Questions of justice in hydrological extremes: advanced review

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Abstract: Current geographies of hydrological risk are rooted in deep inequalities. Every year more than 100 million people are stricken by hydrological extremes, which disproportionally affect low-income and marginalized groups. The severity and the frequency of floods and droughts have often increased as a result of climate and socio-economic changes. In addition to the impacts produced by the event, hydrological extremes also compromise the future of affected communities. The production and distribution of hydrological risk thus raises important questions of justice. Although critical studies have developed different conceptual tools to define and capture how power manifest through unjust water flows, there remains a gap in understanding how this power intersects with hydrosocial extremes and results in disproportionate experiences of drought and flood events. Drawing on different perspectives of justice, this paper reflects on what justice entails in the context of hydrological risk. It argues that understanding injustices in hydrological extremes requires unravelling the dynamics of risk emerging from the mutual shaping of hydrological extremes and society. Finally, the review stresses the need for an inter-disciplinary approach to holistically address the uneven production and distribution of hydrological risks.

Keywords: hydrological extremes, justice, water, vulnerabilities

Introduction: Hydrosocial extremes

Sustainable development of different societal groups hinges on its continuous interactions with risks and losses caused by severe floods or prolonged droughts (Fraser et al. 2017). Every year, these hydrological extremes affect more than 100 million people (Di Baldassarre et al. 2017a). The expansion of the human pressure on water resources, together with other anthropogenic changes, can increase the severity and frequency of hydrological extremes and in turn, affect the environmental and societal systems (Rockström, et al. 2014;Vorosmarty et al. 2013). As a result, in the Anthropocene, floods and droughts do not solely result from atmospheric and hydrological processes, but also continuously re-shaped and triggered by socio-economic processes. These continuous interactions between water and society render floods and droughts hydrosocial rather than solely hydrological extremes.

Socio-economic processes do not merely incubate environmental crises, but also magnify their uneven impacts. If on the one hand, they trigger hydrosocial extremes intensifying the magnitude and frequency of the hazard, on

the other socio-economic processes influence and exacerbate the vulnerability of the systems affected by the hazard (Verchick 2012). In light of this, hydrological risk is best described with the term hydro-social to fairly account for responsibilities and impacts in the production and distribution of floods and droughts risk. We thus define hydrosocial risk as the combination of the probability of occurrence of a hydrosocial extreme and the potential negative consequences it entails. The first component of risk reflects the flood or drought hazard and very much depends on the materiality of water and its continuous interactions with socio-natural systems. The second component instead, reveals the vulnerabilities of the systems exposed to the hazard.

Considering drought and floods hydrosocial extremes means recognizing that they occur within certain political spaces and result from prevailing power structures (Douglass et al. 2018). While water and society co-evolve, they produce uneven geographies of risk. And this co-evolution is marked with power, class, religion, gender and ethnicity (Zwarteveen et al. 2017). As Sanderson (2018) presents it, water flows unevenly, because humans and their social structures are also stratified and unequal. In turn, uneven water flows often result in uneven distribution of hydrosocial risks (Zwarteveen et al. 2017). Current geographies of hydrosocial risk are thus rooted in deep inequalities, which further exacerbate as water and society co-evolve (Fraser et al. 2017).

For this reason, floods and droughts solicit a claim for justice, for the way they unevenly materialize and distribute across nature and society (Douglass et al. 2018; Sultana 2018; Zwarteveen et al. 2017). Driven by this call, this paper aims to create a better understanding of the injustices that produce or are produced by hydrosocial extremes. Although justice debates have long existed within environmental, water and climate studies, they have not entirely retraced the co-evolution of human-water systems, nor have they accounted for the complex facets and manifestations of hydrosocial risk in an integrated form.

This paper develops the concept of hydrosocial justice to capture its dimensions of inequalities and their relations to hydrological risk. Section 2 briefly reviews analyses of justice in relation to water and environment to elaborate on the different dimensions of hydrosocial justice. Section 3 integrates these definitions with an analysis of the relationship between power and vulnerability in hydrological extremes. Section 4 and 5 advocate for an inter-disciplinary approach, which makes allowance for the manifold factors producing hydrosocial injustices. By dialectically engaging socio-hydrology with critical studies, scholars could comprehensively explain the ways hydrosocial injustices are produced and truly experienced.

What Justice for hydrosocial extremes?

Concepts of justice, equity and fairness have a long history in academic debates. Yet it was only a few decades ago, when environmental and climate concerns started to raise scholarly and public attention, that justice debates interweaved also with water and environmental concerns (Lele et al. 2018).

Environmental justice for instance, provided a deep critique of the uneven distribution of costs and benefits of environmental degradation across different societal groups (Holifield 2001; Schlosberg 2013). More recently, global debates on climate mitigation and adaptation, have raised specific questions around climate justice, focusing on equity implications of climate change and its responses (Steele et al. 2015). While the water justice movement questioned how to fairly distribute water access rights and political water decision-making (Zwarteveen et al. 2014; Sultana 2018; Perreault 2014). Lately, disaster justice became concerned with how issues of socioecological justice follow moments of crisis, rupture, and displacement (Douglass et al. 2018; Williamson 2018). The injustice theorized by those scholars, manifests for instance, in the release of pollutants into a river affecting marginalized areas or in the over pumping of groundwater sources which mostly deprive less powerful water users. Injustice materializes as well in government resettlement plans that exacerbate floods' impacts mostly in resettled areas.

Whilst departing from different standpoints (climate, water, and the environment), this scholarship places much attention on distributional justice, which focuses on the outcomes of distribution mainly in economic and material terms (Schlosberg 2013; Perreault 2014; Zwarteveen et al. 2017; Zwarteveen et al. 2014). The procedural and recognition justice instead, emphasise the ways in which decisions are taken and who is involved (Zwarteveen et al. 2014). These concepts have also been expanded to include intergenerational justice, which appeals with ideas of fairness and obligations among different generations (Weiss 1990). Moreover, understanding that distribution, procedure and recognition are necessary but not sufficient conditions, Schlosberg (2013) adds the dimension of capability to better understand and eventually achieve justice. When capabilities are opposed to idealized rights, justice becomes the actual possibility of an individual to fully function and maximize its potential (Schlosberg 2013). Lately, most of these scholars, emphasising the integrity of socio-natural systems, aim to expand the arena of struggle also to non-human species (Schlosberg 2013; Zwarteveen et al. 2014; Strang 2016).

From the dimensions through which these scholarships dissect justice, it becomes clear how justice closely relates to questions of power and how analysis of power structure and power imbalances are essential for understanding injustices (Cook et al. 1986). These many dimensions of justice are all equally relevant and significant when it comes to justice in hydrosocial extremes. Overlooking these aspects would mean to ignore how certain disparities originate and manifest (Klinsky 2017). However, these wide-ranging characterizations of justice give little help to scholars, which seek to recognize the injustices entangled with hydrosocial extremes. Any claim for hydrosocial justice should make allowance for and understand how floods or droughts risk is produced and distributed across nature and society. Particularly, scholars should examine the two components of hydrosocial risk for understanding how hydrosocial extremes can become unjust.

Here, the evolving fields of the political ecology of water, human geography, hazard and vulnerabilities studies or disasters studies, are particularly relevant. These scholars have fundamentally retraced how power reshape the water regime and (unevenly) redistribute water flows. Similarly, they have also illustrated how such power generates differential vulnerability to floods and droughts. The following paragraph recasts major critical studies, with an attempt to describe and define injustices that produce, or are produced, by hydrological extremes.

Unravelling power and injustices in hydrosocial extremes

Injustice in hydrosocial extremes manifests in the disproportionate vulnerability to floods and droughts of certain social groups in relation to others. These inequalities (in risk and opportunity) are largely a function of the power relations operating in every society (Bankoff, 2003). The following paragraphs illustrate how hydrosocial injustices deeply relate with power when it materializes in uneven water flows or when it produces disproportionate vulnerabilities to hydrosocial extremes. This section finally recommend not to discount the materiality of the water systems, and look at the ways power intertwines in the production of extreme hydrological conditions and their uneven experiences.

About power that produces disproportionate vulnerabilities

‘Vulnerability’ (Adger 2006) is defined as the ‘state of susceptibility to harm, powerlessness, and marginality of both physical and social systems’ exposed to stresses (Adger 2006). Therefore, different vulnerabilities imply different hydrosocial risks and result in unequal experiences of hydrosocial extremes.

Vulnerability studies have often guided normative analysis of interventions necessary to reduce risk and subsequently enhance well-being (Adger 2006; Pelling 1999; O'Brien et al. 2004). The many methods and

epistemologies developed in vulnerability research (e.g. Entitlements studies, Human ecology, Natural hazard, Pressure and release model or Vulnerability, adaptation and resilience of social-ecological systems) reflect the divergent objectives of the research and the phenomena studied (Adger 2006). However, Adger (2006) identifies common features among the conceptual tools used for assessing vulnerability. He mentions among them, the resources available to cope with risk exposure or their distribution across space, and the institutions that facilitate the access to these resources and other coping strategies (Adger 2006). In particular, those studies describe vulnerability and its manifold manifestations, as the result of social and economic processes of marginalization and inequalities (O'Brien et al. 2004). Pelling (1999) has been exemplary in following these processes when studying the political ecology of Urban Guyana. There, he showed how the vulnerability to flood hazard, represented by the local conditions of coastal areas, was the result of the global political economy which influence the society-nature relations and therefore the experiences of hazard (Pelling 1999). The reduced access to economic assets, the inadequacy of infrastructure, and underdeveloped civil society for instance, they all contributed to expose Guyana's urban and peri-urban households to floods.

Critical geographers like Mustafa and Collins, use the hazardscape concept (Mustafa 2005; Collins 2010; Huber 2019) to further illustrate the way power through discourses and ideologies, influences vulnerability to hazard at multiple geographical scales. Mustafa (2005), in his work The Production of an Urban Hazardscape in Pakistan, unpacks the politics that shape the geography of hazard in the Lai floodplain, Pakistan. He analyse the vulnerability and response to floods with reference to the material and discursive context influencing those factors. In this way, hazardous places become function of multiple and diverse variables across different scales, i.e. the global political economy (Mustafa 2005). The vulnerability of the Lai floodplain residents is thereby view as the result of policies and projects biased toward engineering solutions. The technical and engineering bias of policy makers and consultants do not entirely reflect the river's hydrology nor the social reality of power imbalances and capitalist structures. As a result, certain residents inevitably end up in harm's way. Mustafa (2005) goes further by arguing that the vulnerability to floods in the Lai floodplain is the consequence of a social structure that systematically excludes the poor from the management of their living spaces, gives power to a bureaucracy hostile to the civil society, and facilitates alliances between that bureaucracy and the land mafias. Similarly, Collins (2010) describes the unequal distribution of flood risk in the 2006 El Paso (USA)-Ciudad Juárez (Mexico) flood disaster. He compares the two areas of El Paso and Ciudad Juárez, to show how their distinct urbanization has influenced differential vulnerabilities to hazard and created different flood-prone landscapes. Through a marginalization/facilitation framework, he further illustrates how USA and Mexican urbanization processes amplified unequal vulnerabilities and reshaped the 2006 flood disaster. In this uneven hazardous landscape, only the elite can expose themselves to hazard in pursuit of environmental amenities and charming locations. Those benefits accessed by the elite are mostly the result of unjust socio-economic processes (Collins 2010).

Also disaster studies scholars emphasize the socio-political production of disasters and their unjust experiences (Douglass et al. 2018; Williamson 2018; Huang 2018; Parthasarathy 2018; Bankoff 2003; Verchick 2012). These scholars refuse to consider disasters merely natural events, as this would obscure and flatten the political space where they unfold and eventually stop any quest for justice. Moreover, framing of such disasters as natural or divine, could refrain from attributing responsibilities to governance processes or uneven development. Each one of these works usually focuses on a specific context and a singular disaster where scholars analyse the anthropogenic sources of uneven vulnerabilities to hazard. Fiona Williamson (2018) for instance, attributes to the political decision to resettle the Paya Lebar farming community into a flood prone site, the exacerbated scale and cascading impacts of the Singapore extreme flood in 1954. She argues that the framing of the flood as an 'Act of God' was a linguistic and legalistic way for Government and responsible authorities to avoid culpability (Williamson 2018). Accordingly, vulnerability to flood (and drought) starts from the political process that produce unsafe conditions and often determine the highest vulnerability among the marginalized and disadvantaged populations (Douglass et al. 2018).

About power that shapes uneven water flows

Following water flows and the manifold ways this flows distribute in space, political ecologists and critical human geographers have unravelled the choreographies of power, structural processes and hydraulic relations that mark water-human interactions (Ahlers et al. 2009; Swyngedouw 2009; Loftus 2009; Budds 2016). By refusing a-political ecologies this scholarship foregrounds the role of power in shaping the water flow and producing uneven geographies of hydrosocial risk.

Loftus (2009) conceptualisation of (in)justice starts from the injustice of water poverty (Loftus 2009). Throughout his research, he identifies the power relationships through which water is produced and distributed thereby exposing the related injustices. In his 'Rethinking Political Ecologies of Water', Loftus (2009) shows how Durban Water provision becomes an "accumulation strategy" because of broader political economic processes. Durban residents do not freely access to drinking water because water distribution needs to ensure profit and return on investment. As a result, Durban system differentiates among people with free access to their means of production and those who can only sale their labour power to get access to water. Using Loftus words "water is divorced from the majority for the profit of the few" (Loftus 2009). While mobilizing the concept of hydrosocial cycle, waterscapes or hydrosocial territories, other critical scholars have conceptualized water as inherently social and political (Linton et al. 2014; Swyngedouw 2009; Boelens et al. 2016; Swyngedouw 1999). This explains how every instance of the hydrologic cycle is shaped by particular social structures and geometries of power (Linton et al. 2014; Swyngedouw 2009). In turn, it also shows how the social or natural induced variations of the water flow change existing social linkages and reshape social spaces and territories (Boelens et al., 2016). While enhancing environmental quality in some places and reducing them in others, those hydrosocial circulations result in processes of inclusion-exclusion, development and marginalization, and distribution of benefits and burdens that differently affect the concerned social groups (Boelens et al., 2016). So far, their theorizations of human-water interplays have not yet explored the way power manifests in extremes conditions of water scarcity or water flooding which are produced by particular human-water dynamics and which inevitably cause different socio-natural responses.

Swyngedouw uses the Spanish and Ecuadorian waterscapes, to demonstrate how water and power are mutually constitutive (Swyngedouw 1997, 1999). In the city of Guadalquivir, he shows that more than a third of the population remains excluded from supplies of potable water. This injustice for Swyngedouw is the result of an urbanisation which is simultaneously a political economic and a political ecological process (Swyngedouw 1997; Loftus 2009). Through the Spanish waterscape, he illustrates the role that water plays in shaping relations of power. In a way that Franco's fascist project for Spain was produced and reproduced through transforming the hydraulic engineering of the country (Swyngedouw 1999). Boelens (2014) employs the hydrosocial cycle to disclose how Andean cultural beliefs were and are still used to reinforce certain power strategies and therefore legitimize uneven reconfigurations of the water flow (Boelens 2014). Budds (2016) adopts the same conceptual framework to discuss a conflict over water resources for agriculture in Chile. Finally, Rusca et al. (2018) explain the Mozambican State projects (the colonial era, the socialist post-independence state and the neo-liberal state) as a "material re-patterning of hydrosocial territories". As if at different stages in history, water infrastructure helped consolidating the state power by materializing its discursive ideologies (Rusca et al. 2018).

Other scholars, as Rusca et al. (2019), have also tried to materialize political ecology in order to show the role infrastructure has in affecting hydrosocial configurations. By means of redirecting ecological flows and harnessing resources, infrastructure does regulate water and society interplays (Slinger et al. 2011). Water infrastructure reshapes hydro-social systems not only by changing the water flow yet also by reordering societies institutionally, politically, economically and culturally (Rusca et al. 2018; Ahlers et al. 2017; Tiwale et al. 2018; Slinger et al. 2011). While Ahlers et al. (2017) for instance, present Dams as agents in dynamic and

contested spatial strategies; Tiwale et al. (2017) employs water pipelines or storage reservoirs to trace uneven water flows across the City of Lilongwe, Malawi and understand how inequity perpetuates throughout the water supply network.

Overall, those studies unravelled hidden human-water dynamics, retraced invisible flows, and revealed how social inequalities materialize throughout water flows. While focusing on politics and power, they also become useful instruments for promoting equitable hydrosocial relations (Linton et al. 2014). However, this same perspective often overlooks the materiality of hydrological flows and risks missing the co-evolution of human-water systems. In fact, those studies rarely retrace how politics and power can lead from normal to extremes hydrological conditions of floods and droughts. Giving to water anthropogenic traits should not obscure its biophysical characteristics and its continuous interactions with the atmosphere, the land surface and the ecosystem. As the climate and the hydrological cycle, strongly relate between each other as well as with land surface and ecosystem processes. As a result, they influence the production of hazard and the resulting geographies of risk.

How does power exacerbate hydrosocial extremes?

The critical studies examined in this review, comprehensively address the role of power in creating inequalities and struggles for justice at different scales. On one hand, vulnerability, hazard and disaster studies describe how powerful interests assimilated by discourses and policies, influence the decision-making process and in turn, the production of disproportional vulnerabilities to hydrosocial extremes (Adger 2006; Mustafa 2005; Douglass et al. 2018). On the other hand, critical water studies show how power intertwines with water. By uncovering powerful voices, authorities, knowledge and expertise of water, these scholars foreground the role of power and politics in shaping water and society dynamics and creating uneven hydrosocial configuration (Ahlers et al. 2009; Swyngedouw 2009; Loftus 2009; Budds 2016; Zwarteveen et al. 2017).

What remains less explored instead, is the way this power, by creating certain hydrosocial configurations exacerbates into hydrosocial extremes and results in disproportionate experiences of drought and flood events. To explore these processes it is important to recognize the materiality of water and the co-evolution of human and water systems (Linton et al., 2014). Water should therefore remain an active co-agent in the production of hydrosocial risks both for its biophysical characteristics, and for its continuous interactions with atmospheric, land surface, ecological and social processes. A short-sighted focus on human processes already had and will continue to have on the long-term detrimental impacts on human and nature (Strang 2016). The following section reflects on the potential of engaging with socio-hydrology to re-materialise the production of hydrological extremes and to account for both physical and social processes in the production of injustice in hydrological extremes.

Materializing the production of hydrosocial extremes

Conceptualizing hydrosocial extremes as the result of human-water interactions, hydrology started to introduce humans and society in the production of hydrosocial risks and expanded his field of study to Socio-Hydrology (Sivapalan et al. 2012). This research strand is thus a major breakthrough in understanding human-nature interactions and describing how hydrosocial risk materializes throughout history. Socio-hydrology stresses the importance of accounting for the mutual feedback between water and society and posits that ill conceptions and poor understanding of those dynamics might lead to counterintuitive and dramatic consequences (e.g. levee effects, supply-demand cycle etc.). While addressing current societal challenges represented by hydrological extremes, this theory stresses the relevance of a more holistic understanding of human and water systems dynamics.

Sivapalan et al. (2012) introduce socio-hydrology as the science of people and water by presenting the case of the Murrumbidgee River Basin in Australia. With this example, he argues that traditional hydrologists cannot entirely predict neither human induced changes on the water system nor their impacts on water cycle dynamics: "*The common history of hydrology and the societal changes seen in the Murrumbidgee is an example of unexpected process dynamics. Prediction of water cycle dynamics over long timescales is not feasible without including the interactions and feedbacks with human systems (Sivapalan et al. 2012, p. 1271)"*

Socio-hydrologists posit that society and nature change interdependently as well as in connection with each other and that their mutual reshaping continues and evolves over time (Di Baldassarre et al. 2018a; Kallis 2010). On the one hand, society importantly alters the hydrological regime. It modifies the frequency and severity of floods and droughts trough continuous water abstraction, dams and reservoirs construction, flood protection measures, urbanization, etc. In turn, hydrological extremes shape societies which respond and adapt to the impacts of floods and droughts spontaneously or through collective strategies (Di Baldassarre et al. 2018a).

Di Baldassarre et al. (2018) elaborate on those human-water interactions explaining the relevance of coupling socio- with hydrology and highlighting that these elements do not merely interact but actually co-evolve and reshape each other over time. In fact, neglecting nature and society interaction and co-evolution might lead to unintended and often counterintuitive consequences. Unforeseeable feedbacks within human-water systems could be i.e. increased flood risk and fatalities due to human settlement in flood prone areas and increased vulnerability due to non-occurrence of flooding or to over-reliance on reservoirs (Di Baldassarre et al. 2018b; Di Baldassarre et al. 2017b; Di Baldassarre et al. 2014; Sivapalan et al. 2015). Di Baldassarre et al. (2017) use the case of Rome to demonstrate how the construction of levees meant to limit future flooding of the Tiber River, by reshaping the socio-economic development of the city has also increased the vulnerability of the people living on the riverbanks (Di Baldassarre et al. 2017b). Through Las Vegas and Athens, Di Baldassarre et al. (2018) demonstrate instead how the construction of complex storage systems by altering the water regime and water availability can increase water demand and people vulnerability to droughts (Di Baldassarre et al. 2018b).

In general, Socio-hydrology should draw on different disciplines and include historical studies, comparative analysis and process based modelling to explain the co-evolution of human and water systems (Sivapalan et al. 2012; Di Baldassarre et al. 2013). Most of the socio-hydrological efforts to date have focused on investigating recurring social behaviour and societal development resulting from their coevolution with hydrological systems (Pande et al. 2017). The majority of these studies have explained coupled human and water systems through quantitative approaches and dedicated efforts to capture human-water interactions and feedback through mathematical model, mostly as non-linear differential equations (Wesselink et al. 2017).

Accounting for both water and nature interactions, socio-hydrology re-establishes an equilibrium that anthropocentric perspectives have so far unbalanced. They have explained and conceptualized the production and of floods and drought risks as the result of human and water interactions. Fewer examples to date explore instead the way those risks unevenly distributes across space. Xi Chen et al. (2016) propose a socio-hydrologic model of the Kissimmee River Basin (Florida, US). This river underwent a channelization in the 1960s and a subsequent restoration in the 1990s for a shift in emphasis from flood protection to ecosystem health policies. Defining this shift as the result of changed human values and preferences, Xi Chen et al. (2016) develop a conceptual model to simulate the interactions between community interests and hydrology. In this model, they are able to account for the power imbalances between the more numerous and wealthy upstream urban residents (in favour of wetland restoration) and the downstream rural residents (in favour of flood protection). Similarly, O'Bannon et al. (2014) are able to expose how the externalization of pollution is disproportionally borne by few countries. They assess the impact of agricultural pollution based on international trade records and nation

specific grey water footprints. By so doing they first show how international trade co-produces and unevenly redistributes pollution. Secondly, they explain how social development status also contributes to such inequality.

So far, socio-hydrologist have mostly formalized hypotheses about generic socio-economic patterns and formulated explicit assumptions about the interactions and feedbacks between human and water systems. Significant aspects that influence the production of hydrological risk as well as shape responses to environmental changes remain unexplored. Except fewer studies similar to the ones presented above, socio-hydrologist did not extensively elaborated on the uneven distribution of risks across nature and society. Also, most of their conceptual tools do not account for the plurality of human values, different human agencies and path dependency of societal power relationships (Massuel et al. 2018). Neglecting power imbalances in hydrosocial extremes can conceal the unfair production of risk and flatten its uneven distribution. As a result, there will remain questions of justice not properly addressed.

Addressing injustices in hydro-social extremes

This reveals how hydrosocial injustices are intertwined with the manifold ways hydrosocial risk is unfairly produced, distributed across, and experienced by those who have power and those who do not. Power materializes in the production of uneven hydrosocial configuration, manifests in disproportional vulnerabilities to hydrosocial extremes and results in unjust experiences of floods and droughts. Together with risk, hydrosocial (in)justice emerges and unfolds within society and nature continuous interactions. As a result, ensuring socially-just governance of hydrological extremes entails unravelling the dynamics of risk emerging from the mutual shaping of hydrological extremes and society. From here, this review leaves three major recommendations to scholars that engage in justice in hydrosocial extremes.

First of all, considering the complexities uncovered throughout this paper, analyses of hydrosocial justice entail moving beyond addressing simple or singular aspect and widening the analysis to broader recognitions of ecological, political and social issues. In other words, this justice requires combining geo-hydrological and climatological insights with understandings of the socio-technical and legal-cultural determinants of water flows. These observations demand an inter-disciplinary approach that combines different disciplines and as a result, is able to make allowance for the manifold factors producing hydrosocial injustices (Massuel et al. 2018). This paper suggests to dialectically engage socio-hydrology with critical studies in order to comprehensively explain the ways hydrosocial injustices are produced and truly experienced.

Second, and more as a philosophical reflection, this review stresses the need to equally appreciate society and nature in the production of hydrosocial extremes. If critical theories have attempted it by insisting on the inseparability of the social and the physical; socio-hydrologists instead, did it by theorizing the co-evolution of social and water systems. This conceptualization should on one hand, help avoid anthropocentric perspectives, which prioritize human needs and gives insufficient significance to the needs of the non-human (Strang 2016). On the other hand, it must also account for the human interventions and consider how existing power structures reshape water flows and related risks (Douglass et al. 2018; Verchick 2012). This conceptual but also practical effort, is crucial when the objective is to ensure a justice for all, which avoids long-term detrimental impacts on human and non-human species (Strang 2016).

Third, questions of justice are scale sensitive as their appreciation also depends on the unit of time and space that are considered. Scale matters when considering those relations and phenomena that are spatially or temporally distant but still contribute to the production of injustice. As a result, justice research should not constrain itself to fixed or predetermined scales but rather maintain time and space scale flexible. In this way any analysis can account for relations and phenomena that may be spatially or temporally distant (Perreault 2014). Studies on justice should explicitly assess the way scales are constructed and how they relate to

hydrosocial dynamics (Zwarteveen et al. 2014). In particular Zwarteveen et al. (2014) suggest to pay attention to terms such as ‘local’ and ‘global’, because so-called ‘local’ phenomena are often manifestations of supra-local processes and powers.

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