The dual-risks context : A systematic literature review for the integrated management of flood and drought risks

International Journal of Disaster Risk Reduction

Alves, Priscila B.R.; Loc, Ho Huu; De Silva, Yenushi; Penny, Jessica; Babel, Mukand et al

https://doi.org/10.1016/j.ijdrr.2023.103905

International Journal of Disaster Risk Reduction 96 (2023) 103905

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

The dual-risks context: A systematic literature review for the integrated management of flood and drought risks

Priscila B.R. Alves [a,*], Ho Huu Loc [b,c], Yenushi De Silva [c], Jessica Penny [d], Mukand Babel [c,d], Slobodan Djordjévic [d,e]

[a] *Stormwater Infrastructure Resilience and Justice (SIRJ) Lab, School of Architecture Planning and Preservation, University of Maryland, College Park, United States*
[b] *Water Systems and Global Change Group, Wageningen University and Research, Wageningen, the Netherlands*
[c] *Water Engineering and Management, School of Engineering and Technology, Asian Institute of Technology, Pathum Thani, Thailand*
[d] *Centre for Water Systems, University of Exeter, Exeter, UK*
[e] *Faculty of Civil Engineering, University of Belgrade, 11000, Belgrade, Serbia*

ARTICLE INFO

Keywords:
Floods
Drought
Literature review
Local conditions
Vulnerabilities
Stakeholders participation

ABSTRACT

Floods and droughts can cause severe impacts for communities. Even with different temporal and spatial scales, these extreme events challenge risk management specially when happening simultaneously, cascadingly or cumulatively over time. However, the number of articles that evaluates the joint occurrence (i.e., interplay) between floods and drought in the same area is still limited in literature. In this sense, this paper aims to evaluate what lessons we can learn from previous studies on both extreme events, and to identify the way forward for understanding floods-droughts interplay and risk reduction in the future. For this, we developed a literature review with articles from 2008 to 2021, aiming mainly to understand the "dual-risks" context internationally (n = 60). Articles are analysed with chronological, descriptive, and geographical factors, methodological aspects, main objectives, and risks interplay. Results show articles still focuses most on the single hazards approach, and when considering the risks interplay, they focus more on risk assessments rather than on assessing the context conditions of communities and their vulnerabilities. This study concludes by discussing the key elements for integrating floods and droughts, including the analysis of local conditions (i.e., social, political, cultural, and physical aspects) vulnerabilities, and the participation of stakeholders.

1. Introduction

The world has become increasingly vulnerable to disasters [1], not only in terms of the number of events but also the severity, and more importantly, yet predominantly overlooked is the diversity of risks. Even though natural hazards, and the study of their risks, constitute one of the most important sections within scientific and policy discourses, our understanding is yet to be sufficient, let alone comprehensive. Virtually regardless of countless lessons drawn from past events, human society has yet to be entirely protected whenever nature strikes as the hazard impacts could not be entirely prevented. This could have been due to the "singular" approach being adopted [2]. When confronted with a natural hazard, the ultimate aim is always to reduce as much as possible the impacts of that particular hazard while neglecting the underlying consequences or needs of the area [3].

* Corresponding author.
E-mail address: pbralves@umd.edu (P.B.R. Alves).

https://doi.org/10.1016/j.ijdrr.2023.103905
Received 24 March 2023; Received in revised form 27 July 2023; Accepted 28 July 2023
Available online 6 August 2023
2212-4209/

With the advancement of earth observation methodologies, we have been able to recognize and monitor a wider range of natural hazards, which has allowed us to look deeper into their correlations, geographically and chronically [4]. While natural hazards can happen at the same time and *dovetail* e.g., earthquakes vs tsunamis, there are others that are appeared to be contradictory, i.e., floods and droughts. When natural hazards contradict, risk management becomes more challenging because reducing the risk on one hazard might increase the risk on the other [5,6]. For instance, artificial groundwater recharge to reduce the risks of drought would substantially saturate the soil and raise the groundwater table, which in turn may increase flood risks. This would call for a multi-dimensional approach to account for the synergistic and trade-off effects of management decisions.

The singular approach to risk management of multi-hazards, especially those that are contradictory such as floods and droughts, could have emerged from the lack of true multidisciplinary or transdisciplinary approaches [7]. For example, flood experts may not be sufficiently trained to deal with droughts and vice versa. Of course, assembling a team that cuts across disciplines is a viable option, still, there is a dire need to systematically investigate the risks, both individually and simultaneously. Notable efforts contributing to this gap include studies like [3,5] that carried out literature reviews covering preparedness and pre-disaster planning, and the evaluation of risk reduction measures for both flood (FR) and drought risks (DR). For [8] beyond strengthening existing policies and governance of FR-DR risks, there is also a need to raise awareness of communities as a possible way to increase acceptance of risk-reducing measures among the population. Other notable studies are [9,10]. These articles provide an overview of floods and droughts disaster impacts in China and Thailand, respectively [9]. focus on the spatiotemporal distribution of floods-droughts impacts on agriculture in China, whereas [10] focuses on the proposal on FR-DR solutions at the Mun River Basin in Thailand.

However, literature shows that even with the frequent occurrence of FR-DR worldwide, there are barriers for floods-drought integration in management. When dealing with multiple risks governance [11], discusses institutional barriers, including multi-risk environments observation, social and institutional context analysis, co-design of risk reduction options between experts and stakeholders, and implementation. Similarly [5], suggest that current literature provides minimal understanding of the simultaneously multi-risk occurrence, called as “natural interplay between FR-DR”. In this paper, the “interplay” refers to the joint occurrence of hazards and also to considering that actions taken to minimise one risk can unintentionally lead to an increase in risk from the other extreme event [2,5]. For example, actions for flooding reduction can generate positive or negative effects for drought risk, which makes vital to consider their interconnections in landscapes and ecosystems that face both risks together [5]. Another recent study

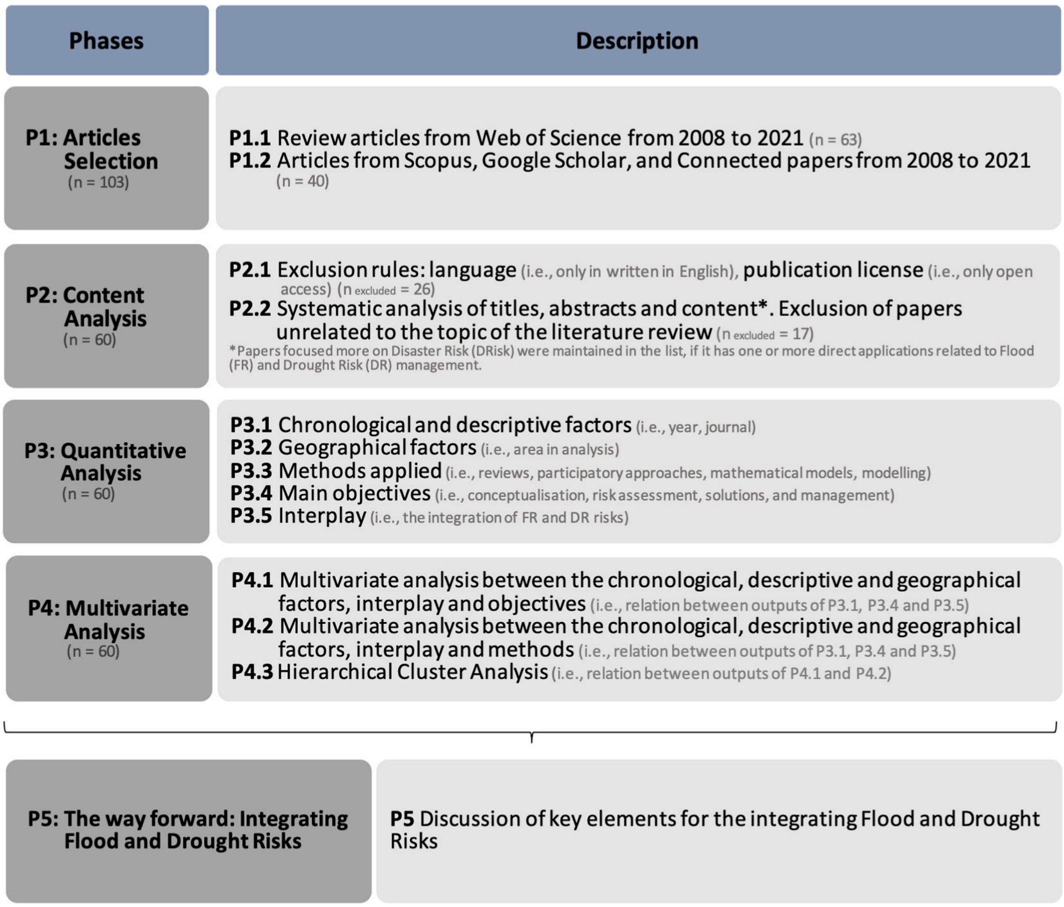

Fig. 1. - Overview of the methodological steps in this literature review.

analysed the case of floods preceded by severe drought in Kenya and Ethiopia is assessed [12]. The approach reveals interactions between FR and DR components with influences on the society. In general, FR-DR literature asks for more flexible and enhanced frameworks to capture the different aspects of analysing flood and drought issues together [7].

In this context, this article aims to first, systematically report the state-of-the-art knowledge of FR and DR analyses, and second, suggest important research directions for future studies, highlighting challenges and barriers of dual risks-oriented management. For this, we consider that (i) while considering the case of areas with both flood and drought risks, they can face potential domino effects created by the dual-risks susceptibility in the area, (ii) when regions are exposed to floods-drought interplay, their risk management will need the knowledge and understanding of risks interplay and their main components (i.e., hazard, vulnerability, and exposure) for disaster risk reduction and for planning adequate adaptation solutions, avoiding *maladaptation* [5,13,14]. A systematic literature review of FR-DR articles was conducted by analysing papers regarding chronological, descriptive and geographical factors, methodological aspects and main objectives, including FR-DR interplay. Those multiple factors are examined with quantitative and multivariate analyses, such as Multi-Correspondence-Analysis (MCA) and Hierarchical Cluster Analysis (HCA) [15–19]. Also, the simultaneous, cascading and cumulatively aspects of FR-DR interplay are discussed with the examination of key elements for the integrated management.

It is important to highlight that, even though other reviews were published in the context of FR and DR previously, they were specific for an application related to FR and DR (i.e., more focused on the proposal of solutions in Ref. [5]; or risk assessments in Ref. [20]; or cases in Kenya and Ethiopia in Ref. [12], country-specific [8,21] or focusing on discussion to the risks separately [22] or [2]). In essence, a review of existing literature that is systematically conducted like the one presented herewith is not available in either Scopus or Web of Science, the two main sources of scientific references. This paper does not intend to provide an exhaustive review of all relevant studies on the topic, rather it aims to provide meaningful discussions about the current practices of FR-DR management in the international context, and its implications for the way forward in future studies. This paper is organised as follows. The methodology is presented in Section 2. Section 3 refers to the quantitative and multivariate analyses of articles, respectively. Section 4 provides a discussion about the key elements for improving FR-DR management. Finally, the study draws up conclusions about the management of multiple hazards in Section 5.

2. Methodology

To explore publications of FR and DR in the international context, a systematic literature review was built with five main phases described in Fig. 1.

2.1. P1: the selection of articles

The selection of articles was divided into two main phases (Fig. 1). P1.1 and P1.2 show details about the articles search. P1.1 was conducted with two main databases, including the *Web of Science* and *Scopus* for they are the main sources of science publications worldwide. To find eligible articles in Web of Science, the search strings "Flood Risk" AND/OR "Drought Risk" AND/OR "Management" were used in titles, abstracts, and keywords. Initially, in favor of updated knowledge, we limited the search of literature to the last 10 years, i.e., between 2011 and 2021. However, the number of eligible publications (32) found was not sufficient to conduct the review in the systematic manner as we expected. Hence, we extended the search to 2008 to include more papers. Ultimately, the articles published from 1 January of 2008 to 31 December of 2021 were included. The first search engendered a list of 63 review articles (P1.1).

Subsequently, more unruled searches were conducted in *Scopus, Google Scholar* and *Connected Papers* tools (P1.2 of Fig. 1). Research articles published from 2008 to 2021, and different than books, books chapters, reports and conference papers were selected, resulting in the addition of 40 references (n = 103). Papers that were also selected in P1.1 were automatically excluded.

2.2. P2: content analysis

The content of literature was analysed in Phase 2. For this, only articles written in English and with Open Access were considered (P2.1). We acknowledge this rule can reduce the number of screened articles in this review, especially because articles can be published in the native language of each country, and without open access. However, since this systematic review had the goal to deeply access the content in each publication, the articles were excluded either for not being able to fully access it or if were published in other languages, not allowing the analysis (n *excluded* = 26).

For the remaining articles, titles, abstract and content were systematically analysed, and papers unrelated to the topic of this literature review were excluded (P2.1 and P2.2 of Fig. 1). Since this literature review aims to discuss contemporary practices of FR and DR management, it was considered that if the article focusses on discussing "disaster risk" but had at least one practical application of FR and/or DR, it could be maintained in the list. Disaster Risk (DRisk) is considered as *"the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure, vulnerability and capacity"* (UNDRR, 2019). From the total, 17 papers were excluded, totalling 60 articles in this review.

2.3. P3 and P4: quantitative and multivariate analyses

Data analysis and interpretation are the third and fourth phases on this literature review (Fig. 1). Articles were organised in different categories following the guidance of P3.1 and P3.2 of Fig. 1. These initial analyses focused only on the general context of publications, such as their trends by publication year, research focus and case study areas. Chronological (i.e., year), descriptive (i.e., journal of publication), and geographical factors (i.e., the area in analysis) were systematically organised for the 60 articles.

Due to the interdisciplinary field of "disaster risk management", each article is unique but have multiple goals and methodologies. These were divided into specific groups that expresses the main angles tackled by the authors in each publication. For a comprehensive understanding of the articles, methodological approaches were divided into: (1) Reviews/commentaries, (2) Participatory approaches, (3) Statistics and mathematical models, and (4) Modelling approaches (P3.3 of Fig. 1). For main objectives, it was considered (A) Conceptualisation, (B) Risk assessment, (C) Solutions, and (D) Management (P3.4 of Fig. 1). It is important to underline articles might have multiple objectives or methods applied, and because of this, some papers are included in more than one category. At this point, it was also investigated if articles considered the "interplay" between FR and DR (P3.5 of Fig. 1). In other words, P3.5 aimed to evaluate if articles considered FR-DR together (i.e., interplay) for formulating a conceptual tool, risk assessments, proposing solutions, and management (i.e., the main objectives).

Phase 4 refers to the evaluation of the overall context of each publication. The relationships between factors, interplay, and objectives (P4.1) and methods (P4.2) were analysed. We used two multivariate analyses to unravel the differences in terms of objectives and methods of the reviewed studies between countries, scales, and more importantly whether or not the authors touched upon the floods-droughts interplay. Specifically, we used the Multi-Correspondence-Analysis (MCA) in which the variables reflecting the methods and objectives of the reviewed studies are included as the primary variables, whereas all the background information, i.e., locations, scales, and interplay are included as supplementary variables. Since the information related to the year of publication and the journal names have been summarised, they were not included in this analysis.

The results from MCA were then further analysed using Hierarchical Cluster Analysis (HCA) to explore underlying trends of the reviewed papers, synthesising both primary and secondary variables (P4.3 of Fig. 1). The clustering was done based on the Euclidean distances of each data point, i.e., reviewed paper projected on the factor map made up by the first two Principal Components (PC) of the MCA. All these analyses were done using R and two packages developed by Ref. [15] for multivariate analyses. The use of MCA and HCA have been widely applied for in-depth data analysis in environmental related studies, see for instance Refs. [16,17,19] or [18].

2.4. P5: the integrated management of flood and drought risks (FR-DR)

Finally, results obtained from P1 to P4 are discussed for integrating FR-DR in studies (P5 of Fig. 1). At this phase, key elements for next studies are discussed in a framework focusing mainly on the trade-offs between defining the context-specific conditions, assessing the dual-risks contexts and implementing integrated solutions for FR-DR reduction.

3. Results

3.1. Chronological, descriptive and geographical coverage or scale of articles

Articles' timeline is shown in Fig. 2. As seen, results indicate an increase of publications in the last decade and most studies in 2021 (n = 22). A reason for this increase may be the recurrent disasters' occurrence worldwide, suggesting that communities are more exposed to FR-DR in recent years [22,23]. In the last decade, worldwide international reports, such as the 5th and 6th reports of the Intergovernmental Panel on Climate Change (IPCC) in 2012, 2014, 2021 and 2022, the Global Assessment Report of the UNDRR in 2019 and the Sendai Framework for Disaster Risk Reduction (UN) in 2015, bring attention to the responsibility for individuals, communities, and governments to minimise the effects of climate change and floods-drought risks, which is reflected in the growing number of publications on the topic [24–26].

From our preliminary analyses, it can be observed that more attention has been given to FR than to DR management not only in academic research, but also in risk management in practice. The frequent and impactful cases challenge institutions to take an action immediately to avoid failure in the future [27]. In general, articles selected for this review show concerns about dealing with the FR-DR

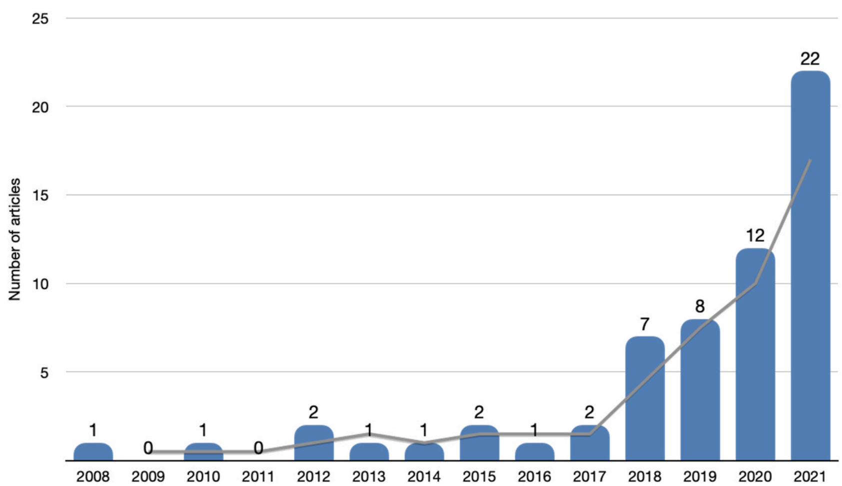

Fig. 2. – The number of articles published from 2008 to 2021.

management in multiple geographical scales. Geographical scales are shown in cities, basins, regions, federal and global scales, in which most case studies are applied for "regions" (Fig. 3). "Region" is defined as any geographical area that extrapolates the perimeter of cities and basins but is still smaller than the "national" scale. 15 of the case studies deal with regions, 10 with national scale, 7 with basins, and only 2 with the global scale (Fig. 3). These geographical areas correspond to *urban, rural* and *mixed urban-rural* case studies. Since part of the published papers are "reviews", in which no case study is analysed, 23 of the case studies are categorised as "theoretical analysis" in Fig. 3.

In addition, considering multiple time scales is also a key component for FR-DR management. This is because DR is usually defined as a recurring climate phenomenon characterised by water deficit over a period ranging from months to years, contrasting to FR which occurs in a smaller timescale [28]. Each disaster therefore will have different temporal and spatial scales [29]. For example, flooding can occur within few hours (temporal scale), and lead to impacts for households, streets, basins, and sometimes whole cities (spatial scale). On the other hand, drought can be specific to areas of various size, and can last for months or even years [28,29].

Despite the spatial and temporal divergence of floods and drought, several studies have found that the frequency, magnitude and spatial-temporal distribution of both have significantly increased in many regions of the world [30]. Impacts increase slowly and often accumulate after a considerable period and may linger for years after termination of the disaster period. For DR, impacts are often non-structural and spread over large geographical areas [28], while for FR the impacts are both structural and non-structural and can be over small but also large areas [31].

FR-DR events are also considered as an "interdisciplinary" topic in the articles. From the 60 articles of this review, 32 journals were selected for publication, which can be an indication of the growing awareness on FR-DR management in the fields of science. In general, journals are focused on either natural hazards, water security, flood risk management, climate risk, water, sustainability, environmental management or disaster risk. Details of each journal can be seen in Appendix A.

As FR and DR are "disaster risks" related to the same water cycle, the journals with more publications are "*Natural Hazards and Earth Systems Sciences*", "*International Journal of Disaster Risk Reduction*" and "*Science of the Total Environment*" with 10% of publications in each (n = 6). Some of these articles focus on how governance of pre-disaster planning and preparedness for floods and droughts remain largely reactive to existing conditions [3], and how a comprehensive "risk management" approach must include views and perceptions of end users in both the development and implementation of action plans, especially for floods and droughts [32]. Public participation is highlighted in many studies but only a minority of articles in fact applies strategies for public engagement. Some examples are [32–35]. Additionally, engineering journals focused on water resources are also seen with examples of Water (7%, n = 4) and Journal of Hydrology (5%, n = 2).

Lastly, journals also focus on sustainability, vulnerability and society (10%, n = 6). Articles highlight that even though further research is required to enhance the environmental and social sustainability of FR-DR reduction [36], there is also a need to incorporate deeper levels of context-specific insights [37] and the analysis of vulnerability in approaches [38].

3.2. Main objectives and methods applied

Articles have different objectives and methods (Table 1). Even though every study reviewed was unique, we observed that there are generally four types of objectives, i.e. (A) *Conceptualisation,* (B) *Risk Assessment, (C) Solutions,* and (D) *Management.* The first group refers to studies that focus solely on commentaries or theories of risks while the second conducted analyses of some sort to evaluate the risks. The third group includes those studies that sought to propose technical solutions, via explicit interventions to reduce the risks while the last group focused on how to comprehensively manage the risks, via both structural and non-structural methods, including policy and governance.

43% of articles (n = 26) were categorised with objective A (Table 1). In general, articles provide meaningful suggestions for risk management and mitigation either in general, or specific contexts. For example [39], affirms that disaster risk literature is fragmented and divided into distinct disciplines, focusing mainly on single hazard analysis. However, authors highlighted how compound and cascading events, like floods and droughts, often generate the most severe impacts, due to a unique combination of drivers and/or hazards, which makes their integrated analysis even more vital for management [39]. Similarly [2], highlights how current projects are still focused on isolated analysis of FR or DR, with no consideration about the possible benefits of addressing trade-offs between FR and DR management. For [40] another challenge is that most studies still focus largely on hazard modelling, while the underlying factors, vulnerability and exposure, are still not well addressed when dealing with risk reduction, emphasizing the need to incorporate

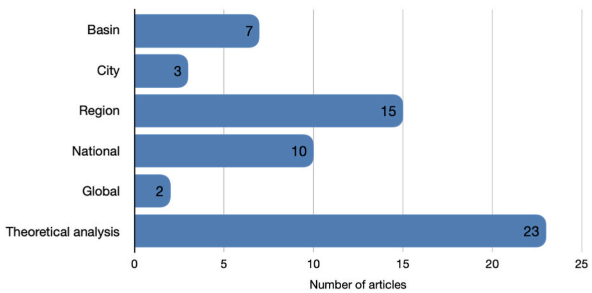

Fig. 3. – The geographical scale of analysis in the reviewed papers. The approaches focused on either on smaller scales such as basin, city, region, or larger scales, such as national, and global analysis. Theoretical analyses are from the review papers.

Table 1
– Analysis from the 60 articles of this review. Articles are categorised according to their main objectives and methods applied.

	Categories	Number of articles (%)
Objectives	A) Conceptualisation	21 (43%)
	B) Risk Assessment	21 (35%)
	C) Solutions	9 (15%)
	D) Management	11 (18%)
Methods	1) Reviews and Commentary	36 (60%)
	2) Participatory Approaches	11 (17%)
	3) Statistics and Mathematical Models	15 (25%)
	4) Hydraulic and GIS Modelling	12 (20%)

the multiple components of risk accordingly [40]. Other authors developed approaches for compound risk analysis, such as [13,36]. When looking to specific contexts, Africa was the continent with more study cases [21,22,41]. United Kingdom [42] and Caribbean Small Islands [38] are also cited. The main methods applied in articles with the objective A are reviews or commentaries, corresponding to 60% of the articles analysed (Table 1).

Results indicates that 35% of publications (n = 21) focus on objective B, referring to the development of risk assessment frameworks (Table 1). Studies are developed with a mix of methodologies, mainly integrating spatial and quantitative methods, such as statistics and mathematical models, and hydraulic and GIS modelling approaches (i.e., seen in Fig. 5c and d). In general, articles with objective B support the *(i)* understanding of compounding impacts to risk reduction with the quantification of cascading paths of DR [43] and FR [44], *(ii)* proposal of alternative approaches to consistently analyse changes in both floods and droughts [30], *(iii)* mathematical models that mimic the interplay between water management and hydrological extremes [4], and *(iv)* statistical analysis and GIS-models for evaluating FR and DR, including the evaluation of urban rainwater management [45] and groundwater irrigation and recharge [46]. Risk assessment frameworks are applied from global to catchment scales. Two models are built for global scales [47,48] whereas the majority considers national [9,43,45,49–51], regional [52–54], and catchment scales [30,46,55,56]. Only one article deals with city scale [44].

In addition, it is also seen that 15% of the articles (n = 9) are focused on proposing risk reduction solutions (i.e., objective C of Table 1). It is important to mention that even though proposing FR-DR reduction solutions is considered in objective C, it may be also cited in other "objectives". For example, when "conceptualising" about FR-DR management (i.e., objective A) or assessing risk (i.e., objective B), solutions can also be considered. In this sense, to avoid repetitiveness, in this section we only discuss articles that consider more directly the proposal of solutions in the context of FR-DR management. In the reviewed articles, "solutions" are acknowledged differently with examples of Ecosystem-based solutions [57], Nature-Based Solutions (NBS) [20,31,58], adaptive strategies [59,60], and mitigation measures [5,10].

Key barriers for the implementation of FR-DR reduction strategies are also discussed. For [57]; most studies do not consider combined mitigation practices and techniques that may in synergy reduce both of FR-DR risks. For [5]; to better design risk reduction measures and strategies, it is important to consider interactions between these closely linked phenomena, including their impacts to the risk components (i.e., hazard, vulnerability and exposure). In their study, FR or DR reduction strategies should be classified considering that: (a) measures can have (unintended) positive or negative impacts on risk of the opposite hazard; and (b) measures can be negatively impacted by the opposite hazard [5]. For [59]; building and strengthening adaptive capacity at the basin scale should be a central goal when it comes to dealing with FR-DR. Adaptation strategies should be developed with participatory and collaborative approaches, allowing site-specific expert knowledge to be incorporated into the planning process and ensure that the response strategies consider local social and political drivers [59]. The methods applied are mainly a combination of spatial and quantitative methods, statistics and mathematical models, hydraulic and GIS modelling approaches.

Lastly, FR-DR management is targeted by 18% of articles (n = 11) (i.e., objective D of Table 1). Management-focused articles incorporate concerns mainly related to social and political aspects for floods-drought reduction. For [3]; there is a need to develop a more integrated risk management approach that includes *(i)* the formal adoption of an integrated system of DR Reduction, human development and legislative and policy frameworks; *(ii)* expanding planning and preparedness to DR in the disaster literature; and *(iii)* developing approaches for transforming floods-drought management to "risk"-oriented [11]. adds to this context by exploring the concept of "multi-risk governance" and discussing key institutional barriers related to its implementation. For [3,11,13]; the implementation of multi-risk frameworks must incorporate a clear identification of responsibilities in the different stages of management, especially because most frameworks for risk reduction remain primarily single risk centred.

Insights for the social context can also be seen. [4] tackles social aspects with the analysis of public perceptions for multiple hazards in Italy and Sweden with national surveys. Recently, a study from Ref. [12] also highlights the social and physical aspects of drought-to-flood events, with case studies in Kenya and Ethiopia. Another example is seen in Ref. [34]; in which hydrogeological risk awareness posed by FR hydrogeological phenomena are analysed with surveys in Italy [34]. [61] provides further insight via interviews and focus group meetings with local stakeholders and government officials for the assessment of community vulnerability and local governance. Studies such as [8,35] discusses experiences of integrating FR-DR with stakeholders' processes in Austria and Asia respectively [8]. share experiences with interviews and workshops for FR-DR management and governance in the European context, whereas [35] evaluates how local knowledge of the spatial and temporal patterns of floods and other key hydrometeorological events can be integrated with scientific information on flooding and rainfall characteristics along a section of the lower Mekong River. Authors conclude with proposals for the regions, including the recommendations for developing risk management approaches linking local knowledge and spatial analysis, to provide interface between risk management practice and political decision-making [8,35].

In summary, "management studies" show how "planned" adaptation (i.e., political aspects) and "people-centred approaches" (i.e., social aspects) to climate change and disaster risk management require the collaboration not only among residents and communities' associations, but also with industry, non-government organizations, and local and regional government agencies [11,61]. Detailed description of articles' main objectives and methods are fully described in Appendix A.

3.3. The "interplay" between floods-drought risks

The final analysis examined considers the integration of FR-DR in studies. The "interplay" refers not only the occurrence of FR or DR in the same area (spatial scale) but also considers that both risks can occur simultaneously and/or consecutively (temporal scale). The scheme of Fig. 4 illustrates the difference between the concepts of multi-risks integration with and without the "interplay". The main premise for building this concept is that multiple risks can occur at the same spatial scale for at least a period [2]. For example, considering that DR usually occur in a larger scale [28], some areas exposed only to DR (Fig. 4b), but others can be also facing FR at some point during the drought period (Fig. 4c). Even though DR and FR represent two opposite water-related disasters with too much water (flood) or too little water (drought), they may "overlap" for a moment, and their impacts will "interact" with each other, creating the "interplay" between risks (Fig. 4b).

From the 60 articles analysed, only 23 articles consider the interplay (Fig. 4a). Most studies have focused on isolated analysis of risks of floods or drought, without considering the possible benefits of addressing tradeoffs between FR and DR management, and practices that may in synergy reduce both risks. This result corroborates with previous studies such as [3,5,7]; and Zalantari et al. (2018).

3.4. Multivariate analyses (MCA)

3.4.1. Overall objectives of the reviewed literature

We first ran the MCA solely for the variables reflecting the objectives of the studies reviewed. In general, the multivariate analysis was able to capture 56.8% of the total variance via the first two principal components, i.e. 33.2% for the first principal component and 23.6% for the second. These variables were Boolean type, i.e. *Yes* or *No* signifying whether a study of interest targeted that specific objective (i.e., conceptualisation, risk assessment, solutions, and management). Shown in Fig. 5 (A-D) are the projections of the reviewed literature focusing on their objectives. Each reviewed article is represented by a small dot whereas the larger dots represent the centroids of each segregated group, hence representing the common attributes of the group. In this study, the reviewed articles are segregated by (A): whether they consider interplay between FR and DR; (B) Study area - here we classify by continents (C) Types of catchments, either Rural or Urban; and (D) Geographical scales (city, region, national or global). The coordinates of each centroid are the averaged coordinates of all the small dots in the respective group. For instance, for Fig. 5A, the large red dot (Yes) is the centroid of all the smaller red dots and represents the overall characteristics (in terms of objectives) of the articles that consider the FR-DR

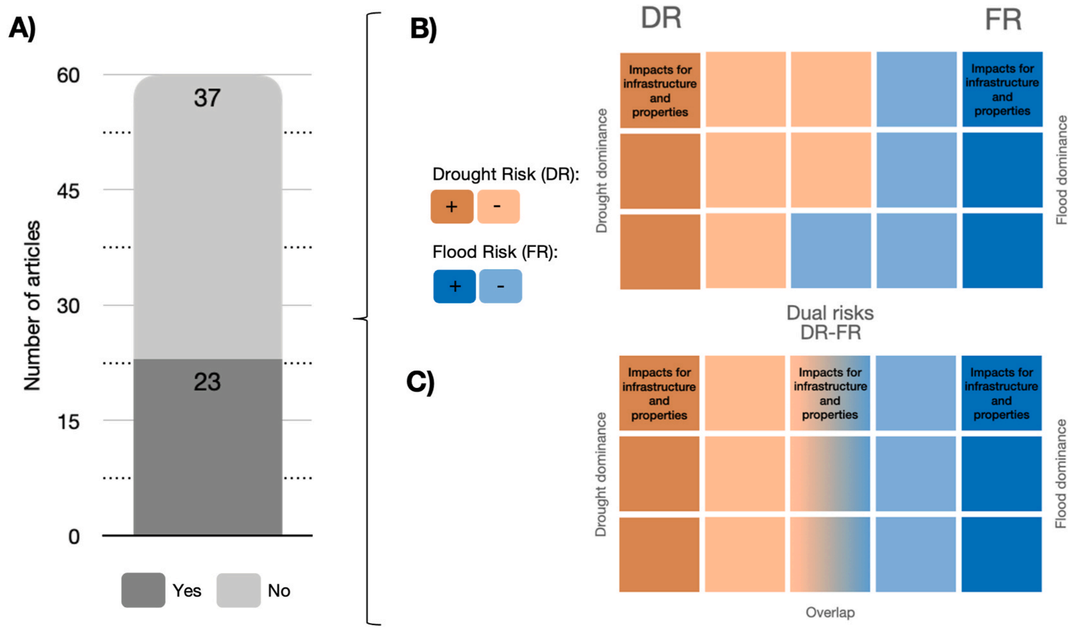

Fig. 4. – Analysing FR-DR "interplay": A) The number of articles that considered the "interplay", B) Illustration of studies which do not consider the "interplay" between risks, hence the discrete blocks. C) the difference of considering the "interplay" in a spatial and temporal perspectives, hence the gradual transition in colours in between. The "interplay" refers to the occurrence of not only FR or DR in the same area (spatial scale) but also considers that both risks can occur simultaneously and/or consecutively (temporal scale). Fig. 4B and C are only figurative and non-quantitative. For both drought risk (oranges) and flood risk (blues), the darker the colours, the higher the risks, represented by the "+" and "-" signs.

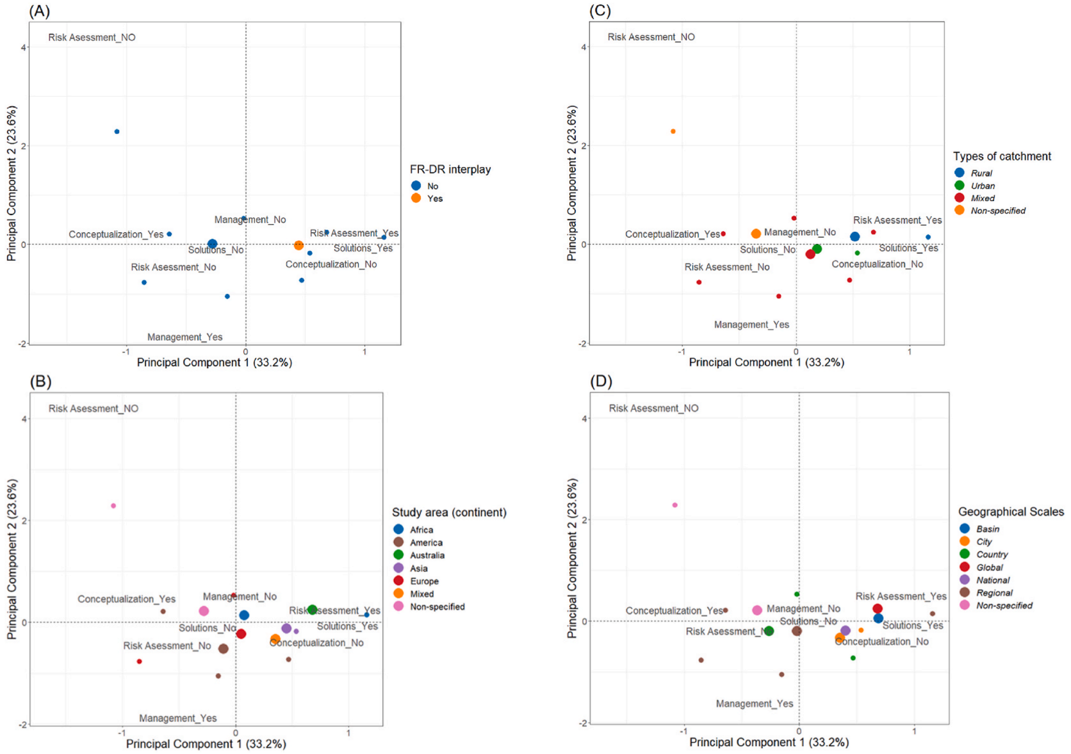

Fig. 5. – Multi Correspondence Analysis focusing on the objectives of the papers grouped by (A) Whether or not they consider Interplay between FR and DR; (B) Study area classified by continents; (C) Rural or Urban; and (D) Geographical scales of the study site. In B, C, D the non-specified category refers to those papers that are purely discursive or theoretical without case studies. In general, each reviewed article is represented by a small dot whereas the large dots represent the centroids of each segregated group, hence representing the common attributes of the group.

interplay whereas the large blue dot (No) is the centroid of the smaller blue dots that represent of the other articles, which do not consider the interplay.

In the first regard, those studies that consider Interplay are more likely to focus on *Risk Assessment* and *Solutions* whereas the studies without focus on *Conceptualisation* and *Management* (Fig. 5a). Secondly, as for the Study area, there are clear associations between *Africa* and *Europe* and *Asia* and *Mixed.* Whereas *Australia, America*, and *Non-specified* are substantially more distinguished. The similarities between *Africa* and *Europe* could have been due to situations where researchers from less developed African countries published their work with their European university affiliations. *Mixed* studies often include *Asia* to cover different contexts, geographically and politically. Finally, those *non-specified* are distinguished by their sole focus on theoretical contributions (Fig. 5b).

With respect to the types of basins, *mixed* and *urban* are indifferent whereas *rural* and *non-specified* are substantially distinguished (Fig. 5c). Studies focusing on rural catchment, most of which also consider the interplay between different risks, are more likely to focus on Risk Assessment and Proposal of Solutions compared to the others. Similar trends can be observed via the classification of geographical scales (Fig. 5d). Global scale studies focus more on Risk Assessment and Proposal of Solutions than finer scaled studies. However, studies looking at global scale are usually less focused on decision-making, due to their inevitable assumptions of homogeneity.

3.4.2. Methods employed in the reviewed literature

In the second MCA, we focus on the variable reflecting the methods employed by the reviewed studies, including *literature review*, *participatory* (such as surveys, focus groups, grassroots or interviews), *statistics*, and *GIS and modelling.* In line with section 3.4.1, the method representing variables were also converted into Boolean type with *Yes* and *No,* i.e., whether a given method had been used or not by the reviewed study. In general, the multivariate analysis was able to capture 79.7% of the total variance via the first two principal components, i.e., 53.1% via the first and 26.6% via the second. Shown in Fig. 6 (A-D) are the projections of the reviewed literature based on the employed methods, classified by the background information.

Similar to Fig. 5, we also see clear separations amongst the studies with respect to (i) whether or not they consider interplay between FR and DR; (ii) Study area - here we classify by continents; (iii) Types of catchments, either Rural or Urban; and (iv) Geographical scales (city, region, national or international). Fig. 7 illustrates the associations between the methods employed in the studies with their background information, included as supplementary variables.

Fig. 6A shows that those studies that consider Interplay are more likely to employ quantitative methods, including *Statistics* and *GIS & Modelling* whereas the other studies rely on qualitative methods, including *Literature Review. Participatory* methods are used by different types of studies, regardless of whether they consider the interplay. As for the Study area, there are clear associations between

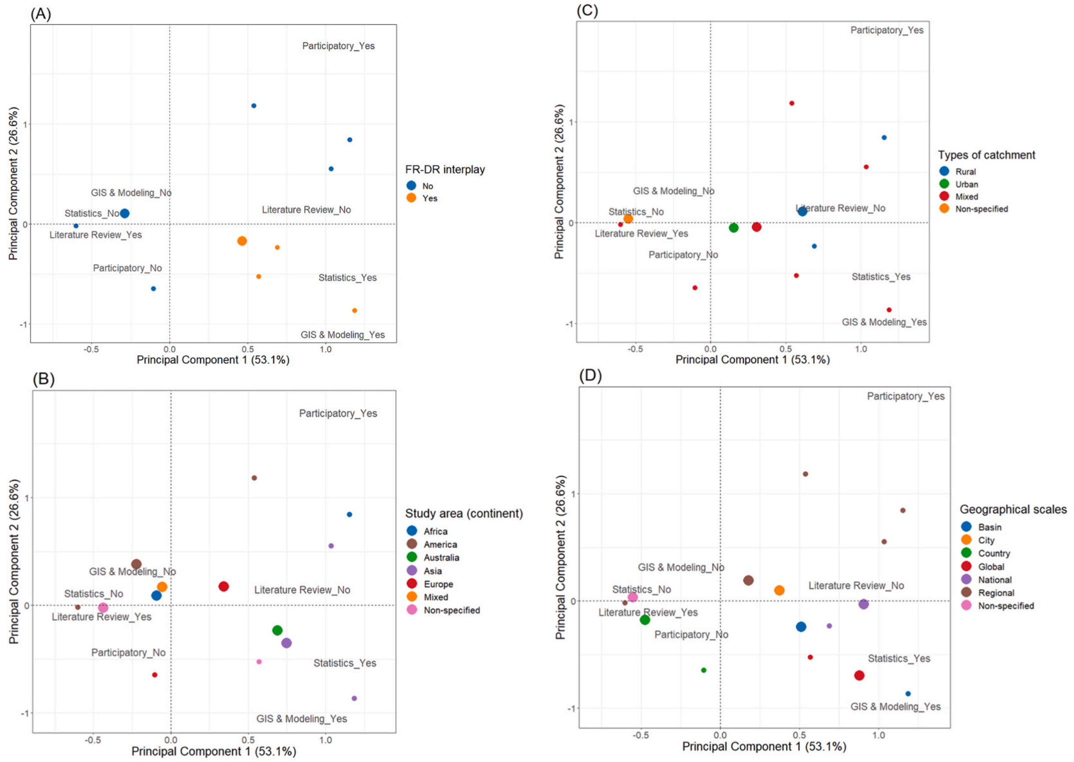

Fig. 6. – Multi Correspondence Analysis focusing on the methods with the papers grouped by (A) Whether or not they consider Interplay between FR and DR; (B) Study area classified by continents; (C) Rural or Urban; and (D) Geographical scales of the study site. In B, C, D the non-specified category refers to those papers that are purely discursive or theoretical without case studies.

Africa and *Mixed* and between *Australia* and *Asia* (Fig. 6B). Whereas *America*, *Europe* and *Non-specified* are substantially more distinguished.

With respect to the types of basins, results shows that *mixed* and *urban* study cases are indifferent in regard to methods, whereas *rural* and *non-specified* are substantially distinguished (Fig. 6C). Focusing on rural catchments, most of which also consider the interplay between different risks, are more likely to focus on literature reviews compared to the others. Similar trends can be observed

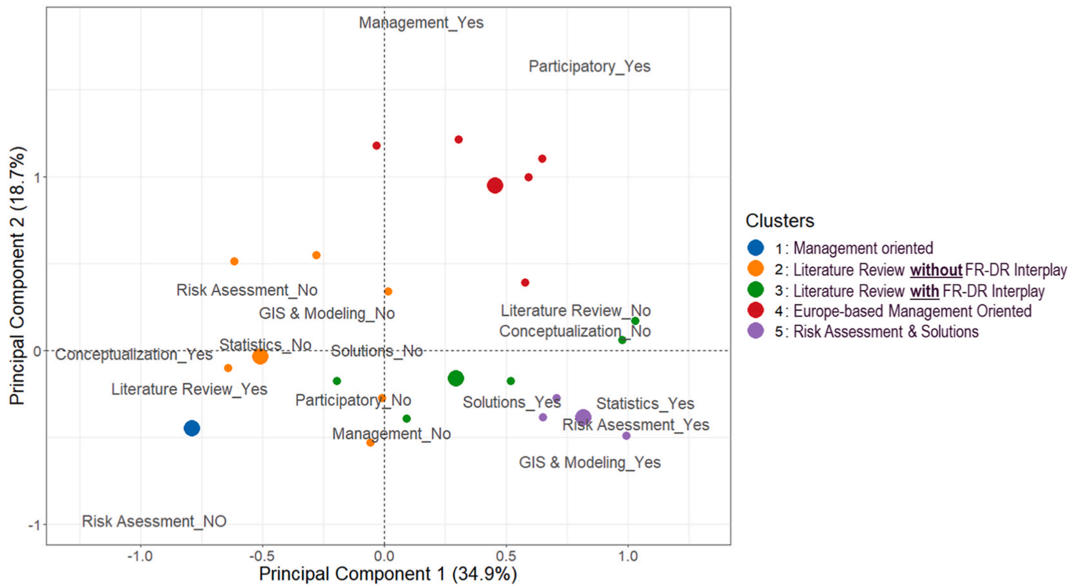

Fig. 7. – Hierarchical Cluster Analysis. The representative studies for each cluster are highlighted with larger filled circles, i.e., the centroids of the individual clouds.

via the classification of geographical scales (Fig. 6D). *Global scaled* studies are more focused on statistical analysis than finer scaled studies.

3.4.3. Hierarchical cluster analysis

Prior to the cluster analysis, we combined all primary variables, i.e., objectives and methods to understand if articles can be grouped in different categories. In general, the multivariate analysis was able to capture 53.6% of the total variance via the first two principal components. Fig. 7 depicts how the reviewed literature can be projected and classified. In general, five distinctive groups or clusters can be produced with statistically significant differences. For each cluster, the closest ones to the cloud centroid were selected to represent the most representative attributes.

The first cluster, represented by the work by Ref. [4] is a *Management* oriented study that considers the *FR-DR interplay* via engaging stakeholders with a participatory process, followed by a statistical analysis. The second and third clusters are the *Literature Review* studies. However, while the latter, represented, by Refs. [5,7]; and [58] includes *FR-DR interplay* in their research design, the former lacks this aspect, for example, [22]. The fourth cluster includes the work of [9]; which is a Europe-based study with a focus on the *FR-DR* interplay. This group is also a *Management oriented study*. The final cluster, represented by the work by Refs. [9,31,47,53] and [10] that focuses mainly on *Risk Assessment and Solutions* with a multidisciplinary approach, combining both *statistics*, *GIS and modelling*.

In essence, cluster 2 is the most representative for studies without FR-DR interplay (Fig. 7). As for the objectives, these studies often focus on Conceptualisation while rarely address Risk Assessment. As for the methods, the most popular method employed by these studies is Literature Review. On the contrary, cluster 5 represents those studies with focus on the interplay (Fig. 7). These studies focus on risk assessment via quantitative methods including GIS, modelling, and statistics. The geographical scales of these studies are mostly global and national.

4. The way forward: key elements for integrating flood and drought risks

Based on the previous discussions, in this section, we selected key elements for integrating floods-droughts interplay in future studies. They were systematically organised into four phases as shown in Fig. 8. This section is discussed regarding Phases A to D aiming to provide an overview of the key objectives that should be considered for integrating floods and drought risks.

4.1. Phase A: the need for understanding context-specific conditions

The first element refers to the impacts generated by floods and droughts risks in a community. The impacted area will be influenced by several conditions, besides the hazard itself (i.e., the extreme or lack of rainfall). Here, we suggest these conditions as “a combination of governance, legislation, and management, including the social, cultural, and political contexts, and physical conditions, such as urbanisation and climate change”(phase A of Fig. 8).

Considering the community do not only mean to specify about its population number. The context will be a sum of the place’s previous conditions, including social and physical conditions, as seen in other studies [12,14,62,63]. Communities’ profiles may increase or decrease disaster risk and impacts and can also interfere in how community responds and cope with disasters. For example, elevation, water bodies and the distribution of the built environment will have direct influence for flooding impacts and can trigger other hazards, like landslides. At the same time, social aspects of communities, such as income, gender, and age (and many other factors) will also affect how they will face and cope with the disaster. However, if the same area is also facing drought, other phenomena such as heatwaves can also occur together, creating compound, or co-occurring, hazards and triggering secondary events such as wildfires (i.e., see more in Refs. [6,28,62]).

In this sense, “context-specific conditions” are called to be a combination of physical conditions of the built environment, such as elevation, water bodies, urbanisation, imperviousness, and climate change (Fig. 8A), but also governance and political elements such

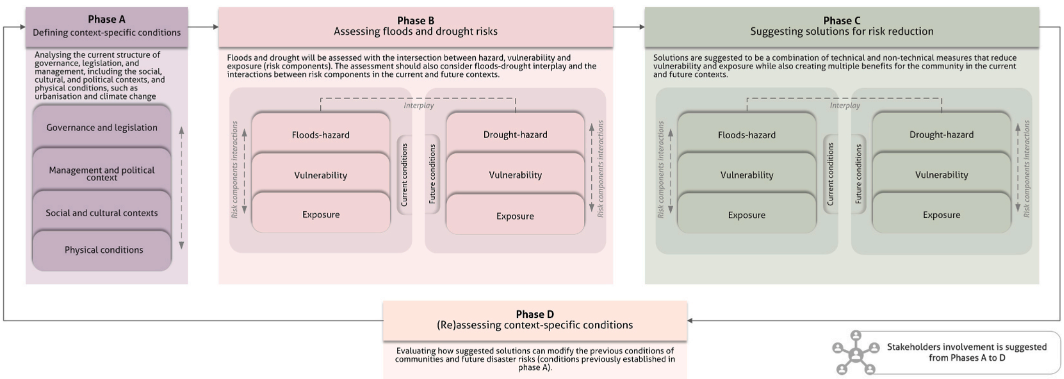

Fig. 8. Key elements for integrating Floods and Drought Risks. “Purple”, “pink”, “green” and “orange” colours refer to the “pre-existing conditions” (Phases A), “floods-drought assessment” (Phase B), “proposal of solutions” (Phase C) and “re(assessing) conditions (Phase D), respectively. Stakeholders engagement is suggested throughout the approach.

as existing policies, institutional bodies, and management. Countries are facing an increasing political pressure to address the climate change crisis, resulting in a growing need for multiple disciplines to create new knowledge for alleviating the disaster impacts [62]. In this sense, disaster risk reduction must be considered as an interdisciplinary challenge and should be targeted with a collaboration from multiple disciplines.

For some authors, risk interdisciplinarity should be merged into the disaster risk reduction approaches in order to avoid obtaining inadequate and deceptive analysis which largely lacks in context for decision making [64]. For others, understanding the current governance structures in specific countries is crucial to develop the effectiveness and efficiency of managing climate-related risks [8]. In any sense, we consider that creating appropriate extreme events policies and legislations are critical for strengthening resilience and well-being of communities facing risks (i.e., see more discussions on [22]). However, due to a lack of legislative and policy frameworks, the formal implementation of an integrated system of disaster risk reduction and human development faces numerous challenges [3], which is even more serious on looking to the international context. This represents the importance of considering current legislation, politics, and management aspects prior to assessing and quantifying the risk itself.

Finally, we also consider the importance of properly understanding the "social, economic and cultural" contexts of the area, including minoritized or gentrified communities in the region. As seen in the results of this review, social aspects are considered in only a minority of articles and constitute a relevant research gap for next studies (i.e., see section 3.2). Therefore, comprehending social aspects such as risk perception, FR-DR previous experiences, coping and adaptive capacities, inequalities, and vulnerabilities of communities facing the dual-risks is also suggested (Fig. 8A). An important social aspect is how floods and drought events can differently impact population. For example, one of the underlying conditions of some regions may be how GI is installed for floods alleviation [65], leading to the "*undergreening*" of some specific populations, especially low-income or communities of colour [66]. Understanding context-specific aspects is an important step to be taken before any measure is applied.

4.2. Phase B: assessing floods and drought risks

We also bring attention to the assessment of floods and drought by considering the dynamic nature of risks in the region affected by the events (phase B of Fig. 8). Several countries have experienced consecutive droughts and floods in recent decades, with the effects overlapping both spatially and temporally, whereas recovery is still ongoing [2]. In this sense, assessing risk components and their interactions (i.e., hazard, vulnerability, and exposure) is extremely important not only to defining disasters-prone areas, but also to the design and implementation of strategies for risk reduction, including land use change (phases B and C of Fig. 8).

Most of the literature in this review have focused on the modelling of hazards ignoring the underlying factors faced by communities, such as vulnerability and exposure. While this seems to be a trend in hazards-focused studies, similarly, other previous studies also showed that a reduced number of studies have considered the intersection between hazard, exposure, and vulnerability when developing risk assessments (i.e., see Refs. [48,61,62,67]). The limited understanding of vulnerability dimensions or the compound character of events constitute serious limitations of risk estimations used in previous studies.

However, there are important aspects of previous studies that should be highlighted. Approaches for assessing FR-DR, with direct guidance for modelling extreme events [30,45], the application of remote sensing, GIS and MCDA tools [68,69], as well as the assessment of FR-DR reduction strategies to build resilience [5,42] can be seen. Studies from Refs. [11,13] together suggests multi-risks frameworks that can lead to a better understanding of how physical systems and governance create impacts when dealing with compound disasters. For [48]; risk should be considered as the intersection between hazard, vulnerability and exposure in their integrative global risk analysis framework, while also considering social, cultural, economic and physical aspects of places. Other multi-risk assessment frameworks are shown in more recent studies [6,7,31,67,70,71]. [7,31] provide overviews of methods and tools used to identify, analyse, and evaluate risks associated with floods and drought. These studies are a valuable preliminary step when looking to methods and applications of risk assessment approaches in different regions. Together, these studies enable to think how the interactions between multiple risks can support the design of risk reduction strategies in an effective manner. However, a challenge in those approaches is the complexity of modelling risks , especially when considering floods and drought as an interdisciplinary topic.

This context is even more challenging since studies also do not consider "interplay" between the risks (Fig. 8B). Although there are numerous studies on drought and flood events over the last few years, the dynamics resulting from their interplay, i.e., both impacts and reactions, are still poorly understood. As a result, while risk reduction efforts based on current quantitative methodologies may succeed in the near term, they are more likely to have unanticipated long-term implications [2,55].

4.3. Phases C and D: implementing solutions for risk reduction, and evaluating changes in the context conditions

Finally, FR-DR integrated management should also consider the implementation of solutions with multiple and integrated objectives. Specifically, we highlight that solutions should target *(i)* the reduction of vulnerability and exposure, and *(ii)* the provision of multiple benefits in the dual-risks context (phase C of Figure 8).

This is based on the different guidance provided by reviewed articles aiming the proposal of solutions (i.e., objective C of Table 1). For example [11], suggests that solutions should be focused on the reduction of the potential domino effects of the multi-risk events, potential interactions among risks and hazards, the identification of consequences of extreme events, and the understanding of stakeholders' perspectives (and needs) and experts' technical knowledge. Similarly [5], discussed how DRR measures for flood and drought reduction can be negatively affected by the opposite hazard (i.e., either flood or drought). In other words, the article also classifies solutions' impacts as "unintended", which means the "undesired" effects that can increase the negative impacts of flooding or drought [5]. This concept is also illustrated with the concept of *maladaptation*, described as "actions or inactions that may lead to increased risk of adverse climate-related outcomes, increased vulnerability to climate change, or diminished welfare, now or in the future" [14,33,72,73].

As seen in section 3.2, risk reduction solutions are acknowledged differently in the literature, with examples of NBS, GI, adaptive solutions, and ecosystem-based solutions. However, findings indicate that most of current research does not show how integrated solutions procedures and techniques could minimise both risks in a synergistic manner [5,57], especially when related to the reduction of vulnerability [62]. When considering that vulnerability reflect the inherent aspects of places with the potential to create a risk (phase A), the proposal of solutions should target the combination of physical and societal drivers, including their interactions.

Another important point is the provision of multiple benefits with solutions. This is seen in many studies, such as [59] which examined how floods and droughts can be coped with by the existing practices. A study focused on agriculture at Mun River Basin, Thailand illustrated that, the overall storage capacity of in-situ and ongoing projects is sufficient to address both flood and drought if the projects are utilised effectively. Small agricultural ponds, a subterranean floodwater collection system, and lake reconnection of oxbow lakes are among the proposed solutions for the region [10].

However, although solutions are called to reduce risk (the environmental benefit), they are also entitled to bring societal and economical benefits for population. Benefits are time and context dependents, which asks for developing frameworks that assess their possible changes and uncertainties that may come over time [74]. This is also endorsed by other studies such as [20,23,31,60] and [72]. Benefits assessment and the (re)evaluation of their impacts to the risk's components (i.e., H, V, E) after solutions implementation are suggested (i.e., in-depth discussions can be seen in Ref. [62]. In other words, solutions should be evaluated with the difference between *(i)* current conditions of hazard, vulnerability, and exposure (before solutions implementation) and, *(ii)* future conditions of risk after solutions implementation (phase C of Fig. 8).

The last phase refers to the analysis if the previous conditions were modified after solutions implementation (i.e., phase D of Fig. 8). The application of solutions in the built environment can modify pre-existing characteristics, altering the next set of "context-specific conditions" for when the subsequent dual-risks takes place [75,76]. For example, management conditions such as governance arrangements and policies in charge can be altered during the process of management; hence this "change" can increase (or decrease) the vulnerability for FR-DR. Because of this, the FR-DR integrated framework require the (re)analysis of the conditions to determine what are the "new" conditions before the next risks takes place (phase D of Fig. 8). The loop between Phases D and A aims to guarantee the continuous analysis of context and social conditions when assessing risk and proposing solutions for the dual-risks environment.

Multiple methods can be applied from Phases A to D (Fig. 8). Although the main objective of this paper was not to provide an overview of the methods applied in FR-DR studies, findings still point that a combination of quantitative and qualitative methods should be used, especially modelling and statistical tools with participatory approaches (i.e., see section 3.2). "Integrated" methodologies with social and physical lenses are still very rarely applied in studies, being another relevant gap for FR-DR frameworks (i.e., see more discussions in Ref. [12]). Other articles such as [8,13,35,67] and [11] are important studies for evaluating the similarities and trade-offs between methods and strategies to be considered for floods-drought mitigation and management.

5. Conclusions

Floods and drought are hazards from the same hydrological cycle. They are closely linked phenomena that can simultaneously take place in the same area for a specific time (FR-DR interplay). Aiming to understand what lessons we can learn from previous published publications on FR and DR, and how to foresee the next steps of future publications, we developed a literature review with published articles from 2008 to 2021. Our results show an increase of FR and DR publications in the last years. We attribute this to intensification of hydrologic cycle leading to more and frequent extreme events worldwide, and the increasing proportion of population exposed to these risks in the recent years, which boost the search for developing appropriate frameworks to risk reduction.

In general, articles are focused on the different phases of risk management (i.e., objectives A to D), with more emphasis on the theoretical aspects of disaster risk approaches, and on methods for risk assessment. "*Theoretical*" papers refer to articles that provide a strong background of manners to achieve risk mitigation and management with better practices, however, these are not implemented yet (i.e., conceptualisation). From the 60 articles, only 17% (n = 10) apply participatory approaches. Additionally, only a few authors considered the "interplay" between FR-DR risks (n = 23). The literature not focused on the "interplay" are mainly reviews and commentaries, focusing on conceptualisation, while *risk interplay* articles focus mainly on risk assessment and proposal of solutions. Our results also show how those articles can be grouped in five clusters with MCA and HCA statistical methods, emphasizing the behaviour and difference between groups, and how those can be targeted for next studies.

As the complexity of dual-risk unfolds, we also contribute to the knowledge by systematically discussing the way forward and the key challenges and barriers for the dual risks-oriented management in next studies. FR-DR integration should consider that context-specific conditions can have different effects to each risk and regions. This understanding is critical for capturing and considering several environmental, socio-economic, political, and cultural characteristics in specific spatial areas, e.g., variables will be important managing FR-DR for multiple locations but not all.

Also, we also discuss the need to consider that multiple risks will be created with the interaction of hazard, vulnerability, and exposure of each risk, and will generate impacts in multiple dimensions, affecting economic, social, and environmental conditions of the place. In this sense, it is key to assess risks not only alone (single hazards approach), but also their interplay, when facing dual-risks susceptibility. In other words, we consider that actions and solutions should be targeted with an integrated approach when areas are susceptible to both FR and DR. We also highlight the need to reframe the manner that simultaneous disaster risks are managed, to inform action without slipping into oversimplicity, as suggested by Refs. [2,64].

Finally, we suggest that solutions should look at the reduction of risk components regarding each disaster, but also focusing on providing multiple benefits for people. Solutions should look beyond environmental advantages, provide social and economic benefits, reducing *maladaptation*. When implementing any action or solution for risk reduction, we also consider that it is fundamental to re-evaluate the previous established conditions, and their effects into risk assessment, and proposal of solutions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Acknowledgements

The presented work is conducted under the project titled "Integrated Management of Flood and Drought in the Mun River Basin, Thailand". Authors would like to acknowledge the funding agency the Natural Environment Research Council (NERC) under NERC COP26 Adaptation and Resilience Project Scoping Call. Data were taken from the research project "Enhancing Resilience to Future Hydro-meteorological Extremes in the Mun River Basin in northeastern Thailand (ENRICH)". Funding agencies of the project of ENRICH-1 include the following: Thailand Science Research and Innovation (TSRI), and the NERC (NE/S002901/1) under the Newton Fund.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2023.103905.

Appendix A

	Authors	Year	Journal	City	Country/Region	Urban/Rural	Scale	Main objectives_ALL
1	[64]	2021	Climatic Change	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
2	[5]	2020	Water Security	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Proposal of solutions
3	[34]	2020	Hydrological Sciences Journal	Vermiglio, Romagnano	Italy	Urban	City	Social-political management
4	[3]	2019	International Journal of Disaster Risk Reduction	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Social-political management
5	[2]	2020	Earth's Future	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
6	[40]	2019	Sustainability	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
7	[61]	2018	Environmental Management	No specific city	Argentina, Canda, Colombia	Rural	Region	Risk assessment
8	[43]	2021	Science of the Total Environment	No specific city	Germany	Urban and rural	National	Risk assessment
9	[57]	2018	Current Opinion in Environmental Science & Health	No specific city	East Africa	Urban and rural	Region	Proposal of solutions
10	[44]	2019	Journal of Flood Risk Management	Cologne, Rhein-Erft-Kreis	Germany	Urban	City	Risk assessment
11	Pavelic et al. (2012)	2012	Journal of Hydrology	No specific city	Thailand	Rural	Basin	Proposal of solutions
12	[30]	2018	Advances in Water Resources	No specific city	Italy	Urban	Basin	Risk assessment
13	[55]	2017	Earth Syst. Dynamics	Brisbane	Australia	Urban	Basin	Risk assessment
14	[31]	2019	Science of the Total Environment	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Risk assessment
15	[54]	2021	Science of the Total Environment	No specific city	Southeast Asia	Rural	Region	Risk assessment
16	[47]	2020	Earth Syst. Dynamics	No specific city	No specific region	Urban and rural	Global	Risk assessment
17	[11]	2015	International Journal of Disaster Risk Reduction	No specific city	Australia and Italy	Urban	Region	Social-political management
18	[9]	2021	International Journal of Disaster Risk Reduction	No specific city	China	Urban and rural	National	Risk assessment

(continued on next page)

(*continued*)

	Authors	Year	Journal	City	Country/ Region	Urban/Rural	Scale	Main objectives_ALL
19	[8]	2020	Climate Risk Management	No specific city	Austria	Urban and rural	National	Social-political management
20	[53]	2020	Environmental Research	Multiple cities in China	East China	Urban and rural	Region	Risk assessment
21	[39]	2021	International Journal of Disaster Risk Reduction	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
22	[28]	2010	Journal of Hydrology	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
23	[11]	2017	Geosciences	Naples and Guadeloupe	Naples and Italy	Urban and rural	Region	Social-political management
24	[58]	2020	International Journal of Disaster Risk Reduction	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Risk assessment
25	Debele et al. (2019)	2019	Environmental Research	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Proposal of solutions
26	[4]	2021	Natural Hazards and Earth System Sciences	No specific city	Italy and Sweden	Urban and rural	National	Social-political management
27	[13]	2014	Climatic Change	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
28	[59]	2008	Ecology and Society	No specific city	Europe, Africa and Central Asia	Urban and rural	Basin	Proposal of solutions
29	[45]	2018	Hydrological Processes	No specific city	China	Urban and rural	National	Risk assessment
30	[46]	2016	Environmental Earth Sciences	No specific city	South Asia	Urban and rural	Basin	Risk assessment
31	[10]	2021	Water Policy (IWA)	No specific city	Thailand	Urban and rural	Basin	Proposal of solutions
32	Chmutina et al. (2021)	2021	International Journal of Disaster Risk Science	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Risk assessment
33	[52]	2021	Natural Hazards and Earth System Sciences	No specific city	Portugal	Urban	Region	Risk assessment
34	[60]	2021	Natural Hazards and Earth System Sciences	Jakarta	Indonesia	Urban	City	Proposal of solutions
35	[48]	2021	Earth’s Future	No specific city	No specific region	Urban and rural	Global	Risk assessment
36	[51]	2021	Environment and Development Economics	No specific city	Malawi	Rural	National	Risk assessment
37	[14]	2020	One Earth	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
38	[35]	2021	International Journal of Disaster Risk Science	No specific city	Cambodia	Urban and rural	Region	Social-political management
39	[32]	2021	International Journal of Disaster Risk Reduction	No specific city	Caribbean	Urban and rural	Region	Social-political management
40	[56]	2021	Natural Hazards and Earth System Sciences	No specific city	Greece	Urban and rural	Basin	Risk assessment
41	[36]	2020	Sustainability	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
42	[7]	2021	Water	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
43	[69]	2018	Water	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
44	[68]	2021	Water	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
45	[42]	2020	Water	No specific city	United Kingdom	Urban and Rural	National	Conceptualisation
46	[49]	2019	Science of the Total Environment	No specific city	United States	Urban and Rural	National	Risk assessment and Social Political Management
47	Khan et al.	2015	Water Research	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
48	Kourigialas	2020	Science of the Total Environment	No specific city	Greece	Urban and Rural	National	Conceptualisation and Risk assessment
49	Tariq et al.	2021	Hydrology	No specific city	Bhutan	Urban and Rural	National	Conceptualisation and Socio political management
50	[41]	2021	SN Applied Sciences	No specific city	Africa	Urban and Rural	Region	Conceptualisation
51	[21]	2019	Wiley Interdisciplinary Reviews-Water	No specific city	Sub-Saharan Africa	Urban	Region	Conceptualisation

(*continued on next page*)

(*continued*)

	Authors	Year	Journal	City	Country/ Region	Urban/Rural	Scale	Main objectives_ALL
52	Meyer et al.	2013	Natural Hazards and Earth System Sciences	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
53	[20]	2021	Science of the Total Environment	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
54	Bedla and Halecki	2021	Ecological Indicators	No specific city	No specific region	Urban	Theoretical analysis	Conceptualisation
55	[37]	2019	Sustainability	No specific city	No	Theoretical analysis	Theoretical analysis	Conceptualisation
56	[23]	2020	Natural Hazards and Earth System Sciences	No specific city	No specific region	Theoretical analysis	Theoretical analysis	Conceptualisation
57	[22]	2018	International Journal of Environmental Research and Public Health	No specific city	Southern Africa	Rural	Region	Conceptualisation
58	Zupanic et al.	2021	Energy sustainability and society	No specific city	Western Balkans	Urban and Rural	Region	Conceptualisation and Socio political management
59	[38]	2012	Sustainability	No specific city	Caribbean	Urban and Rural	Region	Conceptualisation
60	Antwi-Agyeu et al.	2018	Climate Risk Management	No specific city	Northern region of Ghana	Rural	Region	Risk assessment

References

[1] B. Tellman, Satellite imaging reveals increased proportion of population exposed to floods 21 (2021).

[2] M.C. de Ruiter, A. Couasnon, M.J.C. Homberg, J.E. Daniell, J.C. Gill, P.J. Ward, Why we can No longer ignore consecutive disasters, Earth's Future 8 (3) (2020), https://doi.org/10.1029/2019EF001425.

[3] J. Raikes, T.F. Smith, C. Jacobson, C. Baldwin, Pre-disaster planning and preparedness for floods and droughts: a systematic review, Int. J. Disaster Risk Reduc. 38 (2019), 101207, https://doi.org/10.1016/j.ijdrr.2019.101207.

[4] G. Di Baldassarre, E. Mondino, M. Rusca, E. Del Giudice, J. Mård, E. Ridolfi, A. Scolobig, E. Raffetti, Multiple hazards and risk perceptions over time: the availability heuristic in Italy and Sweden under COVID-19, Nat. Hazards Earth Syst. Sci. 21 (11) (2021) 3439–3447, https://doi.org/10.5194/nhess-21-3439-2021.

[5] P.J. Ward, M.C. de Ruiter, J. Mård, K. Schröter, A. Van Loon, T. Veldkamp, N. von Uexkull, N. Wanders, A. AghaKouchak, K. Arnbjerg-Nielsen, L. Capewell, M. Carmen Llasat, R. Day, B. Dewals, G. Di Baldassarre, L.S. Huning, H. Kreibich, M. Mazzoleni, E. Savelli, M. Wens, The need to integrate flood and drought disaster risk reduction strategies, Water Security 11 (2020), 100070, https://doi.org/10.1016/j.wasec.2020.100070.

[6] N.P. Simpson, K.J. Mach, A. Constable, J. Hess, R. Hogarth, M. Howden, J. Lawrence, R.J. Lempert, V. Muccione, B. Mackey, M.G. New, B. O'Neill, F. Otto, H.-O. Pörtner, A. Reisinger, D. Roberts, D.N. Schmidt, S. Seneviratne, S. Strongin, C.H. Trisos, A framework for complex climate change risk assessment, One Earth 4 (4) (2021) 489–501, https://doi.org/10.1016/j.oneear.2021.03.005.

[7] S. Fasihi, W.Z. Lim, W. Wu, D. Proverbs, Systematic review of flood and drought literature based on science mapping and content analysis, Water 13 (19) (2021) 2788, https://doi.org/10.3390/w13192788.

[8] M. Leitner, P. Babcicky, T. Schinko, N. Glas, The status of climate risk management in Austria. Assessing the governance landscape and proposing ways forward for comprehensively managing flood and drought risk, Clim. Risk Manag. 30 (2020), 100246, https://doi.org/10.1016/j.crm.2020.100246.

[9] X. Guan, Study on spatiotemporal distribution characteristics of flood and drought disaster impacts on agriculture in China, Int. J. Disaster Risk Reduc. 13 (2021).

[10] S. Prabnakorn, L. Ruangpan, N. Tangdamrongsub, F.X. Suryadi, C. de Fraiture, Improving flood and drought management in agricultural river basins: An application to the Mun River Basin in Thailand 17 (2021).

[11] A. Scolobig, T. Prior, D. Schröter, J. Jörin, A. Patt, Towards people-centred approaches for effective disaster risk management: balancing rhetoric with reality, Int. J. Disaster Risk Reduc. 12 (2015) 202–212, https://doi.org/10.1016/j.ijdrr.2015.01.006.

[12] A. Matanó, M.C. De Ruiter, J. Koehler, P.J. Ward, A.F. Van Loon, Caught between extremes: understanding human-water interactions during drought-to-flood events in the horn of Africa, Earth's Future 10 (9) (2022), e2022EF002747, https://doi.org/10.1029/2022EF002747.

[13] M. Leonard, S. Westra, A. Phatak, M. Lambert, B. van den Hurk, K. McInnes, J. Risbey, S. Schuster, D. Jakob, M. Stafford-Smith, A compound event framework for understanding extreme impacts, WIREs Climate Change 5 (1) (2014) 113–128, https://doi.org/10.1002/wcc.252.

[14] Schipper, Maladaptation: when adaptation to climate change goes very wrong, One Earth 3 (4) (2020) 409–414, https://doi.org/10.1016/j.oneear.2020.09.014.

[15] F. Husson, J. Josse, J. Pages, Principal component methods-hierarchical clustering-partitional clustering: Why would we need to choose for visualizing data 17 (2010).

[16] H.H. Loc, N. Thi Hong Diep, N.T. Can, K.N. Irvine, Y. Shimizu, Integrated evaluation of ecosystem services in prawn-rice rotational crops, Vietnam, Ecosyst. Serv. 26 (2017) 377–387, https://doi.org/10.1016/j.ecoser.2016.04.007.

[17] H.H. Loc, E. Park, T.N. Thu, N.T.H. Diep, N.T. Can, An enhanced analytical framework of participatory GIS for ecosystem services assessment applied to a Ramsar wetland site in the Vietnam Mekong Delta, Ecosyst. Serv. 48 (2021), 101245, https://doi.org/10.1016/j.ecoser.2021.101245.

[18] E. Park, J. Lim, H.L. Ho, J. Herrin, D. Chitwatkulsiri, Source-to-sink sediment fluxes and budget in the Chao Phraya River, Thailand: a multi-scale analysis based on the national dataset, J. Hydrol. 594 (2021), 125643, https://doi.org/10.1016/j.jhydrol.2020.125643.

[19] T. Plieninger, S. Dijks, E. Oteros-Rozas, C. Bieling, Assessing, mapping, and quantifying cultural ecosystem services at community level, Land Use Pol. 33 (2013) 118–129, https://doi.org/10.1016/j.landusepol.2012.12.013.

[20] P. Kumar, S.E. Debele, J. Sahani, N. Rawat, B. Marti-Cardona, S.M. Alfieri, B. Basu, A.S. Basu, P. Bowyer, N. Charizopoulos, G. Gallotti, J. Jaakko, L.S. Leo, M. Loupis, M. Menenti, S.B. Mickovski, S.-J. Mun, A. Gonzalez-Ollauri, J. Pfeiffer, T. Zieher, Nature-based solutions efficiency evaluation against natural hazards: modelling methods, advantages and limitations, Sci. Total Environ. 784 (2021), 147058, https://doi.org/10.1016/j.scitotenv.2021.147058.

[21] C.F. Grasham, M. Korzenevica, K.J. Charles, On considering climate resilience in urban water security: a review of the vulnerability of the urban poor in sub-Saharan Africa, WIREs Water 6 (3) (2019), https://doi.org/10.1002/wat2.1344.

[22] J. Kamara, B. Akombi, K. Agho, A. Renzaho, Resilience to climate-induced disasters and its overall relationship to well-being in Southern Africa: a mixed-methods systematic review, Int. J. Environ. Res. Publ. Health 15 (11) (2018) 2375, https://doi.org/10.3390/ijerph15112375.
[23] L. Ruangpan, Z. Vojinovic, S. Di Sabatino, L.S. Leo, V. Capobianco, A.M.P. Oen, M. McClain, E. Lopez-Gunn, Nature-Based Solutions for hydro-meteorological risk reduction: astate-of-the-art review of the research area [Preprint, Risk Assessment, Mitigation and Adaptation Strategies, Socioeconomic and Management Aspects (2019). https://doi.org/10.5194/nhess-2019-128.
[24] D. Dokken, Summary for Policymakers, 2014, p. 34.
[25] S. Solomon, in: Intergovernmental Panel on Climate Change, & Intergovernmental Panel on Climate Change, Climate Change 2007: the Physical Science Basis: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2007.
[26] F.Ž. Županić, D. Radić, I. Podbregar, Climate change and agriculture management: western Balkan region analysis, Energy, Sustainability and Society 11 (1) (2021) 51, https://doi.org/10.1186/s13705-021-00327-z.
[27] UNISDR, Terminology of Disaster Risk Reduction, 2019. https://www.undrr.org/terminology.
[28] A.K. Mishra, V.P. Singh, A review of drought concepts, J. Hydrol. 391 (1–2) (2010) 202–216, https://doi.org/10.1016/j.jhydrol.2010.07.012.
[29] P.B.R. Alves, M.J. de S. Cordão, S. Djordjević, A.A. Javadi, Place-based citizen science for assessing risk perception and coping capacity of households affected by multiple hazards, Sustainability 13 (1) (2020) 302, https://doi.org/10.3390/su13010302.
[30] B. Quesada-Montano, Hydrological change_ towards a consistent approach to assess changes on both floods and droughts, Adv. Water Resour. 5 (2018).
[31] J. Sahani, P. Kumar, S. Debele, C. Spyrou, M. Loupis, L. Aragão, F. Porcù, M.A.R. Shah, S. Di Sabatino, Hydro-meteorological risk assessment methods and management by nature-based solutions, Sci. Total Environ. 696 (2019), 133936, https://doi.org/10.1016/j.scitotenv.2019.133936.
[32] R. Roopnarine, Capacity building in participatory approaches for hydro-climatic disaster risk management in the caribbean, Int. J. Disaster Risk Reduc. 9 (2021).
[33] P. Antwi-Agyei, A.J. Dougill, L.C. Stringer, S.N.A. Codjoe, Adaptation opportunities and maladaptive outcomes in climate vulnerability hotspots of northern Ghana, Clim. Risk Manag. 19 (2018) 83–93, https://doi.org/10.1016/j.crm.2017.11.003.
[34] E. Mondino, Exploring changes in hydrogeological risk awareness and preparedness over time: A case study in nort 12 (2020).
[35] N. Pauli, "Listening to the Sounds of the Water": Bringing Together Local Knowledge and Biophysical Data to Understand Climate-Related Hazard Dynamics 15 (2021).
[36] T.-H. Yang, W.-C. Liu, A general overview of the risk-reduction strategies for floods and droughts, Sustainability 12 (7) (2020) 2687, https://doi.org/10.3390/su12072687.
[37] M. Bedinger, L. Beevers, L. Collet, A. Visser, Are we doing 'systems' research? An assessment of methods for climate change adaptation to hydrohazards in a complex world, Sustainability 11 (4) (2019) 1163, https://doi.org/10.3390/su11041163.
[38] J. Mercer, I. Kelman, B. Alfthan, T. Kurvits, Ecosystem-based adaptation to climate change in caribbean small island developing states: integrating local and external knowledge, Sustainability 4 (8) (2012) 1908–1932, https://doi.org/10.3390/su4081908.
[39] D. Nohrstedt, Disaster risk reduction and the limits of truisms: improving the knowledge and practice interface, Int. J. Disaster Risk Reduc. 8 (2022).
[40] P. Peduzzi, The disaster risk, global change, and sustainability nexus, Sustainability 11 (4) (2019) 957, https://doi.org/10.3390/su11040957.
[41] C. Ihinegbu, Conceptualization and management of disasters and climate change events in Africa: a review, SN Appl. Sci. 3 (11) (2021) 848, https://doi.org/10.1007/s42452-021-04829-5.
[42] T. Hess, J. Knox, I. Holman, C. Sutcliffe, Resilience of primary food production to a changing climate: on-farm responses to water-related risks, Water 12 (8) (2020) 2155, https://doi.org/10.3390/w12082155.
[43] M.M. de Brito, Compound and Cascading Drought Impacts Do Not Happen by Chance: A Proposal to Quantify Their Relationships, vol. 11, Science of the Total Environment, 2021.
[44] A. Fekete, Critical infrastructure cascading effects. Disaster resilience assessment for floods affecting city of Cologne and Rhein-Erft-Kreis, Journal of Flood Risk Management 13 (2) (2020), https://doi.org/10.1111/jfr3.12600.
[45] C. Liang, D. Li, Z. Yuan, Y. Liao, X. Nie, B. Huang, X. Wu, Z. Xie, Assessing urban flood and drought risks under climate change 13 (2019). China.
[46] K. Brindha, P. Pavelic, Identifying priority watersheds to mitigate flood and drought impacts by novel conjunctive water use management, Environ. Earth Sci. 75 (5) (2016) 399, https://doi.org/10.1007/s12665-015-4989-z.
[47] P. De Luca, G. Messori, R.L. Wilby, M. Mazzoleni, G. Di Baldassarre, Concurrent wet and dry hydrological extremes at the global scale, Earth System Dynamics 11 (1) (2020) 251–266, https://doi.org/10.5194/esd-11-251-2020.
[48] H. Tabari, P. Hosseinzadehtalaei, W. Thiery, P. Willems, Amplified drought and flood risk under future Socioeconomic and climatic change, Earth's Future 9 (10) (2021), https://doi.org/10.1029/2021EF002295.
[49] O.E. Hart, R.U. Halden, On the need to integrate uncertainty into U.S. water resource planning, Sci. Total Environ. 691 (2019) 1262–1270, https://doi.org/10.1016/j.scitotenv.2019.07.164.
[50] N.N. Kourgialas, A critical review of water resources in Greece: the key role of agricultural adaptation to climate-water effects, Sci. Total Environ. 775 (2021), 145857, https://doi.org/10.1016/j.scitotenv.2021.145857.
[51] N. McCarthy, T. Kilic, J. Brubaker, S. Murray, Droughts and floods in Malawi: Impacts on crop production and the performance of sustainable land management practices under weather extremes 18 (2021).
[52] P. Freire, M. Rodrigues, A.B. Fortunato, A. Freitas, Flood and drought risk assessment for agricultural areas (Tagus Estuary, Portugal), Nat. Hazards Earth Syst. Sci. 21 (8) (2021) 2503–2521, https://doi.org/10.5194/nhess-21-2503-2021.
[53] J. Shi, L. Cui, Z. Tian, Spatial and temporal distribution and trend in flood and drought disasters in East China, Environ. Res. 185 (2020), 109406, https://doi.org/10.1016/j.envres.2020.109406.
[54] M. Venkatappa, N. Sasaki, P. Han, I. Abe, Impacts of droughts and floods on croplands and crop production in Southeast Asia – an application of Google Earth Engine, Sci. Total Environ. 795 (2021), 148829, https://doi.org/10.1016/j.scitotenv.2021.148829.
[55] G. Di Baldassarre, F. Martinez, Z. Kalantari, A. Viglione, Drought and flood in the Anthropocene: feedback mechanisms in reservoir operation, Earth System Dynamics 8 (1) (2017) 225–233, https://doi.org/10.5194/esd-8-225-2017.
[56] P.T. Nastos, N.R. Dalezios, I.N. Faraslis, K. Mitrakopoulos, A. Blanta, M. Spiliotopoulos, S. Sakellariou, P. Sidiropoulos, A.M. Tarquis, Review article: risk management framework of environmental hazards and extremes in Mediterranean ecosystems, Nat. Hazards Earth Syst. Sci. 20 (2021).
[57] Z. Kalantari, C.S.S. Ferreira, S. Keesstra, G. Destouni, Nature-based solutions for flood-drought risk mitigation in vulnerable urbanizing parts of East-Africa, Current Opinion in Environmental Science & Health 5 (2018) 73–78, https://doi.org/10.1016/j.coesh.2018.06.003.
[58] M.A.R. Shah, F.G. Renaud, C.C. Anderson, A. Wild, A. Domeneghetti, A. Polderman, A. Votsis, B. Pulvirenti, B. Basu, C. Thomson, D. Panga, E. Pouta, E. Toth, F. Pilla, J. Sahani, J. Ommer, J. El Zohbi, K. Munro, M. Stefanopoulou, W. Zixuan, A review of hydro-meteorological hazard, vulnerability, and risk assessment frameworks and indicators in the context of nature-based solutions, Int. J. Disaster Risk Reduc. 50 (2020), 101728, https://doi.org/10.1016/j.ijdrr.2020.101728.
[59] V. Krysanova, H. Buiteveld, D. Haase, F.F. Hattermann, Practices and Lessons Learned in Coping with Climatic Hazards at the River-Basin Scale: Floods and Droughts, vol. 27, Ecology and Society, 2008.
[60] M. Wannewitz, M. Garschagen, Review article: mapping the adaptation solution space – lessons from Jakarta, Nat. Hazards Earth Syst. Sci. 21 (11) (2021) 3285–3322, https://doi.org/10.5194/nhess-21-3285-2021.
[61] D.W. McMartin, B.H. Hernani Merino, B. Bonsal, M. Hurlbert, R. Villalba, O.L. Ocampo, J.J.V. Upegui, G. Poveda, D.J. Sauchyn, Limitations of water resources infrastructure for reducing community vulnerabilities to extremes and uncertainty of flood and drought, Environ. Manag. 62 (6) (2018) 1038–1047, https://doi.org/10.1007/s00267-018-1104-8.
[62] M.C. de Ruiter, A.F. van Loon, The challenges of dynamic vulnerability and how to assess it, iScience 25 (8) (2022), 104720, https://doi.org/10.1016/j.isci.2022.104720.

[63] M.D. Hendricks, S. Van Zandt, Unequal protection revisited: planning for environmental justice, hazard vulnerability, and critical infrastructure in communities of color, Environ. Justice 14 (2) (2021) 87–97, https://doi.org/10.1089/env.2020.0054.
[64] E.L.F. Schipper, N.K. Dubash, Y. Mulugetta, Climate change research and the search for solutions: rethinking interdisciplinarity, Climatic Change 168 (3–4) (2021) 18, https://doi.org/10.1007/s10584-021-03237-3.
[65] M.D. Hendricks, G. Newman, S. Yu, J. Horney, Leveling the landscape: landscape performance as a green infrastructure evaluation tool for Service-learning products, Landsc. J. 37 (2) (2018) 19–39, https://doi.org/10.3368/lj.37.2.19.
[66] D.Z. Rivera, M.D. Hendricks, Municipal undergreening: framing the planning challenges of implementing green infrastructure in marginalized communities, Plann. Theor. Pract. 23 (5) (2022) 807–811, https://doi.org/10.1080/14649357.2022.2147340.
[67] S. Hochrainer-Stigler, R. Šakić Trogrlić, K. Reiter, P.J. Ward, M.C. De Ruiter, M.J. Duncan, S. Torresan, R. Ciurean, J. Mysiak, D. Stuparu, S. Gottardo, Toward a framework for systemic multi-hazard and multi-risk assessment and management, iScience 26 (5) (2023), 106736, https://doi.org/10.1016/j.isci.2023.106736.
[68] M.F. Abdullah, S. Siraj, R.E. Hodgett, An overview of multi-criteria decision analysis (MCDA) application in managing water-related disaster events: analyzing 20 Years of literature for flood and drought events, Water 13 (10) (2021) 1358, https://doi.org/10.3390/w13101358.
[69] X. Wang, H. Xie, A review on applications of remote sensing and geographic information systems (GIS) in water resources and flood risk management, Water 10 (5) (2018) 608, https://doi.org/10.3390/w10050608.
[70] S. De Angeli, B.D. Malamud, L. Rossi, F.E. Taylor, E. Trasforini, R. Rudari, A multi-hazard framework for spatial-temporal impact analysis, Int. J. Disaster Risk Reduc. 73 (2022), 102829, https://doi.org/10.1016/j.ijdrr.2022.102829.
[71] H. Kreibich, A.F. Van Loon, K. Schröter, P.J. Ward, M. Mazzoleni, N. Sairam, G.W. Abeshu, S. Agafonova, A. AghaKouchak, H. Aksoy, C. Alvarez-Garreton, B. Aznar, L. Balkhi, M.H. Barendrecht, S. Biancamaria, L. Bos-Burgering, C. Bradley, Y. Budiyono, W. Buytaert, G. Di Baldassarre, The challenge of unprecedented floods and droughts in risk management, Nature 608 (7921) (2022) 80–86, https://doi.org/10.1038/s41586-022-04917-5.
[72] P.B.R. Alves, S. Djordjević, A.A. Javadi, Understanding the NEEDS for ACTING: an integrated framework for applying nature-based solutions in Brazil, Water Sci. Technol. 85 (4) (2022) 987–1010, https://doi.org/10.2166/wst.2021.513.
[73] J. Penny, P.B.R. Alves, Y. De-Silva, A.S. Chen, S. Djordjević, S. Shrestha, M. Babel, Analysis of potential nature-based solutions for the Mun River Basin, Thailand, Water Sci. Technol. 87 (6) (2023) 1496–1514, https://doi.org/10.2166/wst.2023.050.
[74] R. Ashley, B. Gersonius, B. Horton, Managing Flooding: from a Problem to an Opportunity, vol. 22, 2020.
[75] S.L. Cutter, L. Barnes, M. Berry, C. Burton, E. Evans, E. Tate, J. Webb, A place-based model for understanding community resilience to natural disasters, Global Environ. Change 18 (4) (2008) 598–606, https://doi.org/10.1016/j.gloenvcha.2008.07.013.
[76] F.H. Norris, S.P. Stevens, B. Pfefferbaum, K.F. Wyche, R.L. Pfefferbaum, Community resilience as a metaphor, theory, set of capacities, and Strategy for disaster readiness, Am. J. Community Psychol. 41 (1–2) (2008) 127–150, https://doi.org/10.1007/s10464-007-9156-6.