kaniewski et al., 2015; Xiao et al., 2013). Worryingly, future projections are more alarming since droughts are expected to increase in frequency, intensity, and duration in many regions across the world (Arnell, 2015; Guerreiro et al., 2018; Leng et al., 2015; Spinoni et al., 2019; Trenberth et al., 2014; Van Lanen et al., 2013).

These patterns have been attributed to expanding anthropogenic pressure including urbanization, deforestation, unsustainable water consumption, and human-induced climate change (AghaKouchak et al., 2015). In turn, this evidence led to broader definitions of drought (e.g., anthropogenic, human-induced drought) which include social pressures and account for the feedback between human actions and natural systems (AghaKouchak et al., 2021; Van Loon et al., 2016). Central to this emerging literature is the idea of advancing current understanding of drought by investigating the anthropogenic processes that intersect with the production and distribution of drought risks and their socioenvironmental implications. Such novel ideas lay the groundwork for this systematic review, which examines the multiple ways and extent to which physical and engineering scientists have empirically and theoretically engaged with social processes in relation to the production and distribution of drought risk. Drought risk is usually defined as the potential socioenvironmental impacts that result from the interactions between exposure and vulnerability to drought hazard (UNDRR, 2021). This review identifies four interrelated processes that influence the production and redistribution of drought risk. These processes—which are respectively: (a) the propagation of drought hazard; (b) the production of drought vulnerability and impacts; (c) the development of drought resilience and adaptation capacities and lastly; (d) long-term dynamics between drought risk and society—represent also the main objects of study of the publications reviewed in this paper (Figure 1).

In this paper, we first outline the methodology employed to identify relevant literature. Next, we undertake a quantitative examination of the 221 publications selected for this study to identify trends and major developments in the field. This section is followed by in-depth qualitative analyses that examine how social processes are conceptualized and incorporated in physical and engineering studies. Each analysis focuses on one of the four socioenvironmental processes influencing the production and distribution of drought risk (Figure 1). Furthermore, throughout the review, we also consider the latest methodological advances in numerical modeling, data processing, and remote sensing analyses

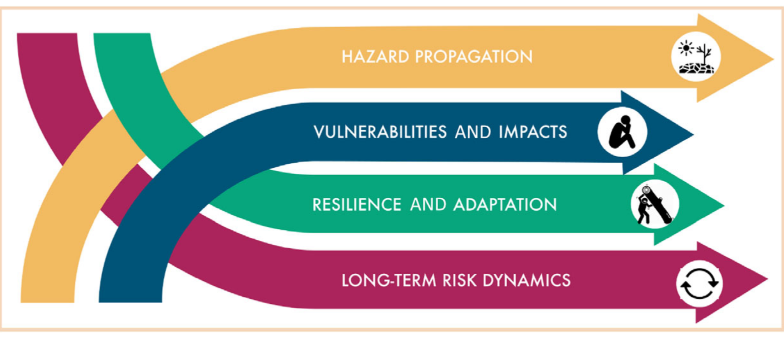

FIGURE 1 The figure exemplifies the four interrelated processes examined by engineering and physical sciences on drought risk and society over the past two decades. The intersection and direction of the arrows reflect respectively the interrelation and the evolution of these processes

to understand to what extent these methods are able to explain increasing anthropogenic transformations of droughts and their ever so critical manifestations.

We argue that physical and engineering studies on droughts and society have significantly progressed in terms of reconceptualizing drought risk in relation to anthropogenic processes. Moreover, these disciplines have advanced their methodologies so as to capture the intensity of anthropogenic transformations of drought hazard and their impacts. Concurrently, we observe that physical and engineering scientists still overlook the complexity of anthropogenic drivers of droughts' manifestations. Often, their analyses tend to portray humans as *universal victims* rather than *heterogeneous political subjects* (Swyngedouw, 2021). Thus, society results as a homogeneous entity and decision-making processes as apolitical.

This resistance in engaging explicitly with politics and inequalities can be attributed to the predominance of positivist epistemologies in physical and engineering sciences. In fact, a preference for observable and quantifiable knowledge can prevent an explicit consideration of social power despite the major role it has in reshaping the propagation and impacts of drought. We suggest that an engagement with critical social sciences theories would benefit drought and society studies. This interdisciplinary effort would expose the power dynamics that intersect with the production of anthropogenic droughts while at the same time, link broader patterns of inequality with the uneven distribution of drought risk (Savelli et al., 2021).

2 | METHODOLOGY: SYSTEMATIC REVIEW

This work employs a systematic review methodology to identify scientific evidence concerning the interactions of droughts and society. This allows minimization of bias and provides more accurate findings (Hasan et al., 2019). The methodology follows six stages, which include (1) framing the research question; (2) identifying relevant works; (3) selecting most significant literature; (4) assessing the appropriateness of the articles; (5) classifying final selected articles, and (6) performing quantitative and qualitative analyses (Figure 2).

The main research question that this review seeks to answer is "In which way and to what extent does current physical and engineering scientific research on drought and society consider social processes in relation to the production and distribution of drought risk?" (Figure 2, Stage 1). With social processes we refer to any human action or sociopolitical change that directly or indirectly influences drought risk and its manifestations. Stage 2 established the inclusion–exclusion criteria of this study based on the research question and the definition of social processes. In particular, during this stage we set up the Web of Science search engine in order to obtain only articles that had drought and societally relevant words[1] in the title. Web of Science was selected because it has a large database and is considered among the most trusted and accurate search engines (Mongeon & Paul-Hus, 2016). Year of publication, language, and type of documents were other basic criteria used to limit the number of articles. The research was restricted to academic publications written in English and published since 2000. The search was limited to English publications due to the linguistic competences of the authors. This might have caused the exclusion of some relevant contributions to this field and of some geographical areas. Similarly, the selection of the world *drought* inevitably excluded studies that employed terms such as water shortage, water scarcity, or dry spell. This criterion might partially explain the greater scientific focus on agriculture relative to urban case studies, where the most common terminology is "water shortages" and "urban water crises."

The criteria identified in Stage 2 resulted in the preliminary selection of 568 scientific publications on drought and society. Stage 3 encompassed the exclusion of papers that did not pertain to the physical and engineering sciences disciplines. The selection was limited to hydro-climatology, engineering, environmental, and earth sciences publications. Consequently, 230 papers that Web of Science categorizes as pertaining to social sciences, biology, biochemistry, paleobiology, agroforestry, or medicine were excluded from the review. Interdisciplinary studies combining physical and engineering sciences with other disciplines have been included in the study. Stage 4 encompassed a qualitative selection based on the abstract content to include only papers that investigated social processes and their interactions with drought risk production and distribution. In turn, this qualitative assessment excluded 42 publications which focused on the effects of anthropogenic climate changes as well as 75 publications that used historical time series of drought or assessed historical drought. These papers, despite somehow related to drought and society interplay, did not include analyses of social processes.[2] Based on this, the final selection was limited to 221 papers. During Stage 5 the articles were classified according to their abstracts into the four interrelated categories of (a) the propagation of drought hazard, (b) the production of drought vulnerability and impacts, (c) the development of drought resilience and adaptation

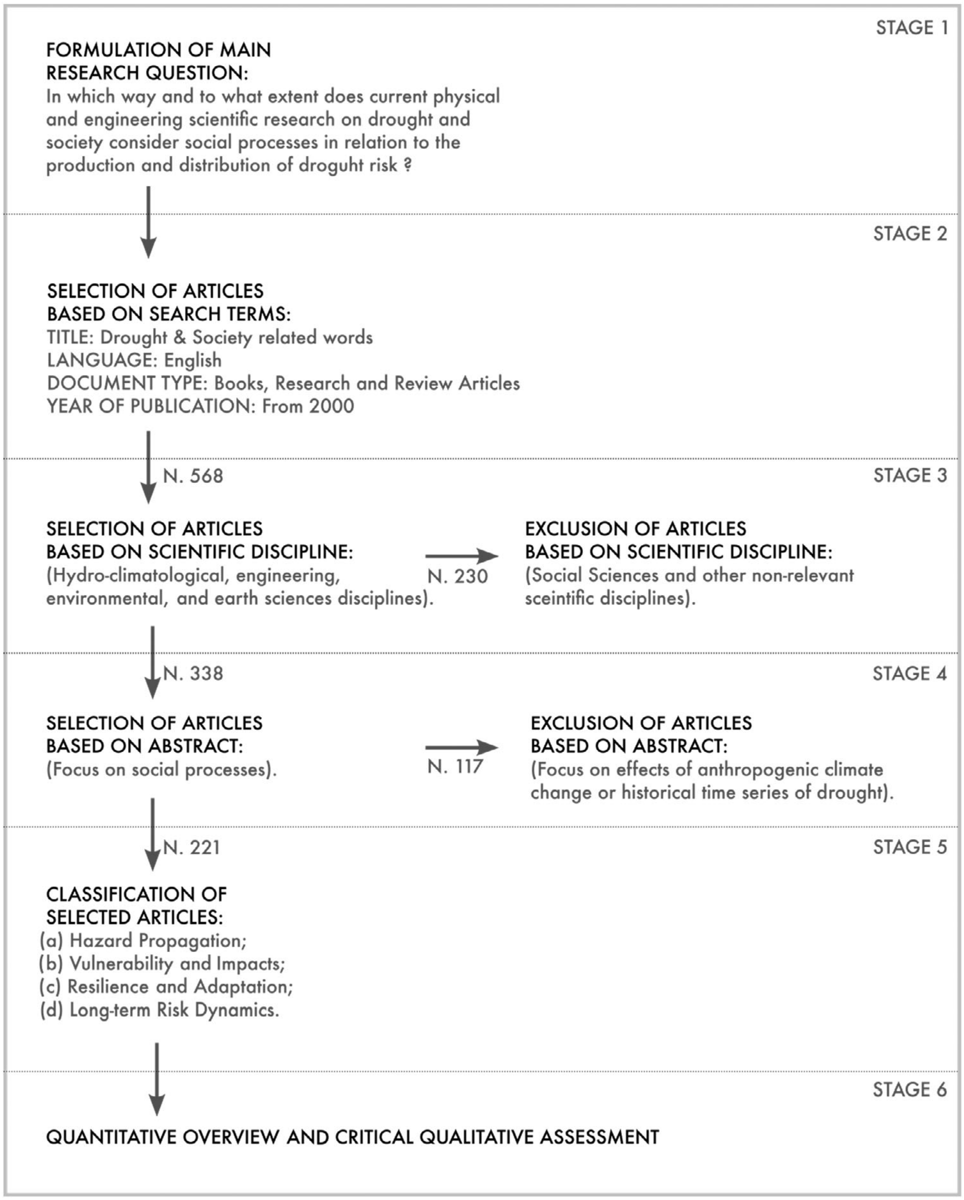

FIGURE 2 Systematic review methodology.*Source*: Readapted from Hasan et al. (2019)

capacities, and lastly (d) long-term dynamics between drought risk and society. In particular, category (a) includes contributions which discuss agricultural, hydrological, and socioeconomic droughts for they represent different phases of the propagation of drought hazard from a meteorological event into a socioeconomic drought. Category (b) includes studies on drought vulnerability and impacts, but also drought perception and discourses because of their influence on the manner in which drought is experienced both at the individual- and community-level. After classification, publications have been analyzed both quantitatively and qualitatively to disentangle anthropogenic processes along with examining the methodologies employed (Stage 6).

3 | RESEARCH TRENDS ON DROUGHT AND SOCIETY

Since the 1970s, social scientists have argued for the recognition of sociopolitical drivers in drought risk analyses (Garcia & Escudero, 1982; Meillassoux, 1974). However, drought research carried out by physical and engineering scientists, primarily focused on meteorological aspects, such as rainfall statistics and drought indices (Dolan, 1990; Dracup et al., 1980; Heddinghaus & Sabol, 1991; Heim, 2000; Maybank et al., 1995; Rossi et al., 1992; Sheffield & Wood, 2011;

Smakhtin, 2001; Tallaksen & Van Lanen, 2004). Only during the early 2000s these disciplines began to more significantly recognize the limitations of their approach to drought risk (see for instance, Mishra & Singh, 2010; Wilhite & Glantz, 1985). Concurrently, international organizations adopted social science perspectives in the field of disasters—including drought—emphasizing the role of social vulnerability (Revet, 2011). Furthermore, along with Crutzen's (2006) popularization of the term Anthropocene, physical and engineering scientists started considering humans as major agents of change (Sanderson et al., 2002). In line with this progress, several hydrologists have explored how human activities not only determine drought vulnerability and impacts, but also influence the propagation of drought from the atmosphere to the ground (AghaKouchak et al., 2015, 2021; Di Baldassarre et al., 2017; Garcia et al., 2016; Van Loon et al., 2016).

The quantitative analysis of engineering and physical sciences publications on drought and society reveals that over the last two decades, research has mostly considered social processes in relation to the impacts and manifestation of droughts. The assessment shows that about 64% of the reviewed literature conceptualizes society mostly as the system impacted, vulnerable, resilient, and/or adapting to drought events (Figure 3). Only 26% of the literature seeks to measure the extent to which society influences the duration and intensity of drought hazards. Most of these studies have retraced the different phases of drought hazard which hydrologists classify into agricultural, hydrological, and socioeconomic drought depending on which water is deficient and where. Fewer scholars (10%) have been retracing the long-term dynamics between society and drought risk. They employ longer time scales which exceed the timeframe of a drought, to study the ways drought events reshape society as well as the manner in which societal responses can, in the long term, alter the occurrence of future drought.

The focus of physical and engineering studies has changed over these two decades. During the last 5 years, greater attention has been placed on social processes that influence the occurrence of hydrological and socioeconomic drought (Figure 4). Drought impacts on society are also gaining growing consideration. Figure 4 reveals an increasing proliferation of articles focused on drought and society even when compared with the global rate of growth of scientific publications.[3] In fact, the number of articles focusing on drought and society has increased by a factor of 10 over the last 10 years.

The geographical analysis of the case studies reveals that China and United States alone cover about 40% of the studies (Figure 5). With a total of 87 articles, the two countries have been significantly more studied relative to any other geographical area. China and United States are followed by Australia, Brazil, and Spain which count respectively 13, 11, and 10 cases studies. These geographical patterns might partially be explained by the fact that those regions have been and continue to be exposed to severe drought conditions (Carrão et al., 2018; Meza et al., 2020). In particular,

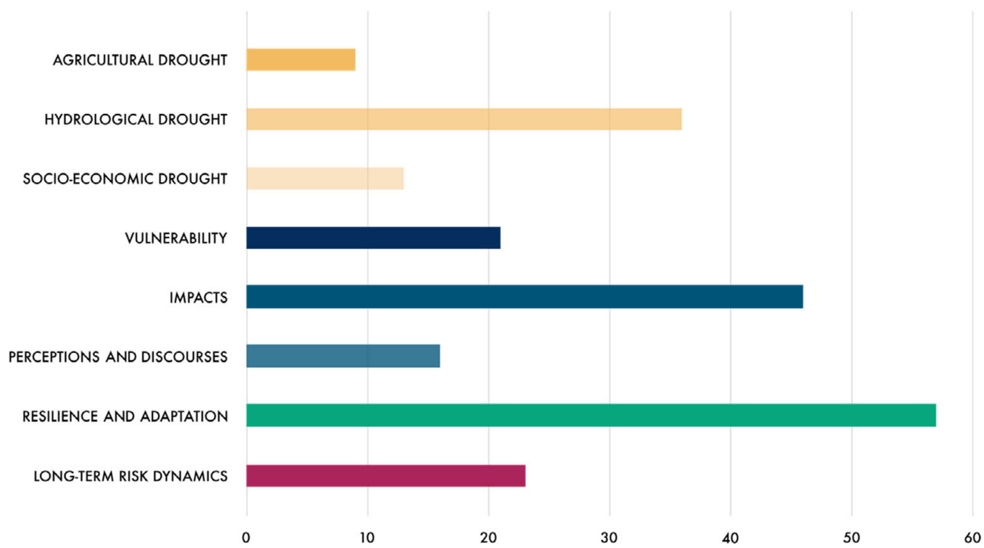

FIGURE 3 Thematic distribution of publications on drought and society. The *x* axis refers to the number of publications, while the *y* axis displays the category of the publications. The yellow bars refer to publications concerning hazard propagation including agricultural, hydrological, and socioeconomic drought (26%); the blue bars refer to drought vulnerability, impacts, perception and discourses (38%); the light green bar refers to drought resilience and adaptation publications (26%), and the magenta bar refers to publications about long-term risk dynamics of drought and society (10%)

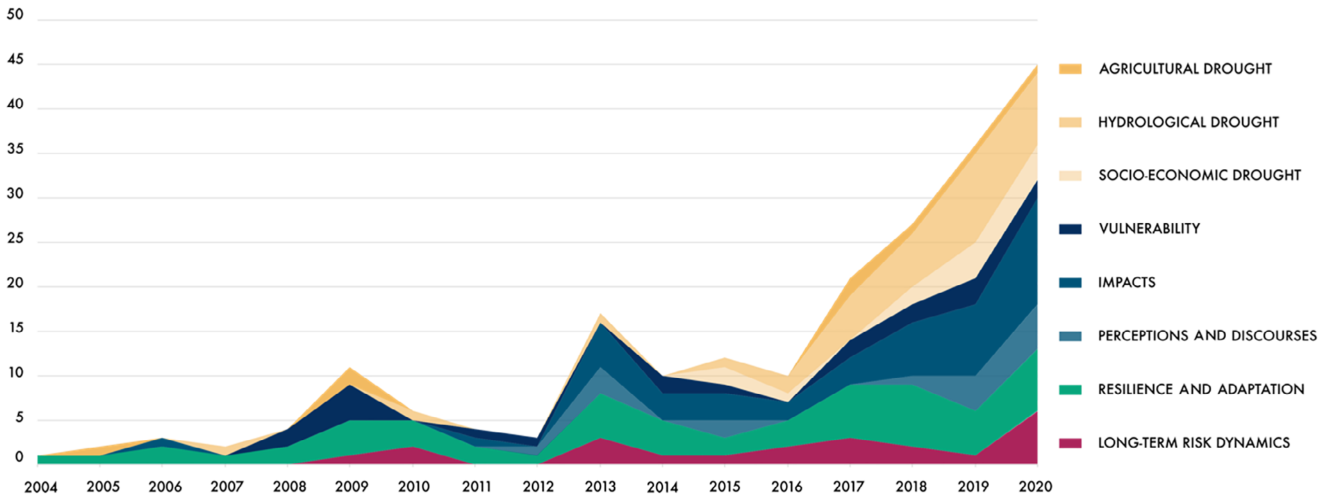

FIGURE 4 Progress in research on drought and society. The *x* axis refers to year of publication, while the *y* axis displays the publications' category. Yellow areas refer to publications concerning hazard propagation including agricultural, hydrological, and socioeconomic drought; blue area refers to drought vulnerability, impacts, perception, and discourses; the light green area refers to drought resilience and adaptation publications and, finally, the magenta area refers to publications about long-term risk dynamics of drought and society

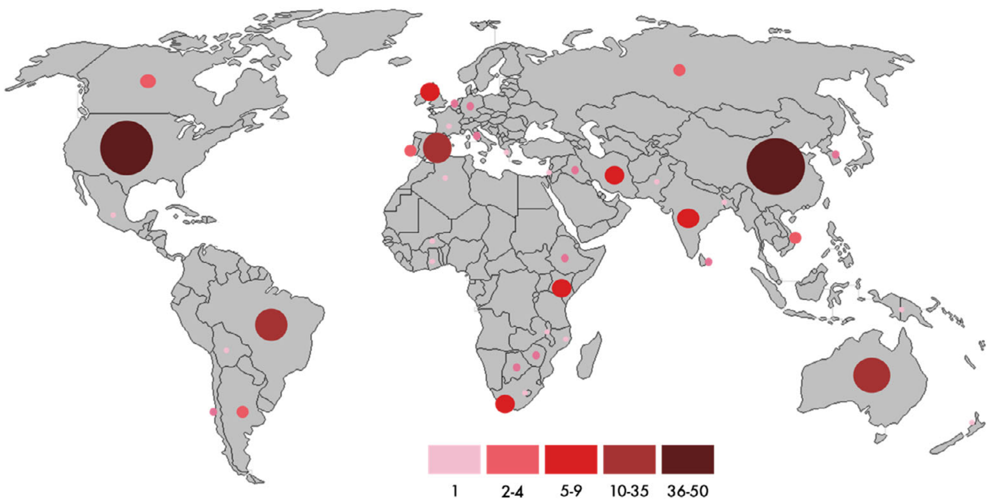

FIGURE 5 Geographical concentration of case studies. Both color and size of the circles correspond to the number of publications focused on a given geographical area

research on China has largely focused on the occurrence of socioeconomic and hydrological droughts. In contrast, publications based on case studies in the United States, Spain, Australia, and Brazil mostly aim at understanding drought related impacts along with processes of resilience and adaptation. Only 10 of the selected papers perform a global analysis, but the interest in this less explored research area has also grown over the last 5 years.

Overall, the latest publications along with the increased attention to drought impacts seem to reflect the growing concern that drought represents for society as a result of expanding anthropogenic pressures and human-induced climate change (AghaKouchak et al., 2015, 2021; Van Loon et al., 2016). More importantly, the latest publications recognize society as an active force rather than just a passive subject during the occurrence of drought events.

In the next sections, we perform an in-depth analysis of the literature as a way to understand how social processes are studied across drought-related physical and engineering sciences literature and unravel the reasons behind such an increasing interest in anthropogenic activities. In particular, the review closely examines the social processes that can influence the propagation from agricultural, hydrological, and socioeconomic drought. From there, the analysis unravels the processes that influence the production of vulnerabilities and the ultimate unfolding of drought impacts.

Subsequently, the focus shifts to the resilience and adaptation mechanisms that society develops during and/or after the occurrence of drought. Lastly, the review zooms out to understand the manner in which drought risk interact with society over a long-time scale.

4 | FROM DRY WEATHER TO WATER SHORTAGES: SOCIAL PRODUCTION AND PROPAGATION OF DROUGHT HAZARD

Over the last two decades physical and engineering scientists have increasingly focused their attention toward the influence that society exerts on the production of drought hazard and its propagation over time and across space (from meteorological, to agricultural, hydrological, and lastly socioeconomic drought). Initially, drought hazard was interpreted as a component of risk that society could not control, but only measure or predict (Salvador et al., 2021). Thus, drought propagation was considered a unidirectional process mostly influenced by catchment physical properties (e.g., geology and vegetation cover). Human processes remained confined at the downstream end of such propagation and were responsible of reshaping exposure, vulnerabilities, and impacts of the system affected by drought hazard. More recently, literature has shown that society influences also the propagation of the hazard itself (de Freitas, 2020; Jaeger et al., 2019; Lange et al., 2017; Omer et al., 2020; Taylor et al., 2009; Van Dijk et al., 2013; Van Loon et al., 2016).

The recognition of the role that humans play in the production and transformation of drought hazard represents a crucial scientific advance of recent studies on drought and society. Physical and engineering scientists' fundamental contribution has been to identify the major social processes that interfere with drought hazard alongside retracing the ways and extent to which social and hydro-climatological processes intertwine, transform themselves, and produce nonlinear propagations of drought. Explicitly or not, these studies conceptualize drought hazard as socioenvironmental rather than just hydroclimatic in that its propagation becomes as much a result of anthropogenic activities, as it is of climatic or geophysical processes (Taylor et al., 2009; Van Dijk et al., 2013).

Most of the recent contributions have focused on exposing the social processes that intersect with the transformation of a drought from a meteorological event, into soil moisture drought (Cook et al., 2009; Deo et al., 2009; Kandakji et al., 2021; Satgé et al., 2017; Taufik et al., 2020; Yang et al., 2017; Yu et al., 2018), hydrological drought (Al-Faraj & Tigkas, 2016; Jehanzaib, Shah, Kwon, & Kim, 2020; Jehanzaib, Shah, Yoo, & Kim, 2020; Liu et al., 2016; Somorowska & Łaszewski, 2017; Wada et al., 2013; Wan et al., 2017; Wanders & Wada, 2015; Wang, Duan, et al., 2020; Wang, Jiang, et al., 2020; Yang et al., 2020; Yuan et al., 2017), and ultimately, socioeconomic drought (Edalat & Stephen, 2019; Guo, Huang, Huang, Wang, Fang, et al., 2019; Guo, Huang, Huang, Wang, Wang, & Fang, 2019; Heidari et al., 2020; Huang et al., 2016; Liu, Shi, & Sivakumar, 2020; Liu, Zhang, et al., 2020; Mehran et al., 2015; Shi et al., 2018; Zhao et al., 2019). Across these studies, the social processes that engender or exacerbate drought propagation are usually proxied by the expansion of agriculture activities, population growth, urbanization, and industrialization, with agriculture seen as the most significant social driver across the various phases of drought propagation. Literature on soil moisture drought, for instance, argues that crops cultivation together with the grazing of pastures, constitute the prevailing reasons behind the reduction, conversion, as well as degradation of native soil and vegetation. In the long run, these agricultural transformations increase the amount of energy available on the surface of the land, alter local hydro-climatological processes and in turn, induce temperature anomalies alongside changes in evapotranspiration and precipitation rates even beyond the region of disturbance (Cook et al., 2009; Deo et al., 2009; Kandakji et al., 2021; Satgé et al., 2017; Taufik et al., 2020; Yang et al., 2017; Yu et al., 2018).

Hydrological drought studies argue that most of the artificial diversion, abstraction, and/or regulation of water resources that produce streamflow deficits are caused by irrigation for agriculture and to a lesser extent, by industrial and domestic water uses (Al-Faraj & Tigkas, 2016; Jehanzaib, Shah, Kwon, & Kim, 2020; Jehanzaib, Shah, Yoo, & Kim, 2020; Liu et al., 2016; Somorowska & Łaszewski, 2017; Wada et al., 2013; Wan et al., 2017; Wanders & Wada, 2015; Wang, Duan, et al., 2020; Wang, Jiang, et al., 2020; Yang et al., 2020; Yuan et al., 2017). Besides modifying the spatiotemporal distribution of hydrological processes, these anthropogenic activities also alter the quality of water and its biochemical characteristics with significant impacts on the entire process of drought propagation (Somorowska & Łaszewski, 2017).

More recently, socioeconomic drought scholars have closely investigated the condition in which the demand for water exceeds the available water supply (Edalat & Stephen, 2019; Eklund & Seaquist, 2015; Guo, Huang, Huang, Wang, Fang, et al., 2019; Guo, Huang, Huang, Wang, Wang, & Fang, 2019; Heidari et al., 2020; Huang et al., 2016; Liu, Shi, & Sivakumar, 2020; Liu, Zhang, et al., 2020; Mehran et al., 2015; Shi et al., 2018; Tu et al., 2018; Zhao et al., 2019).

Their works focus mostly on the ways artificial reservoirs change the spatial and temporal distribution of water resources and in turn, exacerbate or less frequently absorb, water shortages (Guo, Huang, Huang, Wang, Fang, et al., 2019; Guo, Huang, Huang, Wang, Wang, & Fang, 2019; Huang et al., 2016; Liu, Shi, & Sivakumar, 2020; Liu, Zhang, et al., 2020; Mehran et al., 2015; Shi et al., 2018; Tu et al., 2018; Zhao et al., 2019).

Concurrently, physical and engineering scientists have successfully quantified anthropogenic alterations of soil moisture, hydrological, or socioeconomic drought. One of the most significant assessments is Wada et al.'s (2013) global analysis which estimates that anthropogenic activities have intensified the magnitude of hydrological drought up to 500% worldwide (Wada et al., 2013). Other assessments of hydrological drought at smaller scales (i.e., regions or catchment areas) estimate that humans can induce a 200% more intense hydrological or socioeconomic drought (Al-Faraj & Tigkas, 2016; Jehanzaib, Shah, Kwon, & Kim, 2020; Jehanzaib, Shah, Yoo, & Kim, 2020; Liu et al., 2016; Somorowska & Łaszewski, 2017; Wan et al., 2017; Wanders & Wada, 2015; Wang, Duan, et al., 2020; Wang, Jiang, et al., 2020; Yang et al., 2020; Yuan et al., 2017). Analyses of soil moisture drought found that land cover changes can lead to twice as severe and/or three-times more frequent drought hazards than under pristine conditions (Taufik et al., 2020).

To quantify the influence that agriculture and other human activities have on the frequency, distribution, and/or propagation of drought hazard, physical and engineering scientists have mostly employed numerical indexes (Al-Faraj & Tigkas, 2016; Deo et al., 2009; Edalat & Stephen, 2019; Ghale et al., 2019; Guo, Huang, Huang, Wang, Fang, et al., 2019; Guo, Huang, Huang, Wang, Wang, & Fang, 2019; Huang et al., 2016; Jehanzaib, Shah, Kwon, & Kim, 2020; Li et al., 2019; Liu, Shi, & Sivakumar, 2020; Liu, Zhang, et al., 2020; Margariti et al., 2019; Mehran et al., 2015; Muhammad et al., 2020; Satgé et al., 2017; Shi et al., 2018; Tijdeman et al., 2018; Wan et al., 2017; Wang, Duan, et al., 2020; Wu et al., 2019; Xu et al., 2019; Yang et al., 2017; Zhao et al., 2019; Zou et al., 2018), statistical or geospatial analyses (Deo et al., 2009; Ghale et al., 2019; Jehanzaib, Shah, Kwon, & Kim, 2020; Kandakji et al., 2021; Liu et al., 2016; Liu, Zhang, et al., 2020; Mehran et al., 2015; Panda et al., 2007; Satgé et al., 2017; Wang, Duan, et al., 2020; Wang, Jiang, et al., 2020; Yang et al., 2017; Zou et al., 2018), and hydro-meteorological models (Cook et al., 2009; Firoz et al., 2018; Ghale et al., 2019; He et al., 2017; Jehanzaib, Shah, Yoo, & Kim, 2020; Jiang et al., 2019; Kakaei et al., 2019; Kingston et al., 2021; Margariti et al., 2019; Mehran et al., 2015; Muhammad et al., 2020; Taufik et al., 2020; Tu et al., 2018; Wada et al., 2013; Wan et al., 2017; Wanders & Wada, 2015; Wang, Duan, et al., 2020; Wang, Jiang, et al., 2020; Wu et al., 2019; Yang et al., 2017, 2020; Yu et al., 2018; Zhu et al., 2019). Common practice for capturing the human influence on drought propagation is to assess the changes of water contents, and other drought characteristics by comparing human modified with pristine or naturalized environments. While observation-based methods use empirical data (Rangecroft et al., 2019; Van Loon et al., 2019), model-based approaches artificially reproduce hydro-meteorological systems both under pristine or human-modified conditions and simulate the socioenvironmental processes of land use change, water management, regulation, and abstraction.

Recently, there has been an increasing use of satellite observations and remote sensing analysis that allows the collection of information over large geographical areas and to characterize data in terms of their hydro-climatological or geological features over long time scales. Societal processes are often implicitly incorporated as land cover changes, water resources abstraction, water storage, and regulation. Other social trends like population dynamics or GDP/economic growth usually serve to introduce or explain the genesis of socioenvironmental transformations. However, neither hydrological models nor statistical analyses explicitly account for or demonstrate the existence of a direct link between population or economic growth and increased human pressure on local—hydro-climatological—conditions. The acceptance of such dynamics without a thorough exploration of the mechanisms that drive socioenvironmental propagation of drought, simplify and depoliticize social processes.

Although such processes remain largely unexplored, the context and description of the case studies provide relevant information to better understand societal characteristics and dynamics. Several cases point to rapid economic development as the major process at the root of unsustainable uses and alteration of water sources. Many of those instances suggest that agriculture becomes unsustainable as a result of the global economy that requires productive and competitive farming at a global scale (Yu et al., 2018). The Dust Bowl that affected North American Great Plains during 1930s is a common example of an extreme drought event that resulted from unsustainable agricultural practices driven by the overexpansion of the economy (Cook et al., 2009; Kandakji et al., 2021). Satgé et al. (2017) explore a more recent transformation of the agricultural sector in Bolivia. Their study shows that for about 10 years (2005–2015), the replacement of native vegetation with intensive quinoa production has accelerated the desertification process across many regions and completely dried up one of Bolivia's largest lakes (Satgé et al., 2017). Like with the production of cotton in the Dust Bowl, in this case, the production of quinoa became unsustainable as a result of increased (international) demand and market prices. Dai et al.'s (2010) work quantifying human interference on the Yangtze River in China, reaches similar conclusions. Their work suggests that humans have rapidly and extensively changed local ecosystems to boost economic development and meet the demand of international and national markets.

Overall, these case studies link the needs for expansion of the global economy with the increasing occurrence of socioenvironmental droughts. Yet, across their analyses, society is reduced to an "undifferentiated whole" (Moore, 2017, p. 595), a homogeneous entity that, by growing economically and demographically, will inevitably consume more water. This conceptualization conceals a heterogeneous reality where society's economy grows unequally and water is consumed at different rates by diverse social groups (Savelli et al., 2021). This means that only some social groups are responsible for the pressure exerted on hydro-climatological process and, in turn, for aggravating drought hazard and its propagation from a meteorological into a socioeconomic drought. Furthermore, the development and use of water infrastructure are always intertwined with complex political and economic interests which make the infrastructure's benefits and costs unevenly distributed across different social groups (Kaika, 2006; Molle, 2006; Rusca et al., 2019; Savelli et al., 2021; Tiwale et al., 2018). These dynamics are not fully considered in these studies, which generally focus on the correlation between modified inflow, outflow, and water storage with the occurrence of socioenvironmental drought. The alterations of water flows, however, are not the causes but rather the symptoms of anthropogenic changes.

5 | FROM HAZARD TO RISK: THE SOCIAL PROCESSES THAT RESHAPE DROUGHT VULNERABILITY AND IMPACT

Drought hazard becomes risk when, throughout its propagation, it affects socioenvironmental systems that are vulnerable to such hazard. Only then, droughts can impact society. Thus, literature that focuses on drought vulnerabilities and its impacts is that which more closely examines the relationship between drought hazard and society.

In the earliest physical and engineering studies, vulnerability was mostly considered as a function of biophysical and technological factors (Gibb, 2018). This conception often assumed that scientific expertise and technological solutions were the most suitable options to reduce vulnerabilities and therefore risk. Consecutively, in response to the ineffectiveness of technical interventions, social scientists have advanced novel conceptualizations of vulnerability that diverged from the dominant physical science discourse and considered more socially aware interpretations of risk. These critical works rejected one-dimensional and static understandings of vulnerability explaining it as a function of both biophysical and socially constructed conditions (Bankoff, 2001; Blaikie et al., 2004; Brookfield, 1999; Hewitt, 1983). Gradually, both the influence and increased collaborations with social scientists have contributed to enrich physical and engineering studies on drought vulnerability. Most of the works examined in this review try either to assess the level of vulnerability of an affected system or to retrace its underlying causes. In doing so, these interdisciplinary efforts have contributed to unearthing the major social processes at play in the production of vulnerability. At the same time, these studies recognize the heterogeneity of society and the implications thereof (Acosta-Michlik et al., 2008; De Silva & Kawasaki, 2018; Dumitraşcu et al., 2018; Taenzler et al., 2008; Tubi, 2020; Yaduvanshi et al., 2015).

Few researchers have conducted in-depth examinations on the social production of drought vulnerabilities and their close relation to the global political-economic system (Acosta-Michlik et al., 2008; Eriksen & Silva, 2009; Tubi, 2020). Their studies show that while on the one hand, increasing levels of international trade and commercialization have boosted economic growth worldwide. On the other hand, such political-economic transformations have brought about commodity price fluctuation, concentrated capital availability among fewer hands, reduced formal employment opportunities, alongside triggering unfair competition over access to land and natural resources. Thus, even though in the immediate occurrence of a drought, poor farmers or households might be facilitated by the market, in the long-term, the increased competition and fluctuation of prices will most likely undermine their livelihoods. These dynamics imply that the global economic system can exacerbate people's vulnerabilities to drought, by locking them into unsustainable survival strategies with adverse consequences for their long-term livelihood and economic security (Eriksen & Silva, 2009).

The (in)ability of the market to provide socioeconomic security during droughts is often associated with performances of national or local governance. Some articles use the term state capacity to describe the ability of governance processes to provide key public goods and services to all segments of society under severe drought conditions (Acosta-Michlik et al., 2008; Eriksen & Silva, 2009; Taenzler et al., 2008; Tubi, 2020). Thus, the interweaving of market processes and state capacities is at the genesis of drought vulnerabilities (De Silva & Kawasaki, 2018; Dumitraşcu et al., 2018;

Liu & Chen, 2021). In particular, these analyses highlight the uneven distribution of vulnerabilities alongside predicting that future droughts will be much more alarming for the least advantaged and already vulnerable populations.

Disciplinary works have placed most of their efforts into measuring vulnerabilities to drought across different socioenvironmental systems. These assessments represent useful references for policymakers for they visualize and capture different degrees of vulnerability. Among those studies, vulnerability is expressed through data-driven indicators or indexes that represent the socioeconomic conditions of the system affected by drought (Antwi-Agyei et al., 2012; Boultif & Benmessaoud, 2017; Gil et al., 2011; Liu & Chen, 2021; McNeeley, 2014; Naumann et al., 2019; Taenzler et al., 2008; Wang, Qiao, et al., 2020; Yaduvanshi et al., 2015). Datasets include population density, demographics, economic growth, agricultural or industrial development, GDP per capita, percentage of population accessing to welfare policies, level of education, infrastructure availability, and so on. When the system affected by drought is a rural area and/or heavily relies on agriculture, researchers employ specific indicators to measure cropping patterns, livestock, harvesting yields, and irrigation (Antwi-Agyei et al., 2012; Gil et al., 2011). More recently, satellite observations have become common tools to show the expansion of cropland, livestock or human settlements, and their relative socioeconomic vulnerabilities (Bhavani et al., 2017; Naumann et al., 2019; Yaduvanshi et al., 2015).

While essential to visualize and quantify vulnerability, these indicators or indexes have a number of disadvantages. First, they are contingent upon the availability of data, which means that the proxies selected might not always be the most appropriate to represent the vulnerabilities of certain contexts. Second, indicators indiscriminately merge distinctive social processes into a unique variable. In doing so, they hinder more nuanced understandings of the social relationships and processes that engender drought vulnerabilities. For instance, most indicators represent average values of socioeconomic characteristics, thus they overlook heterogeneity and its implications. Last, indexes can remain superficial if they fail to capture nonquantifiable social conditions. To overcome these limitations, researchers usually employ statistical tools to better correlate local vulnerabilities with socioeconomic indicators (Antwi-Agyei et al., 2012). McNeeley (2014) has combined vulnerability indicators with on-the-ground assessments of drought experiences.

Literature on drought impacts faces similar limitations in that scientists often define impacts as observable socioeconomic losses or changes that expand themselves over time and across space (Bachmair et al., 2016; Bahinipati, 2020; Freire-González et al., 2017; Gil et al., 2013; Jenkins, 2013). Observable changes are thus mostly quantitative assessments which are unable to express experiences of drought in their full complexity.

Most literature on drought impacts engages exclusively with the effects that drought causes on agricultural systems (Bahinipati, 2020; Bosongo et al., 2014; Ding & McCarl, 2020; Forni et al., 2016; Gil et al., 2013; Jenkins, 2013; Lin et al., 2013; Lopez-Nicolas et al., 2017; Musolino et al., 2017, 2018; Redondo-Orts & López-Ortiz, 2020; Salite & Poskitt, 2019; Salmoral et al., 2019; Ward et al., 2006; Yokomatsu et al., 2020). Generally, these papers assess the economic impacts which result from reduced crop production and agricultural growth alongside the disruption of the annual harvesting cycle. Their analyses investigate the relationship between different hydro-climatological alterations brought about by drought events, the amount of water available for agricultural production, and the resulting micro- or macro-economic implications. The secondary or long-term impacts related to changes in agricultural production are measured as changes in the agri-food industrial gross value added and in agricultural employment.

Agricultural impacts are often assessed through mathematical models that simulate economic changes or losses using linear and nonlinear equations combining socioeconomic aspects with different measurements of drought (Daneshmand et al., 2014; Ding et al., 2011; Forni et al., 2016; Freire-González et al., 2017; Gil et al., 2013; Jenkins, 2013; Lin et al., 2013; Lopez-Nicolas et al., 2017; Maia et al., 2015; Wang et al., 2015; Yokomatsu et al., 2020). The models most commonly used are computable general equilibrium models or input–output models (Ding et al., 2011; Freire-González et al., 2017; Gil et al., 2013; Jenkins, 2013; Lin et al., 2013; Wang et al., 2015). They both try to capture the casual chains that transform water shortages (precipitation, soil moisture, surface, or groundwater) into direct and ultimately indirect impacts within a specific region and/or sector—that is, the agri-food and its related industries. The main objective of these models is to maximize economic benefit, production value, or the utility of water within a sector or geographical area (Daneshmand et al., 2014; Ding & McCarl, 2020; Forni et al., 2016; Lin et al., 2013; Ward et al., 2006). Similar assessments can be problematic for two main reasons. First, they are unable to capture the differences among farmers cultivating in the same geographical area, thereby equating impacts of smallholders with those of large-scale industrial farmers. Second, these economic evaluations confine scientific understandings of drought impact to economic variables which only partially reflect the complexity of drought related impacts. When used in isolation, technocratic and efficiency-oriented approaches to study the impacts of drought may perpetuate or even exacerbate unsustainable socioenvironmental dynamics—such as intensive agricultural production—because these approaches fail to engage with the root causes of drought impacts.

While most of the disciplinary literature performs quantitative assessments of agricultural production, interdisciplinary works have recently expanded the analysis to incorporate also intangible impacts of drought (Quandt, 2019; Towler et al., 2019; Wu et al., 2018; Yun et al., 2012). These analyses focus on perceptions of drought which, despite their immaterial nature, can change the manner in which society experiences a drought. A distinct section of those studies examines collective perceptions of drought exploring the manner in which they play out at different scale eventually reshaping future phenomena (Bryant & Garnham, 2013; Müller, 2020; Nash et al., 2019; Paneque Salgado & Vargas Molina, 2015; Ruiz Sinoga & León Gross, 2013; Sarmiento et al., 2019; Smith et al., 2020; Sullivan & White, 2020; Tang et al., 2015). In some instances, powerful actors can impose their ideas, steer public discourses, and reshape public perception of drought (Paneque Salgado & Vargas Molina, 2015). More recently, this powerful role is frequently played by social media (Ruiz Sinoga & León Gross, 2013; Smith et al., 2020; Tang et al., 2015).

Collectively, literature on drought impact has shown the implications of the slow onset and long-term propagation of drought hazards. Yokomatsu et al. (2020) state that drought affected areas experience drought impacts only when the drought has already occurred or the consequences of water shortage have already spread to other regions. Such a delayed and prolonged manifestation causes additional and protracted interactions between the propagation of drought and socioenvironmental systems affected. This explains also why impacts are not directly proportional to drought hazard but mostly conditioned by the socioenvironmental processes that characterize the systems affected (Haigh et al., 2019; Salmoral et al., 2019).

6 | FROM IMPACTS TO RECOVERY? SOCIAL RESILIENCE AND ADAPTATION TO DROUGHT

Socioenvironmental systems have different inherent, acquired, or granted capacities to cope with or recover from the adverse implications of drought events. Resilience is the term that most commonly describes the ability of a socioenvironmental system to absorb, adapt to, or recover from drought impacts yet at the same time, retaining its original structure and way of functioning (Wreford & Adger, 2010). While resilience is a rather conservative feature of a socioenvironmental system, adaptation instead is the capacity that the system has to transform itself and influence its future resilience to drought (Pelling, 2010).

Drought resilience and adaptation literature have identified the adaptation strategies that are usually adopted across different agricultural or rural settings (Booker et al., 2005; Chen et al., 2014; Hurlbert & Gupta, 2019; Laforge & McLeman, 2013; Makaya et al., 2020; Medeiros & Sivapalan, 2020; Mwangi, 2019; O'Farrell et al., 2009; Sapountzaki & Daskalakis, 2018; van Duinen et al., 2016; Wenger et al., 2017; Yila & Resurreccion, 2014; Zipper et al., 2017). One of the oldest strategies is the transhumance or seasonal migration toward new climatic regions. Farmers can also change their livestock, diversify their crops using drought-resistant species, and eventually rotate their cultivations to follow drought-resilient patterns. Another common drought response is the adoption of water conservation measures that can either increase the amount of water available for farming or improve the efficiency of the farmers' irrigation practices. When these solutions are not possible or sufficient, farmers rely on financial solutions to diversify their sources of income, buy drought-insurances, or develop new infrastructure (Carrico et al., 2019; Chen et al., 2014; Downard & Endter-Wada, 2013; Laforge & McLeman, 2013; Lindoso et al., 2018; Moore et al., 2018; Mwangi, 2019; Ranjan, 2014; Wreford & Adger, 2010).

With yet a prevalent interest on agricultural practices, other resilience and adaptation studies have advanced understanding over the major social factors that enhance resilience and adaptation potentials (Carrico et al., 2019; Chen et al., 2014; Downard & Endter-Wada, 2013; Echeverría, 2020; Kruse & Seidl, 2013; Laforge & McLeman, 2013; Li et al., 2012; Moore et al., 2018; Pendley et al., 2020; Ranjan, 2014; Sapountzaki & Daskalakis, 2018; Su et al., 2017; Wenger et al., 2017; Wiener et al., 2016; Wreford & Adger, 2010; Yila & Resurreccion, 2014). Socioeconomic status, previous experiences of drought, access to social capital, and gender are the most investigated aspects both at individual and household level. Interdisciplinary work recognizes that at this scale, there is no such thing as uniform adaptation potential because more powerful groups and/or individuals disproportionately accumulate high resilience and adaptation capital while at the same time reducing the opportunities of the powerless to adapt (Sapountzaki & Daskalakis, 2018).

Most of the literature uses quantitative surveys, statistical analyses, and mathematical models to measure resilience levels and estimate the correlation between prevailing adaptation strategies and socioenvironmental characteristics of the area (Carrico et al., 2019; Chen et al., 2014; Du et al., 2018; Gonzales & Ajami, 2017; Hund et al., 2018; Lindsay et al., 2017; Moore et al., 2018; Pendley et al., 2020; Quiroga et al., 2011; Sapountzaki & Daskalakis, 2018; Su et al., 2017; van Duinen et al., 2016; Yates et al., 2013; Yila & Resurreccion, 2014). Sociohydrological studies apply numerical models to simulate adaptive behaviors of different stakeholders and their long-term socioenvironmental dynamics (Hund et al., 2018; van Duinen et al., 2016; Wens et al., 2019). Interdisciplinary examinations often employ qualitative methods to elaborate deeper investigations about local contexts and historical trajectories (Downard & Endter-Wada, 2013; Du et al., 2018; Hurlbert & Gupta, 2019; King-Okumu et al., 2018; Laforge & McLeman, 2013; Lindsay et al., 2017; Makaya et al., 2020; Mwangi, 2019; Sousa Júnior et al., 2016; Wiener et al., 2016).

What distinguishes resilience and adaptation studies from the other literature on drought are the bodies of work they belong to. Besides sociohydrologic and water resources management studies, most of the works engage with socio-ecological system theory, or disaster risk reduction and climate adaptation. Such analyses differ from other literature for they offer techno-managerial solutions and policy advice rather than just retracing the socioenvironmental processes that produce resilience or influence adaptation strategies. Some studies use their analyses to define a set of tools aimed at building more resilient governance systems and institutions or developing innovative adaptation strategies for future drought events (Du et al., 2018; Hurlbert & Gupta, 2019; King-Okumu et al., 2018; Lordkipanidze et al., 2015; Nguyen et al., 2021; Sousa Júnior et al., 2016; Sullivan et al., 2019; Vignola et al., 2018). Other studies devote their effort to design novel analytical frameworks that support policy making alongside natural resources or risk managements practices (Bettini et al., 2013; Habiba et al., 2011; Harou et al., 2010; Hund et al., 2018; Loch et al., 2020; Yates et al., 2013).

The instrumental and at the same time, prescriptive character of such works tends to favor apolitical and pragmatic explanations of drought resilience and adaptation strategies. Apolitical analyses usually provide observable and proximate causes of issues or phenomena —that is, the behavior of local farmers in grazing or cultivating (Mollinga, 2008). Thus, instrumental literature tends to ignore the power relations that trigger and play out in particular policies or interventions. Despite being appealing for policy makers and other professionals, similar apolitical explanations and their relative techno-managerial solutions place the onus on individuals and communities to be resilient and adapt to the logics of the global political-economic system of production (MacKinnon & Derickson, 2013). In doing so, drought resilience and adaptation literature end up privileging the current political-economic order, which is shaped by and continuously reproduce unequal and unsustainable socioenvironmental patterns. More politicized investigations of drought adaptation and resilience could further understandings and unravel the underlying causes of more or less resilient socioenvironmental systems (Pelling, 2010).

7 | FROM INTERACTIONS TO CO-EVOLUTION: THE LONG-TERM DYNAMICS OF DROUGHT RISK AND SOCIETY

The social components of drought risk tend to be mostly examined within the timescale of a particular drought event. Only some of the literature zooms out to retrace long-term dynamics of drought and society interplay thereby providing useful insights on the manner in which society and drought risk co-evolve over longer time-scales (Breyer et al., 2018; de Carvalho Alves et al., 2020; Di Baldassarre et al., 2017; D'Odorico et al., 2010; Guevara-Murua et al., 2018; Kaniewski et al., 2015; Kuil et al., 2016; Lucero et al., 2017; McLeman et al., 2010; Sear et al., 2020; Xiao et al., 2013). The relevance of these analyses stems from the unexpected dynamics that they are able to investigate. These works reveal how the same sociotechnical interventions that are meant to absorb drought risk can, in the long term, make society (or at least part of it) much more sensitive to droughts and other risks (Breyer et al., 2018; Di Baldassarre et al., 2017; Kuil et al., 2016). Reservoirs, for example, are built to increase water availability and reduce risk of future shortages. Nevertheless, long-term dynamics reveal that social groups that are reliant on reservoirs for water provision, in the long run, become more vulnerable to drought than their counterparts (Di Baldassarre et al., 2017; Kuil et al., 2016). Even water restriction measures that should reduce human pressure on water resources can have negative impacts. Breyer et al. (2018) argue that reduced water use can contract the amount of water flowing downstream and in turn, compromise the ability of both vegetation and streamflow to recover from drought conditions.

Another unexpected development that this line of inquiry has shed light on relates to the long-term effects of globalization and economic liberalization. Few studies warn that despite short-term economic benefits, over time the global political-economic system might produce riskier than usual drought (Breyer et al., 2018; D'Odorico et al., 2010). Generally, the long-term risk dynamic literature has diagnosed the current modes of production, trade, and globalization as key factors that shape drought propagation over time. Significant in this respect is the study of D'Odorico et al. (2010), which focuses on the relationships between drought and food industry, the most water intense sector. Like other

TABLE 1 Main findings of the review

	Scientific methods	Social processes	Scientific contribution	Main criticism
Hazard propagation	- Numerical indexes; - Statistical and/or geospatial analyses; - Hydrometeorological and sociohydrological models.	- Agriculture and to a lesser extent, industrial and domestic water uses; - Economic growth; - Population growth.	- Recognize the role that humans play in the propagation of drought hazard; - Retrace manners in which society reshapes the propagation of drought hazard; - Assess the extent to which society reshape the propagation of drought hazard.	- Incomplete or superficial understanding of social processes; - Society results simplified and reduced to a homogenous entity; - Apolitical analyses ignore the power relations that trigger drought propagation.
Vulnerability and impacts	- Indicators or data-driven indexes; - Statistical and/or geospatial analyses; - Numerical models; - Interdisciplinary engagements with social sciences.	- Agricultural production and to a lesser extent, urban activities; - Global economic system of production, trade, and commercialization.	- Identify major social processes at play in the production of vulnerabilities; - Identify major social impacts and dynamics resulting from drought events; - Provide heterogenous portrayals of society; - Reveals the slow-onset and long-term implications of drought propagation; - Recognize that impacts are not directly proportional to hazard but mostly conditioned by socioenvironmental processes and conditions of systems affected.	- Quantitative assessments provide superficial and partial representation of social processes and conditions; - Almost exclusive engagement with agricultural systems; - Prevailing focus on economic productivity restrains scientific assessments of drought impacts to economic variables.
Resilience and adaptation	- Quantitative surveys; - Statistical analyses; - Numerical and sociohydrological models; - Interdisciplinary engagements with social science.	- Socioeconomic status; - Social capital; - Gender; - Previous experiences of drought; - Governance and Institutions.	- Identify the most common adaptation strategies; - Provide extensive review of major factors that enhance resilience and adaptation potentials; - Measure and assess resilience levels; - Investigate the dynamic nature of human adaptation over long-time scales.	- Disproportionate focus on agricultural systems; - Apolitical analyses ignore power relations.
Long-term risk dynamics	- Sociohydrological models; - Interdisciplinary engagement with social sciences.	- Affluence and economic growth of restricted social groups; - Global economic system of production, trade, and commercialization; - Infrastructure development.	- Provide useful insights about the manner in which society and drought risk co-evolve over time and across space; - Reveal unexpected dynamics resulting from the interactions between drought risk and society; - Account for drought risk and society coevolution.	- Apolitical analyses ignore power relations.

Note: The table summarizes the major findings resulting from the examination of the physical and engineering scientific publications on drought and society. The table follows the same classifications discussed in the review, that is, (a) hazard propagation, (b) vulnerability and impacts, (c) resilience and adaptation, (d) long-term risk dynamics. The four columns summarize the most relevant scientific methods employed, main social processes identified, major scientific contributions, and primary criticism for each category.

sectors, the food industry has also been transformed by processes of globalization and market liberalization which have caused a disconnection between consumers and the availability of water resources. As a result, if any country has constraints in producing food, they can import their products from any other area that have means and resources to produce in exceedance. International trade of food brings about also virtual trade of water resources. In the short term, this trade can compensate for local water deficit and avoid the occurrence of food shortages and famine. However, in the long run, the global interconnectedness between food markets and water resources becomes unsustainable and engenders a disproportionate growth in water-poor regions (D'Odorico et al., 2010).

Last, an interdisciplinary study on long-term risk dynamics examines the manner in which social power can reshape drought events (Breyer et al., 2018). The research posits that society's political-economic system, by concentrating disproportionate wealth within one restricted group, gave them the ability to use resources unsustainably and eventually trigger more severe drought conditions. According to Breyer et al. (2018), it is exactly the uneven affluence that drives water stress especially amid drought event. The most affluent neighborhoods in Austin, USA consumed unsustainable amounts of water prior to the drought, reduced water use the most during the drought and in turn, saw the least relative recovery in vegetation. Conversely, in less affluent areas the vegetation drought recovery was more pronounced in that these areas tend to use less water outdoors (Breyer et al., 2018). These results indicate that in the long term the main driver of water withdrawals was not population growth or the general growth of Austin economy, but rather the economic growth of a restricted social group.

8 | DISCUSSION AND CONCLUSIONS: TOWARD CRITICAL EXPLORATIONS OF DROUGHT AND SOCIETY INTERPLAY

The interplay between drought and society has occurred since the beginning of human civilization, yet these interactions have become more intense and the consequences increasingly extensive. To reveal how today's society plays a more dominant role in the production and distribution of drought risk, this review has examined 221 scientific papers on drought and society that have been published over the last two decades. Table 1 summarizes the major findings.

Overall, physical and engineering scientists have recognized and, more importantly, quantified the prominent role that humans play in the propagation of drought hazard. Furthermore, by acknowledging the slow onset and long-term impacts of drought hazard, these studies have notably recognized that the unfolding of drought impacts is not directly proportional to the hazard but mostly conditioned by the socioenvironmental processes and characteristics of the systems affected by drought. Another significant contribution is the recognition of long-term interactions and co-evolution between drought risk and society. Explorations of drought risk and society interactions over long-time scales are crucial for they reveal unexpected or counterintuitive dynamics that are often detrimental for the socioenvironmental systems involved. Thus, even though each scientific publication holds different and, at times, conflicting perspectives, all together their analyses characterize droughts as socioenvironmental rather than just hydro-climatological events.

The large majority of the studies associate human activities with agricultural production in that crops cultivation or grazing of pasture require unsustainable amount of water and very often, lead to the degradation of soil and vegetation. What also emerges from most of the analyses is that the unsustainability of agricultural activities often originates from current modes of production, trade, and commercialization. However, physical and engineering scientists attribute the increasing human pressure on hydro-climatological processes to population and economic growth rather than the political-economic regimes that reshape agriculture alongside most social processes. In doing so, they tend to depoliticize social processes while also promoting a Malthusian portrayal of drought and society interplay—one that considers the exponential growth of population as the major factor to cause the Earth's inability to provide food and resources for humanity. Yet, in the neoliberal world we live in, it is not population growth to cause poverty or starvation but rather the unequal distribution of the wealth and its accumulation by a restricted social group (Breyer et al., 2018).

Across the publications reviewed, the sociotechnical and political-economic mechanisms that drive human activities and their interactions with hydrometeorological processes are mostly ignored or rather displaced into the terrain of their symptoms that need to be managed—that is, water shortages, soil degradation, and reduced agricultural productions. These reductionist interpretations locate solutions into technical, techno-managerial, and institutional practices that seek to escape the consequences of the current political-economic system, while at the same time preserving it (Swyngedouw, 2019).

Here we argue that one reason behind this resistance in engaging with social power stems from the formative experience of most physical and engineering scientists, which is based on positivist theories and beliefs. Positivism (in its broader sense) asserts that the only valid knowledge is the one that can be observed, measured, or experimented. Yet, as we have shown throughout our analysis, not all social processes can be quantified or experimented. In fact, even though numerical models or data-driven indexes have been able to capture the intensity of drought hazard and impacts, they have also overlooked the complexity of their drivers and lack the potential to capture the power relations underlying those drivers. Often, quantitative methods inconsiderably merge distinctive social processes into a unique variable, and in turn, hinder the understanding of such complexities.

This observation leads to the last point of this discussion, which examines the manner in which physical and engineering scientists portray society. Literature on drought and society describes people (and the environment) as potential victims of drought impacts alongside acknowledging the disproportionate effects of droughts on less privileged and disadvantaged social groups. The same literature also invokes humanity as the main agent responsible of socioenvironmental transformations and ultimately, drought manifestations. However, society is not homogeneous nor every individual or social group has the same ability to interact with and reshape hydro-meteorological processes (Savelli et al., 2021). Thus, terms like human or anthropogenic pressure to describe current or future manifestations of drought, cut across ideological and social differences, but also obscure the disproportionate agency of privileged subjects relative to the most vulnerable ones (Acha, 2020; Swyngedouw, 2019).

Ultimately, this review argues that it is not possible to draw a complete picture of drought current and future crises without considering the structural and historical systems of power that form a heterogenous society and engender most socioenvironmental processes (Acha, 2020). Without this understanding, drought and society studies are unlikely to capture where and why unsustainable patterns or cumulative dis/advantages are reproduced and exacerbated (Rusca & Di Baldassarre, 2019). Throughout this review, we have shown that interdisciplinary engagements with critical social sciences have proved helpful in explaining the manners in which drought risk is socially constructed and distributed. In fact, critical social science theories are able to relate distinctive power dynamics with the uneven distribution of drought risk alongside retracing the prominent roles that most powerful actors and ideas play in reshaping development trajectories and as a result, anthropogenic drought (Lövbrand et al., 2015; Rusca et al., 2021; Zwarteveen et al., 2017). In addition to this, critical social sciences offer multiple ways of knowing and represent a valid alternative to positivist traditions of knowledge (Haraway, 1988). Thus, we call for more interdisciplinary conversations between physical or engineering scientists and critical social scholars to foster politically aware explorations of drought and society. This will eventually offer more sophisticated ways to deal with the role of politics in shaping human–environment relations (Walker, 2007).

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

AUTHOR CONTRIBUTIONS

Elisa Savelli: Conceptualization (lead); data curation (lead); formal analysis (lead); investigation (lead); methodology (lead); visualization (lead); writing – original draft (lead); writing – review and editing (lead). **Maria Rusca:** Conceptualization (supporting); formal analysis (supporting); supervision (lead); writing – original draft (supporting); writing – review and editing (supporting). **Hannah Cloke:** Conceptualization (supporting); methodology (supporting); supervision (supporting); writing – review and editing (supporting). **Giuliano Di Baldassarre:** Conceptualization (supporting); funding acquisition (lead); methodology (supporting); supervision (supporting); writing – review and editing (supporting).

DATA AVAILABILITY STATEMENT

The authors confirm that the data supporting the findings of this review study are available within the article.

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ENDNOTES

[1] Societally relevant words selected for this review were: society, social, societal, socio-, human, Anthropocene, anthropogenic, politic, power, governance, psycho-, economic, justice, cultur-, gender, history, religio-, hydrosocial.

[2] The presence of these additional publication is explained by the fact that the world anthropogenic and history were among the Web of Science selection criteria.

[3] The National Science Board of the National Science Foundation reports that science and engineering publications have increased by a factor of 1.45 over the last decade (https://ncses.nsf.gov/pubs/nsb20206/data#figure-block).

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How to cite this article: Savelli, E., Rusca, M., Cloke, H., & Di Baldassarre, G. (2022). Drought and society: Scientific progress, blind spots, and future prospects. *Wiley Interdisciplinary Reviews: Climate Change*, e761. https://doi.org/10.1002/wcc.761