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Review

Less to Lose? Drought Impact and Vulnerability Assessment in Disadvantaged Regions

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Abstract: Droughts hit the most vulnerable people the hardest. When this happens, everybody in the economy loses over the medium- to long-term. Proactive policies and planning based on vulnerability and risk assessments can reduce drought risk before the worst impacts occur. The aim of this article is to inform a global initiative, led by the United Nations Convention to Combat Desertification (UNCCD), to mitigate the effects of drought on vulnerable ecosystems and communities. This is approached through a rapid review of experiences from selected nations and of the available literature documenting methodological approaches to assess drought impacts and vulnerability at the local level. The review finds that members of the most vulnerable communities can integrate available methods to assess drought risks to their land and ecosystem productivity, their livelihoods and their life-supporting hydrological systems. This integration of approaches helps to ensure inclusive assessments across communities and ecosystems. However, global economic assessments often still fail to connect to holistic consideration of vulnerability at a local scale. As a result, they routinely fall short of capturing the systemic effects of land and water management decisions that deepen vulnerability to droughts over time. To ensure proactive and inclusive drought risk mitigation, multiscale, systemic approaches to drought vulnerability and risk assessment can be further reinforced at a global level.

Keywords: drought; vulnerability; impacts; adaptation; inclusive; marginal drylands

1. Introduction

Droughts and water scarcity hit hardest where people are least able to adapt [1–3]. Extensive guidance is available for assessments of drought impact on national Gross Domestic Product (GDP) in developing countries [4]. However, this is rarely applied, leaving the available assessments incomplete and susceptible to risks of exacerbating inequality [5]. Losses that are disastrous for vulnerable people remain obscured or appear relatively insignificant to national and international actors. This is because most national accounting systems fail to recognize the contributions that vulnerable communities and individuals make to the formal and informal national economies. Nor do they recognize the value of the ecosystem services that such communities rely on. Furthermore, the global and regional costs of continued drought crises and their interaction with other threats may be more than the sum of the costs of impacts occurring within individual countries. As a result of these problems, the avoidable costs of drought, degradation and desertification are underestimated globally, and simple preventive actions are routinely overlooked, deprioritized and underfunded [6].

According to the Intergovernmental Panel on Climate Change (IPCC) [7], droughts impact lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the vulnerability of an exposed society or system. The physical impacts of drought are a subset of the general drought impacts.

Vulnerability is the predisposition to be adversely affected. It encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Every person who is exposed to drought (i.e., much of the world's population) may be vulnerable in some way. But some people are much more vulnerable than others. Assessing vulnerability to drought involves predicting the severity and extent of the hazard as well as its likely effects on the economy and society. This is useful because vulnerability to droughts and their impacts can be altered by the actions of society [8,9]. This can be achieved, for example, through adjustment of land and water management practices, amongst others. While the drought hazards themselves are less tractable, anticipation of their potential to cause avoidable disasters should be enough to trigger the necessary preventive actions.

This article draws on a recently completed rapid review of available methodological approaches to assess drought impacts and vulnerability and the experiences of applying them in various nations [10]. The review was prepared to support discussion of the needs, if any, for additional arrangements enabling the mitigation of drought risks to be put in place at an international level. Reflecting on the theme of the 2019 World Water Development Report and the Stockholm Water Week, "Leaving no one behind", this paper revisits the completed review to explore how drought vulnerability assessments can include consideration of the social imperative for sustainable development to leave no one behind [3]. This is an important issue for drought risk mitigation policy and planning. The theoretical framework speaks primarily to the disaster-risk management literature [11–15]. This focuses on vulnerability as the determinant of the extent of damage that will be done to exposed populations by a given hazard level. It also draws from and contributes to the broader conceptual and practical literature on vulnerability, resilience and adaptation to climate change [1,2,7].

Assessing Vulnerability through Decentralized and Community Level Assessments

Growing inequalities that are exacerbated by droughts exist not only between various regions of the world, but also on the national level, and within countries, between urban and rural areas, social groups, and genders [3]. They also occur at catchment and community levels where increasing access to water for some can leave others ever more exposed. At all levels, social decision-making tends to involve some individuals and groups more than others. Where the needs and priorities of the marginal groups are overlooked, this adds to their vulnerability. Age, gender, socio-economic status and impairments can limit the inclusion of certain individuals and groups. Other factors can involve occupation, wealth, tenure, citizenship, ethnicity, religion, language or others.

Partly as a result of these inequalities, fundamental practical and methodological challenges hamper global efforts to account for drought impacts and vulnerability. Drought risks affecting marginalized communities and ecosystems in the developing world then remain poorly mitigated. Instead, systemic multipliers deepen and perpetuate the impacts and vulnerability, exacerbating global insecurity and threatening future generations [12].

The IPCC considers equity to be [16]:

> "The principle of being fair and impartial, and a basis for understanding how the impacts and responses to climate change, including costs and benefits, are distributed in and by society in more or less equal ways. It is often aligned with ideas of equality, fairness and justice and applied with respect to equity in the responsibility for, and distribution of, climate impacts and policies across society, generations, and gender, and in the sense of who participates and controls the processes of decision making."

The most vulnerable groups during droughts include those who depend most heavily on natural resources, especially poor and marginalized sectors of society. Because they tend to be affected

most directly, these groups often have the greatest knowledge and experience of drought impacts and vulnerability. They are informed by their own strategies for mitigating drought impacts and vulnerability and their experience of what works and what does not [17,18]. To collect this knowledge and experience and convey it effectively to decision-makers requires an objective, scientific and unbiased approach. However, this must also be inclusive, well-informed and fully reflect drought impacts on the most vulnerable [19]. Assessments of drought impacts by the international community have often been criticized for their failure to include communities and to fully capture their understanding of how drought affects them [5]. To respond to this problem, community scale or 'bottom-up' assessments are often recommended [20]. Community-scale assessment processes can be carefully designed and implemented to ensure that vulnerable women, youth, the elderly, handicapped and minorities are engaged and their perspectives are included.

To many of the most vulnerable individuals and groups, the impacts of drought are already all too familiar, and vulnerability assessment is already an ongoing informal process that is part of their day to day decision-making. Elucidating, integrating and coordinating the myriad of these informal private assessments with well-documented, formal, collective processes that involve civil society organizations, local and national governments and other institutions can create a more comprehensive shared understanding. It also offers a more promising basis for sharing and managing risk at all levels. High-level support and leadership should ensure that gender sensitivity and other key dimensions of vulnerability are neither overlooked nor exacerbated unnecessarily in formal assessment processes.

2. Materials and Methods

This article focuses on the ways in which a range of different approaches to drought vulnerability assessment accommodate consideration of inequity in terms of vulnerability to drought. As already mentioned, it draws on a recently completed rapid review of available methodological approaches and experiences from nations where they have been applied [10]. Four illustrative case studies were selected from amongst the practitioner accounts that were compiled during the review. Following the completion of the review, these were further reviewed and discussed with researchers and policy-makers through a series of sessions at the Stockholm World Water Week, Cairo Water Week and the fourteenth UNCCD Conference of the Parties (CoP14), held in New Delhi, India. This discursive process fed into the preparation of this paper.

For the preparation of the original review, experiences of practitioners conducting drought impact and vulnerability assessments in developing countries were collected through a series of key informant interviews. These interviews were conducted with expert practitioners from eight countries (Brazil, Mexico, Colombia, India, Slovenia, Nigeria, Senegal and Kenya. The names and affiliations of the expert practitioners are listed in the full report which is available online at: https://www.unccd.int/sites/default/files/relevant-links/2019-09/190829%20UNCCD%20A%20Rapid%20Review%20Web.pdf). The interviews included questions about which methods were used to assess drought impacts and vulnerability in the practitioners' countries, what results were generated, and what might be the priorities for improving the assessments in the future. In particular, practitioners were asked whether they felt that the existing assessments were sensitive to the differentiated needs of different areas and vulnerable groups within the population (including gender-sensitive approaches, as well as specific vulnerability and needs of elderly, youth, disabled and minority groups). These questions were emailed to the interviewees in advance of the interviews, which were then held either by skype or phone. Not all of the interviewees felt ready to answer all of the questions.

For each of the country cases considered, a range of background reports and other materials describing and assessing drought impacts and vulnerability were identified. This process was supported by targeted keyword searches of peer reviewed international scientific publications and a review of gray literature on the assessment of drought impacts and vulnerability at the global, national and subnational levels. This began in advance of the interviews and continued in parallel. Keywords initially entered to the SCOPUS online bibliographic search engine included: 'drought

impact assessment' (27 records), 'drought impact' (779 records), 'drought vulnerability assessment' (22 records) and 'drought vulnerability'(254 records). The geographic scope of the bibliographic search was not limited. Although it was not our aim to produce a purely bibliographic analysis, a subsequent publication of this type has been prepared by other authors [21].

The completed review focused on seeking out assessment methods that should be integrated across sectors, scales and timeframes, and include particular consideration of the most vulnerable groups. The extent to which the assessment methods could inform adaptation actions was also explored. The focus was oriented primarily toward methods that could be applied at the local level, ideally through support and coordination from a global level.

A broad characterization of the available methods for proactive vulnerability assessments into three overlapping types was developed (Figure 1), comprising ecosystem-based mapping and modelling, a people-centered livelihoods approach, and basin-wide resource accounting focusing on water balance, availability and demand. This allowed us to provide a commentary on the strengths and weaknesses of each assessment type or approach (Table 1). Ideally, impact and vulnerability assessments applied at the local level should integrate all three of these, and connect them across scales to national and global assessment processes including economic assessment. However, in practice, such a comprehensive approach is very demanding. No perfect examples were identified during the review.

Initial findings were discussed with drought management practitioners and policy-makers by skype, phone, email and through two international workshops held in Oxford, UK (https://aboutdrought.info/report-back-from-drought-water-scarcity-conference/), and Antalya, Turkey (https://www.unccd.int/news-events/new-drought-toolbox-validation-workshop-kicks). These activities were an important reflective step in the thought process that led to the finalization of the analysis. A nonexhaustive list of colleagues who contributed insights is presented in the acknowledgements section of the final report on the review [10].

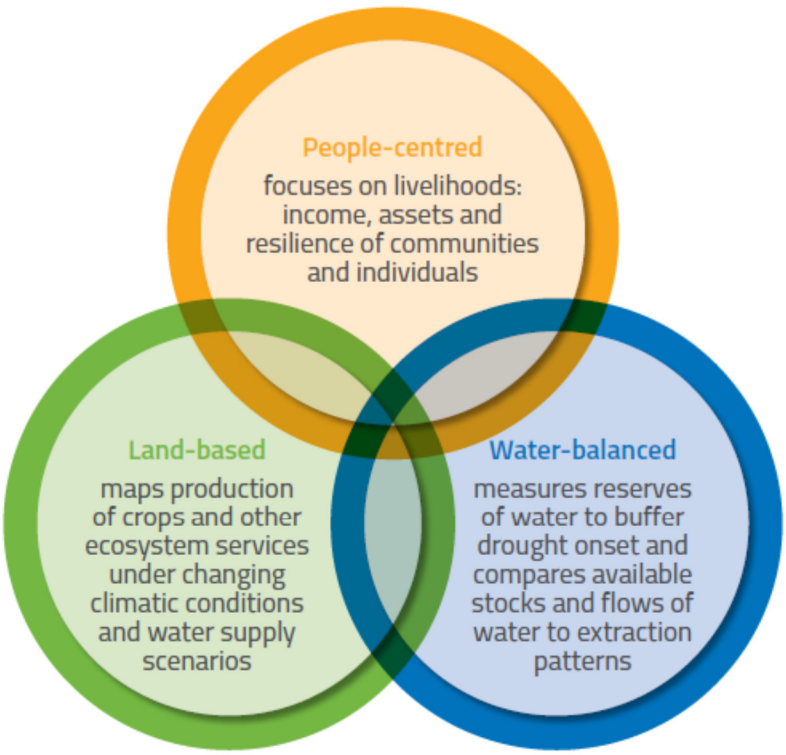

Figure 1. Three approaches to assessing three dimensions of vulnerability at the local level (source: [10]).

Table 1. Summary of assessment approaches, strengths and weaknesses (source: [10]).

Approach	Characterization of Approach	Strengths	Weaknesses
People-centred	Focuses on people, their assets and ability to recover from drought	Ensures people-centered analysis, broader than income only Includes presentation of economic case at household level Can accommodate long-term time horizon Considers capacities of different kinds Familiar to practitioners. Connects to agro-ecosystems	Data-intensive and time consuming Focuses on household scale—may not be multiscale May not capture effects on the national and regional economy Can favor recommendations to diversify the livelihood portfolio Can miss effects that deepen long term systemic vulnerability Often misses identification of strategic water management solutions
Land or ecosystem-based	Focuses on ecosystems, their productivity and responses to climate anomalies	Ensures coverage of resource-dependent production systems Can connect to climate models and to economic models Can be mapped and monitored at low cost using satellite derived data Many agricultural adaptation options likely to be identified Familiar to agricultural extension systems and capacities in place	Inclusion of poor and marginal groups not always systematic More oriented to agriculture than other sectors May not capture vulnerabilities in urban areas Not necessarily long term Focuses on field scale—may not be multiscale May have relatively short time horizons Does not consider water needs in other sectors of the economy
Water balanced	Focuses on water availability, and relation to demands from different sectors of the economy, management systems and hydro-climatic cycles	Considers water availability and demand across the economy including in urban areas Makes effective use of climate models and scenarios Connects to drought monitoring and early warning systems Can enable identification of capacity needs Can enable identification of risk management actions	Institutional challenges to coordinate data collection, management and analysis Data on water extractions often incomplete in drought-affected areas May require information on groundwater management Municipal and industrial water extractions growing faster and less well understood than agricultural water use Transboundary issues, political and security sensitivities in some countries

For more detail on specific assessment tools associated with each approach, see the full report at: https://www.unccd.int/sites/default/files/relevant-links/2019-09/190829%20UNCCD%20A%20Rapid%20Review%20Web.pdf.

3. Identification of Equity Issues Within the Three Assessment Approaches

In this section, equity issues arising from the use of the three broad methodological approaches are illustrated, drawing on the findings from the completed review.

3.1. Ecosystem-Based Mapping and Modelling: Examples from Latin America and the Sahel

Methods for assessing vulnerability to drought based on the mapping of agro-ecological activities and sensitivities to water stress are relatively well-established after [22]. These are often used at the local level with participatory assessment methods to assess drought effects on agro-ecological zones and ecosystems [23–25]. Numerous examples of agro-climatic or agro-ecological approaches were identified through a keyword search on 'drought vulnerability assessment' amongst the peer reviewed scientific publications e.g., [26,27]. These approaches are widely used for national level vulnerability assessments for drought as well as other climatic changes and land degradation processes. Often, they focus on mapping a selection of physical and social indicators or indices. Similar mapping and modeling approaches can also be used to map vulnerability at the local level.

The World Meteorological Organization and Global Water Partnership (WMO/GWP) [28], and International Bank for Reconstruction and Development (IBRD) [29] described how staff and researchers from national institutions sought to design and roll out standardized programs for drought vulnerability mapping across Mexico. Teams of investigators in each watershed were given standardized guidance prepared by the Instituto Mexicano de Tecnología del Agua (IMTA) to apply

with watershed councils. However, due to limited and uneven availability of datasets, they found that they could not apply consistent procedures or methods across the whole country. Progressively, a comparison of the methods used, including various indicators and weighting systems [30], provided a basis for refinements [31,32], and the development of a standardized index for mapping vulnerability to the level of the municipalities [31].

Often, vulnerability maps remain qualitative, and do not explicitly provide a value for the potential losses of the productive resources that they identify to be at risk. After droughts have happened, rapid value assessments of losses may be produced retrospectively using available maps and value estimates. For example, UNGRD [33] identified effects from El Nino in Colombia including impacts on agricultural production value, the number of hectares sown per department and GDP per department [34]. Such assessments provide a powerful case for preventive actions. Many other examples are available in the literature on drought impacts. See: https://www.gfdrr.org/en/publications However, when there is no emergency imperative to justify them, quantitative economic assessments of vulnerability can be considered controversial and raise very difficult questions about equity issues.

It is important to realize that the vulnerability of land uses and production systems belonging to groups whose interests are politically and economically well-established is often more readily mapped and assessed than those of more marginal groups. This means that the value of the economic activities and contributions of the most vulnerable people can easily be overlooked in land- and ecosystem map-based assessments. For example, across much of the Sahel, land may be used by both settled farmers and migratory pastoralists who come and go on a seasonal basis [35].

It is relatively straightforward to map the land uses and production systems of those with secure land tenure, such as some crop farmers, and to model their propensity to be affected by changes in productivity under varying climatic extremes. However, where there are several different user groups that must continuously renegotiate and share access to the land on a seasonal basis, droughts may affect access to resources for some groups more than others, and in ways that are more complex than ecological maps and decision-support modeling tools would anticipate.

Groups that are weaker, financially, or politically, or which entrust the management of land to others for part of the year, may return to find their access to resources more reduced during drought. Assessments that rely on physical mapping and modeling alone will not capture this differentiated vulnerability. Indeed, if the maps show only the claims of the groups that have permanent access rights (tenure), the existence of these maps themselves can be used to exclude the marginal land users. This will further perpetuate and deepen unequal vulnerability to drought. In societies where men are more likely to own land than women, approaches to vulnerability assessment that rely on land-based mapping techniques will also overlook women's resource uses and economic activities in other related sectors such as postharvest processing, hospitality or other associated professions.

In some cases, it is possible to connect (agro-) ecological maps and models to additional contributions to the economy that will be made via the value chains that they create for processing, transportation, demand for agricultural inputs, etc. It may also be possible to model environmental externalities associated with agro-chemical use, groundwater depletion, land tenure, access to capital and other effects of ecosystem management. A further range of methodological issues surrounds the conversion of effects on physical production systems into economic effects on households, regions and national economies. In some cases, these will also interact with global economic processes. Additional methodological questions concern the prediction of future economic value and prices.

The more stages, products and values that are included in the model of a land-based production system, the more it may be necessary to accommodate complexities and uncertainties. To begin with, understanding the vulnerability to drought of a cropping system producing forage or other crops is simpler than it is for a livestock production system. This is because the livestock production system model must include possible climatic effects not only on forage production, but also on livestock health and nutrition. To capture these more complex processes and interactions will require the layering of a range of different methods, modelling tools and databases. If the land-based production systems are

seen as part of a larger ecosystem and economy including urban areas and other associated activities, this will introduce many more layers of complexity and uncertainty to a land- or ecosystem-based assessment of vulnerability.

3.2. People-Centred Livelihoods Assessment Approaches: Examples from the Horn of Africa

Well-established rapid appraisal methods provide a way for community groups to document the effects of drought. (See Appendix A) Consistent iterative assessment and validation of results can guide an objective qualitative understanding of the nature of drought impacts and vulnerability. In Ethiopia and Kenya, qualitative findings generated in this way have been compared to quantitative data on household characteristics generated via programs such as the Productive Safetynets Programme (PSNP) in Ethiopia and the Hunger Safety-nets Programme (HSNP) in Kenya, together with data on child nutrition collected through the national early warning system for drought monitoring in Kenya [36,37].

Efforts to assess the economic losses associated with drought in this region e.g., [38] routinely refer back to an impact assessment that was conducted following the 2008–11 drought [39], which identified the values of lost production, productive assets, basic services and living conditions from the Kenyan economy at Ksh 968.6 billion (US$12.1 billion), and the damage in terms of loss of economic growth at 2.8% per year for three years. The productive activities and assets that were considered most-affected by the drought were livestock raised in the extensive grazing systems in the drought-prone areas. However, in 2011, the value of these assets to the national economy was systematically underestimated within the national statistical data collection systems [40].

Since the 2011 drought, national drought management responses have been strengthened and early warning systems have been put in place at the national level in Kenya [41,42] and regionally [43] to trigger actions based on the observation of drought conditions. A series of assessments [44–48] have explored the returns to local livelihoods that can be secured through community-scale investments to reduce vulnerability through supplementary feed distribution, rehabilitation of water pans, micro-basins, micro-credit and community institution-building for rangeland management, amongst others.

Based on this, some commentators have argued that drought management responses are improving [36]. On the other hand, over the same period on the larger catchment scale, the flows of water to the drought-prone areas of northeast Kenya have reduced, leaving the downstream populations more exposed to drought. This growing systemic problem requires a more proactive approach [19,42]. The increasing upstream extraction is illegal, and the downstream community are considered to have a right to access sufficient water to meet their basic needs. When they cannot do so, their livelihoods are threatened, and they are exposed to higher levels of risk during drought. Similar increases in catchment-level inequalities in access to water have been observed in other parts of the Horn of Africa, as some communities are able to invest in improved water supply infrastructure, while others who are located downstream receive reduced flows [49,50].

The international humanitarian community often pays a high price for drought relief, and yet still cannot restore the livelihoods that are lost. The growing upstream–downstream inequalities have been considered by some national development planners and economists still to be justified in light of the recognized economic value of crop production in the upstream areas that are irrigated using the extracted water [51,52]. By some assessments, this contributes more to the national economy than maintaining the downstream populations and their extensive livestock raising activities. Although such justifications have been contested, the problem is that the public authorities and local enforcement officers are not empowered to prevent private extractions in the upstream areas because some of the land-users concerned are more powerful than they are.

When the most vulnerable people in the downstream areas lose their livelihoods during drought, this is only the beginning of the losses. Trades and value chains that are destroyed alongside the livelihoods of the vulnerable communities have attracted increasing attention and estimates of their net worth are growing. Deepening vulnerability and exposure to drought cause further draining of the local economy due to increasing uncertainty, insecurity, transaction costs, underinvestment

and outward transfer of resources (including people and currency as well as natural assets) [49]. In light of these problems, it is important that rapid livelihood-focused vulnerability assessments be integrated with drought risk assessments at other scales. It is also important that assessments of the immediate humanitarian responses to drought do not overlook effects on the sustainable management of hydrological systems.

3.3. Basin or Catchment Level Resource Accounting: Examples from India

Areas with greater water utilization can be considered more vulnerable to drought than those with low water utilization [53]. Water stress occurs when the ratio of water extraction is high in relation to resource availability, as happens during hydrological drought. Water stress and scarcity during drought can cause the costs of accessing water to escalate, which will disadvantage lower income groups. Sometimes, hydrological drought and water stress may be temporary phenomena. But if water extractions reduce flows in surface water bodies and cause the water table to be lowered, this will alter the availability of water in the soil profile as well as surface water bodies and subsurface reserves unless/until the systems are replenished. Water stress can be exacerbated by rising water demands, causing a situation where insufficient water resources are available to meet demands for water for agricultural and other uses [54].

Basin- or catchment-level water resource accounting enables assessments to be made of vulnerabilities and exposure to drought risks due to water stress. Various water accounting and balance modeling approaches focus on the available volumes of water in different parts of the ecosystem (see: https://seea.un.org/content/seea-water and http://www.fao.org/land-water/water/water-management/water-accounting/en/) [55–57]. This supports comparisons of the volumes of available water to the volumes extracted [58]. Since, as described in the previous section, increased or reduced availability of water in one part of a basin can affect flows and availability in other areas, assessments should focus on hydrological units (basins or catchments), rather than on administrative units. Basin-level water accounts can be calculated on an annual basis, based on the volumes of precipitation and extraction. However, these accounts should also consider the opening balance of water volumes stored in surface water bodies and underground.

In India, following a severe drought in 2015–2016, accusations of inconsistent and unfair use of drought emergency measures led the Supreme Court to order that the national Drought Management Manual [59,60] be revised to include objective scientific measurements that could be used to assess drought conditions equitably and uniformly in all parts of the country. In addition to rainfall and agricultural conditions, water storage levels in reservoirs, surface water and groundwater were to be measured as indicators of drought.

Whereas earlier in the century, droughts were buffered by stored groundwater reserves, in many areas, these reserves have now been depleted as part of the coping strategies for previous droughts. Where the stores of water cannot be replenished, this affects ongoing vulnerability to drought. Changing hydrological conditions in various parts of India have reduced water levels in the rivers and surrounding subsurface areas. Where water tables have fallen, flows of groundwater that once fed into riverbeds are no longer contributing to the river flow volumes. Now, instead, water seeps out of the riverbeds into soil that has been left dry due to the groundwater deficit.

The Supreme Court has also been called upon to make rulings about the minimum flows of water from one state to another during droughts. But no court can order water not to flow out of a porous riverbed if the water-table is depleted. This depends on the local environmental conditions, which will vary temporally and spatially. It is very difficult for states to regulate the competing demands of different water users. In the 2016 drought, the State of Maharashtra was forced to curtail nonessential uses of water (e.g., for watering cricket-pitches), but it still could not prevent overextraction of water by other groups, including sugar-cane farmers, from causing shortages of water for drinking and other basic needs [61].

To reduce the hydrological deficits and increase the rate of groundwater recharge, water harvesting programs, both rural and urban, have been launched in many parts of India [62]. Even though the wider basin or catchment scale is important for understanding the overall effects on the water balance, monitoring and assessments of water levels to ascertain vulnerability to drought can be carried out at the local (village) level. The implementation of water harvesting programs to reduce localized vulnerability can also be practiced at this level, where communities are sufficiently aware, organized and empowered to do it. It is important to recognize that the feasibility and effectiveness of systems for local monitoring and management of hydrological vulnerability to drought depend on local people and their livelihoods; therefore, these types of assessments cannot be divorced from the people-centered and livelihood-oriented approaches described in the previous section [63].

4. Discussion

The review that is discussed in this paper [10] has demonstrated that there is no shortage of methods for assessment of the impact and vulnerability to drought that could be applied with vulnerable people on the ground. This should help to ensure that drought impacts on vulnerable people are better understood and accounted for. Practitioner interviews and the supporting literature review revealed an infinite range of evolving tools and methods available to assess drought risks to livelihoods, land and ecosystem productivity and their underlying hydrological support systems. Each of the broad assessment approaches identified in this paper can connect to an infinite range of evolving tools and methods that are complementary and can be adapted according to context. They can identify and enhance adaptation capabilities, highlight opportunities for actions to reduce drought impacts and help to build the economic case for actions to be taken locally, as well as at other levels.

Each of the assessment types has different strengths and weaknesses in the ways that it considers social inequality and the tendency for droughts to impact the most vulnerable groups the most. This is why, ideally, impact and vulnerability assessments applied at the local level should integrate all three of the identified approaches, and connect them across scales to national and global assessment processes to better inform global economic assessments of the case for more proactive approaches to investment in drought risk reduction. Furthermore, the assessment methods should be integrated with objective global scientific measurement systems that combine measurements based on remote sensing with systematic ground-truthing. However, in practice, such a comprehensive approach is demanding, both methodologically and in terms of time and resources. Perhaps as a result of this, no perfect examples were identified during the review.

More research is needed to guide effective policy-making. The only way to overcome the constraints that we have observed in terms of data, resources, time, etc. is through practice and the review and progressive application of the latest methods of performing vulnerability assessments. Lately, in 2013 a group of 36 expert organizations co-led by the World Meteorological Organization (WMO) and the Global Water Partnership (GWP) have put in place an Integrated Drought Management Programme (IDMP) which offers a helpdesk through which expert advice and guidance can be sought: https://www.droughtmanagement.info/.

A concerted effort is needed from institutions at all scales, including those that work at the international level. The UNCCD and partner institutions have begun work to make drought risk and vulnerability assessment tools more available to governments and other stakeholders in drought-affected areas through an online Drought Toolbox: https://knowledge.unccd.int/drought-toolbox. However, it is important to underline that the challenge does not only concern the availability of the tools, but also how they are applied, by whom and what use is then made of the results to enable proactive management and avert unnecessary harmful impacts on vulnerable people and ecosystems. For example, to apply the assessment methods and tools through inclusive bottom-up processes, as explored in this paper, requires the identification of and participation by members of vulnerable communities. Where the identification and inclusion of these target groups is challenging, or where certain groups (such as women and youth) are routinely marginalized from decision-making, the assessment may need to

be repeated several times before it can achieve effective participation and produce results that could improve decision-making at all levels.

Although vulnerability assessment tools and their application at the community level will always merit further consideration, it is important that decision-makers at other levels should already be willing to take heed and be informed by them. Many of the completed assessments already provide strong justifications for more proactive approaches to drought risk mitigation. Unfortunately, global economic assessments often still fail to connect to holistic consideration of vulnerability at the local scale. They also fall short of capturing the systemic effects of land and water management decisions that deepen vulnerability to droughts over time for communities that are already disadvantaged. Nor do they properly account for the disastrous chain of ripple effects that emanate from the perpetuation of avoidable drought impacts on people who are already disadvantaged, dispossessed or disenfranchised. National policies often do little to improve this, and tend to fail to give consideration to the effects on communities and ecosystems that take place beyond their borders.

Ercin et al. [64] map the EU's global dependency on virtual water imports and assesses how water scarcity and drought may disrupt supplies of key food crops that it imports. More fundamentally, wealthy governments are already counting the costs of coping with economic migration and security threats from regions where inadequate systems are in place to protect vulnerable populations and their ecosystems from drought. The global economic cost of uninsured drought risk goes beyond the cost of losses and damage caused by each drought event in the area where it hits. This is because anticipation of high risks, low returns and poor economic prospects in drought-prone economies causes systematic underinvestment [36,65]. Even when there is no drought, negative perceptions of drought-prone areas can still hold back investment. The effects that this has on national economic growth rates and profiles have far-reaching consequences that multiply the cost of inaction [66].

To ensure proactive and inclusive drought risk mitigation, multiscale, systemic approaches to drought vulnerability and risk assessment should be further reinforced on a global level. A coordinated international process is needed to ensure that the available methods for drought vulnerability assessment are systematically applied, coordinated and improved, to better inform global understanding. Examples in this paper included an international capacity building approach led by the World Bank in Latin America, current multilateral, bilateral and regional initiatives in Africa, and an ongoing national capability building and sharing process across Asia supported by governments, including those of the UK, India and others. A proactive and inclusive global drought vulnerability assessment approach could strengthen the capacities of responsible agencies in drought affected countries to apply the available methods to vulnerability assessments of the most vulnerable communities. Such an approach would provide a strong basis for more effective drought policy and preventive measures.

5. Conclusions

From a short-term financial point of view, the most vulnerable may have less to lose during droughts. But when they are routinely and repeatedly hit unnecessarily by preventable disasters, the damage done to society as a whole goes far beyond local accounts for the immediate losses. It is more feasible and a more responsible course of action for society to assess and mitigate drought risks ahead of time through iterative anticipatory assessments, rather than following a reactive postdisaster drought impact and needs assessment process.

Vulnerability assessments can effectively capture the factors that make some groups and individuals more vulnerable than others if they adopt an inclusive participatory approach (as described in this article) so that the most vulnerable people can inform the design and implementation of the assessment. These can then be compared to available statistical information and other datasets that are available at either national or global levels. At the local level, members of the most vulnerable communities can integrate the available methods to assess drought risks to their livelihoods, land and ecosystem productivity and their underlying hydrological support systems. This integration of approaches helps to ensure

equitable assessment across communities and ecosystems. To ensure effective support, such approaches should be connected across scales of governance from local to national and international, as needed.

At the present time, global economic assessments of drought impacts and the case for investing in proactive management approaches often still fail to connect to holistic and inclusive local understandings of vulnerability. Available global assessments of the costs of continued and increasing risks also fall short of capturing the systemic effects of land and water management decisions that deepen vulnerability to droughts over time. To ensure proactive and inclusive drought risk mitigation, multiscale, systemic approaches to drought vulnerability and risk assessment can be reinforced on a global level. The creation of an Intergovernmental Working Group based on effective policy and implementation measures for addressing drought under the UNCCD could guide and encourage the international community on where and how to begin. This will require the full engagement of the wider community in drought management and resilience-building.

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Appendix A

Participatory diagnostic tools for vulnerability assessment (source: [10])

A range of rapid qualitative assessment methods are available for assessment of vulnerability to climate change [67–69]. These draw on well established participatory appraisal techniques which have been widely used by rural development and extension workers for community-based adaptation project planning since the 1970s [70]. More recently, this body of work has expanded to include assessments of urban vulnerability [71] and resilience assessments. These tools are useful to establish shared understanding of issues within groups and to communicate this understanding to external stakeholders, donors and decision-makers. See Hovland [12,13,72].

These tools can also be applied by local government officers and community representatives as well as Non-Governmental Organization (NGO) staff see e.g., [73]. Various international NGOs have produced field guides to the application of these methods in different parts of the world [67,69,74–79]. The approach provides a framework for dialogue within communities, as well as between communities and other stakeholders, enhancing scientific data with local knowledge and building adaptive capacity. For case study applications in East Africa see: [73,80–84].

The participatory tools and methods documented in the guides above and others include:

Historical Timeline to identify when droughts have occurred in the past and what happened.

Rivers of Life: participants are invited to use the symbol of a river to reflect on key stages in their experience, identify positive influences (tributaries) and challenges (rough waters).

Mapping of resources and hazards: to locate and characterise resources used and impacted during droughts, how they are accessed, by whom, etc.

Seasonal Calendar to identify practices in drought and nondrought years.

Tree diagrams: tree drawings or causal loop diagrams are used to explore cause and effect relationships, explain problems, and impacts, break down factors and their relationships and facilitate understanding of interconnected issues.

H Diagram: literally, a diagram shaped like a wide H—can be used in numerous settings to rate something along a scale (e.g., level of individual or community concerns about drought—from not worried at all, to extremely concerned), providing an easy-to-understand visual representation of participants' responses.

Vulnerability Matrix to score the severity of different effects on different groups. See example in [69].

Force field analysis: to understand the factors that drive movement toward a particular goal (motivating forces) or blocking such movement (constraining forces or barriers). See Hovland [14,15,72].

Participatory scenario development is a process that involves the participation of stakeholders to explore the future in a creative and policy-relevant way. It can be used to identify the effects of alternative responses to emerging challenges, to determine how different groups of stakeholders view the likely impacts of hazards such as droughts see [23,25]. IBRD [85] includes detailed instruction for convening workshops to discuss adaptation options. The first session of the workshop focuses on vulnerability assessment, including a Plenary Explanation, then Table-group Activity using impact chains to identify climate change most relevant to the area, list the social groups most vulnerable to climate change, and identify why these groups are most vulnerable.

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