Integrated Flood and Drought Measures

A Qualitative Systematic Literature Review

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SUMMARY

This study investigates integrated flood and drought approaches. This stems from integrated flood and drought management. And is a relatively new field. In this field they focus on a muli-hazard approach. This entails an approach that mitigates the effects, risks, and interplay of multiple hazards.

This research will investigate the existing and novel measures within the field of integrated flood and drought management. This will be done by answering the central question: “What are effective integrated flood and drought approaches?” aided by the following secondary questions “Which integrated flood and drought approaches exist?”, “Which integrated flood and drought measures have been put into practice?”, “When is an integrated flood and drought approach considered effective?”.

In order to answer the research question a systematic qualitative literature review has been conducted. After finding a relevant search string, articles were gathered using Scopus. These articles are all in English and are published in the past 5 years. Deductive coding was used to create general themes. After which the articles have been read though for the first time. After that they have been read though again while using inductive coding. These end results were then used to write the results.

When looking at the different type of measures, most of them are overarched by nature-based solutions. This concept describes measures that make use of ecosystems to provide additional benefits to humans. An example of this is the use of wetland, which not only store and clean water, but can also provide educational and recreational opportunities. When looking at their impacts. Articles have rarely discussed negative impacts of integrated flood and drought measures and focused mainly on the positive impacts. There also does not seem to be a detailed concepts of what integrated flood and drought measures should achieve. Arguments surrounding this topic mainly focus on the management around the measures. For example it is found important that the implementation are beneficial to the end users. And that the process should be participatory also to non-experts.

As the study proposes a starting point to categorize the different type of measures. Future research could dive deeper into the different type of measures. Especially what the drawbacks are of the measures. In addition to that, most benefits of the measures were overlapping. So a more detailed approach overall would also be a good addition.

CONTENTS

1 INTRODUCTION

Climate change is a topic that has gained increased attention in recent years. Within this topic studies have looked at how the hydrological cycle is affected by climate change. It has been found that droughts and floods are likely to occur more frequently in the future. But not only that, droughts and floods are expected to become more severe over time. This is due to the rise in global temperatures caused by climate change (Rahmani & Fattahi, 2024).

Not only does climate change increase the risks of floods and droughts, ongoing population growth and economic growth are causing an increase in the negative impacts of floods and droughts. Even though floods and droughts are both part of the hydrological cycle, studies attend to investigate these hazards separately. As they are part of this bigger water cycle measures focussing on one hazard singularly can lead to vulnerabilities. So can a measure singularly focussed on decreasing floods risks, increase drought risks (Ward, et al., 2020).

Witte et al. (2020) explains how this can be seen within the Dutch water management. They describe this phenomenon as 'verdroging' which translates to 'desiccation' and is used to categorize water management implementations which increases drought risks. They argue that this increases the damage caused by droughts in the Netherlands. An example of this is the dewatering system meant to optimize agricultural conditions. A low water level allows for a longer growing season (Bartholomeus, et al., 2023) and ensures that the famers can still go onto the land with heavy machinery (Witte, et al., 2020). However, to combat droughts it is very important to retain groundwater and allow for a higher groundwater level (Bartholomeus, et al., 2023).

Alves et al. (2023) also describes this phenomenon as a singular hazard approach and similar to Ward et al. (2020) calls for an integrated approach, which they then refer to as a multi-dimensional approach. But within the context of flood and droughts it is often referred to as integrated flood and drought management. This entails an approach where there is looked into the interplay between floods and droughts. Alves et al. (2023) conducted a systematic literature review to assed the current understanding of the floods and drought interplay. And as they provide insights into key elements of the field, they overlook the measures that can or have been taken in this field. Likewise Grobicki et al. (2015) investigates integrated approaches, but does not go into the practical measures. And rather review progress within management. Information about specific measures does come to light in the studies, but the information about the measures is discrepant. An systematic overview of these measures is missing in the current literature.

This study will try to fill that research gap by providing a systematic overview of the different measures that have been thought of or applied within the field on integrated flood and drought management. This overview can aid future research by providing an oversight of the current information about the different measures. In addition to that, this would help to put more of these measures into practice, as their advantages and disadvantages can be compared more easily.

The main question this study will investigate and try to answer is: "What are effective integrated flood and drought approaches?". To answer this central question the following secondary questions will be discussed adjoiningly: "Which integrated flood and drought approaches exist?", "Which integrated flood and drought measures have been put into practice?", "When is an integrated flood and drought approach considered effective?".

In the following chapter, chapter 4, the theoretical framework is discussed. Relevant theories will be discussed and a conceptual framework as well as a hypothesis will be developed. Chapter 5 will go into the methodology and explain the usage of a systematic qualitative literature review. Then in chapter 6 the results will be presented coming forth from analysing the selected articles.

2 THEORETICAL FRAMEWORK

2.1 FLOOD AND DROUGHT TYPES

Yang and Liu (2020) analysed different literature covering risk-reduction strategies for floods and droughts. Among which they have provided an overview of different definitions and classifications within this theme. The first distinction they make is between the different type of floods and droughts. Floods are divided into three different categories: pluvial, fluvial, and coastal flooding. Pluvial flooding is caused by rainfall, when the rainfall exceeds the capacity of the water network, such as the infiltration rate in rural areas or the drainage system in urban areas. When the rainfall excels river capacity you speak of fluvial flooding and is also called riverine flooding. Lastly there is coastal flooding. This occurs when sea water is pushed land-inwards, e.g. by the wind blowing waves inwards or elevated water levels.

Droughts are divided into four categories: meteorological, hydrological, agricultural, and socio-economic. Meteorological drought is the most direct and is divined as a lower average precipitation over a period of time. The other categories discuss the indirect impacts of meteorological drought. Hydrological drought covers water resource management and can be spoken of when the demand for established water uses of a certain waterbody exceeds its supply. Moving on to agricultural drought, this entails the failure of crops when no measures are taken. With its main component a decrease in soil moisture. Lastly, they discuss socio-economic drought which is similar to hydrological drought. The difference being that the demand for water is used for an economic good and not established water usage (e.g. drinking water).

2.2 MULTI-DIMENSIONAL APPROACH

Studies about integrated flood and drought management are still relatively new. They stem from the notion of a multi-dimensional approach. Alves et al. (2023) conducted a systematic literature review and explains that a multi-dimensional approach looks at the interplay between different management decisions and focusses more on multi-risk occurrences. This approach came forth in opposition to the singular approach. Which in turn focusses on one hazard and tries to eliminate the effects of that particular hazard the best possible. However, this approach does not keep into account that a measure decreasing the risk of hazard A can increase the risk of hazard B.

In addition to that, the study makes a distinction between a spatial scale and time scale. These are both seen as key components of the flood and drought interplay. Especially as floods have a smaller time scale compared to droughts.

These along with other components, that came firth out of the review, have been integrated into a model. This model can be seen in figure 1.

As can be seen in the figure, the different components are divided into different phases. Briefly summarized Phase A can be seen as pre-existing conditions relevant to the context, Phase B as possible risks evaluation, Phase C as finding effective solutions and finally Phase D which

essentially for reassessment.

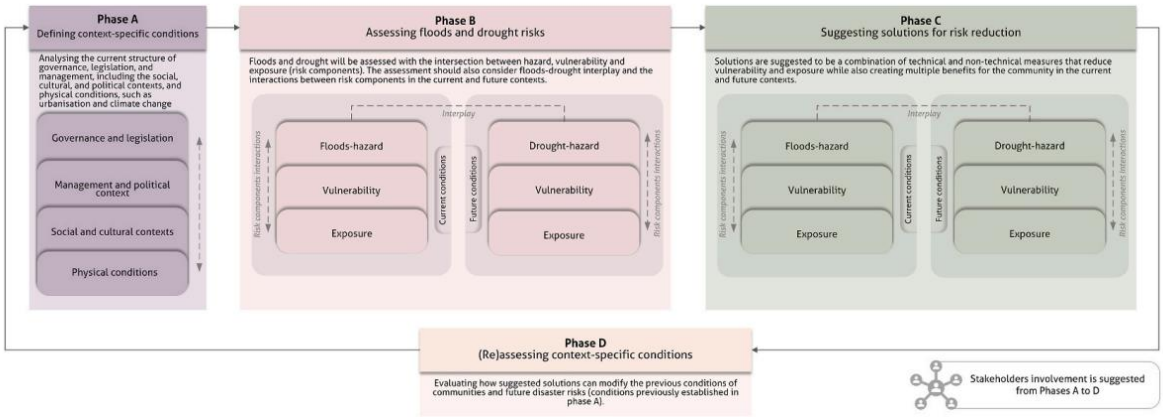

Figure 1: Model of key component Integrated flood-drought risks (Alves, et al., 2023)

A study by Grobicki et al. (2015) looks, amongst other concepts, into Integrated Flood Management (IFM). Here they argue that IFM should include six pillars; 'manage the water cycle as a whole, integrated land and water management, asses and manage risk and uncertainty, adopt a best mix of strategies, ensure participation decision-making approach with a range if stakeholders, adopt integrated risk management approaches'. Here some similarities can be found between the six pillars of Grobicki et al. (2015) and the phases of Alves et al. (2023) as they both focus on an area specific and broad approach.

Another element of the model that can be found back in other studies is the role of the interplay. However here a big difference can be found in between the found importance of the interplay. Alves et al. (2023) highlights the interplay as they have found that it is important to analyse the risks of both hazards and how they influence each other, the interplay between risks. Ward et al. (2020) on the other hand finds the interplay between floods and drought important as this is important for ecosystems.

2.3 MEASURES TYPES

One of the categories that can be found back within the measure types are structural and non-structural measures. Yang & Liu (2020) discusses a division between flood and drought measures, structural and non-structural measures. Structural measures are the physical structures, and the non-structural measures encompass the non-tangible measures such as actions and legislation. An example of this is a early warning system. Another study by Grobicki et al. (2015) also gives the early warning system as an example, but in this case as being a 'soft' intervention'. The opposing category is called 'hard interventions', as an example they give dykes. Even though they use different terms, they division between the measures seem the same. The categories between the different measures seem scattered and a clear mapping of all these different concepts are currently lacking.

When looking at the effectiveness of measures, Velasco et al. (2018) concluded that when it comes to flood measures, structural measures attend to be more effective than non-structural measures. However information about the effectiveness of measures focussed on the interplay between droughts and floods seems to be limited within the literature.

2.4 Conceptual Model

The conceptual model of this research can be found back in figure 2. The conceptual model exists out of two variables, 'Integrated floods and drought measures' and 'Effect on floods and droughts. The model will be used to investigate the relationship between these variables. The independent variable is 'Integrated flood and drought measures' and the dependent variable is 'Effects on floods and droughts'.

Figure 2: Conceptual model research (Author)

3 METHODOLOGY

This research will be conducted using a qualitative systematic literature review. And will follow the literature review steps as suggested by Snyder (2019). These steps are 'design', 'conduct', 'analysis', and 'structuring and writing the review'. In this chapter the first three phases will be discussed. The fourth phase will be discussed in chapter 6, 'Results'.

This chapter will start with describing phase one, 'design'. Here an explanation will be given to why a qualitative systematic literature review is chosen. And the draft of the search strategy will be given. The next section is 'conduct'. Here it will be explained how the search strategy is executed, and which articles were selected for the review. Once the articles are gathered the analysis follows. Here there will be looked at what information is needed from the found articles.

Since this study conducts a literature review the ethical considerations are limited compared to for example an interview-based study. The ethical considerations this study has taken are mainly in relation to the various gathered articles. All these articles are from Scopus, which should ensure a good quality of the articles. And limit the possible bias withing the collected data. Next to that the search strategy will be discussed transparently, so that it is clear what exactly has been done. Lastly, all the found articles are sourced using the Harvard system. So that all the claims can be traced back to the right source. And all the authors are correctly cited.

3.1 DESIGN

This will make use of a qualitative systematic literature review to answers the research questions. This method is chosen for several reasons. To start with, the current information about the different integrated flood and droughts measures are scattered though out the existing literature. So as information of the measures can be found, there is not a consistent structure or overview within the literature. This combines well with a literature review as method. As these reviews are adequate for analysing and gathering existing research data (Snyder, 2019). This method will allow to connect the different data of the articles into a better understandable systematic overview (Kalpokaite & Radivojevic, 2021).

A qualitative approach is chosen as this study wants to gain better understanding of the measures, and to assess when they are considered effective. A quantitative literature review on the other hand would not be suitable. As more in depth analysis is needed to gain the needed information about the measures (Kalpokaite & Radivojevic, 2021).

After choosing the methods a scoping of the literature was conducted, see figure X. Here a sequence of different terms was entered in Google Scholar to explore whether these were fit to find the wanted results. Eventually the following string was chosen: 'integrated AND flood AND drought AND measures'. The database Scopus was used for the Boolean search to the quality of the articles. As this dataset only allows for academically peer reviewed articles.
The next section will follow up on how the search strategy was conducted.

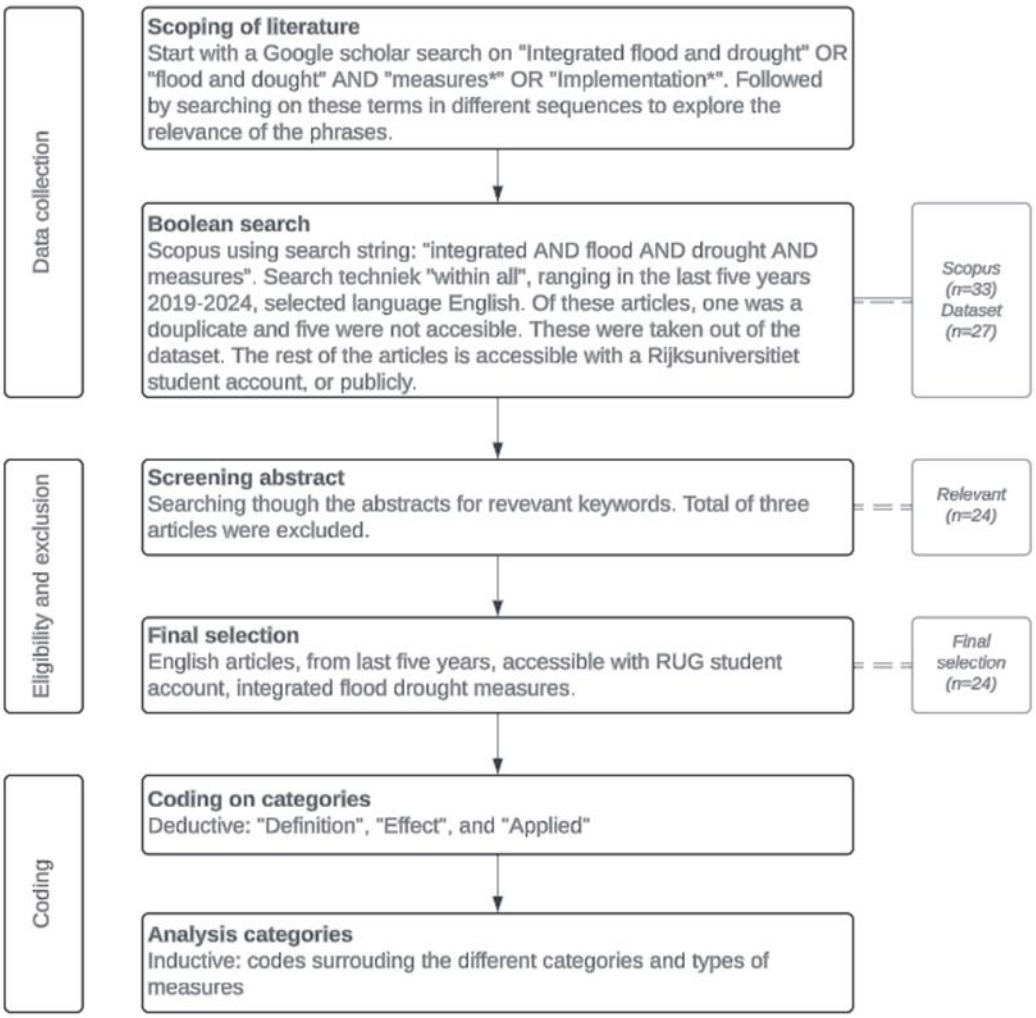

Figure 3: Diagram of the applied literature review (Author)

3.2 CONDUCT

This section will talk though the used search strategy and its execution, see figure X.
As previously mentioned, the Scopus database was used to find the articles for the review. In this database the search strategy 'within all' was selected, to obtain a wider range of articles. To ensure that the articles are better comparable, the search was limited to English articles only. Next to that, a search range was applied to guarantee that the articles would still be relevant. For a rang of 5 years was chosen, 2019-2024.

A total of 33 articles were found on Scopus. Within these results a duplicate article was found. This narrowed the results down to 32. In the end this number was narrowed down to 27 articles. These articles were either publicly accessible or accessible using a student Rijksuniversitiet account. The other 5 articles could not be accessed in this way, and where thus not selected. An overview of the 27 articles can be found in Table 1. This table is placed in the appendices.

After screening the abstract three additional articles were removed. These were article 2, 6, and 18. The screening was conducted by reading the full abstract and searching for key words. These were then compared to each other by using the software Obsidian, see figure X. In this figure it can be seen how these articles do not relate to the other articles and their key terms.

Figure 4: Overview of abstract screening (Author)

3.3 ANALYSIS

This analysis makes use of a combination between deductive and inductive coding. The deductive coding was used to create general themes for the coding. These themes will surround the themes of the research questions, see Table 2. This way the data is easier to link to the different sub-questions. Which in turn will aid to have more relevant results (Bihu, 2023). The following categories were used: “Definition”, “Effect”, and “Applied”. In Table X the categories are discussed in more detail.

Table X: Deductive coding categories (Author)

Categories	
Definition	Data that discusses what a certain measure entails or means
Effect	Data that discussed possible impacts of the measures
Applied	Data that discusses whether the measure has been applied and what has been learned from its application

Next to that, inductive coding is also applied. As different types of measures are spread across the multiple articles. There is not yet an overview of all the different measures and themes amongst them. This means that the coding cannot be predefined from the literature. By using inductive coding these codes can be derives from the data (Bihu, 2023).

First all the literature has been read though. While reading the deductive coding was used to highlight data in the text, relevant to the categories. With the insights gained from this, the process of inductive coding was started. Here the relevant parts were further divided into categories surrounding the different type of measures. This information was gathered in the

program Obsidian. Here links were made between the different terms and the data was recorded per article.

Central question	"What are effective integrated flood and drought approaches?"
Secondary questions	"Which integrated flood and drought approaches **exist**?" "Which integrated flood and drought measures have been put into **practice**?" "When is an integrated flood and drought approach considered **effective**?"

Table 2: Overview of the central question and the secondary questions (Author)

4 RESULTS

Within the analysed articles there was a lot of variances between topics and focus. As most of them were related to integrated water and flood management in some way, not all of them were relevant to this research. For example Marzuki et al. (2023) conducted a study about extreme rainfall patterns in New Capital Indonesia. And as it does call for the cruciality of decreasing flood risks, it is only a message to take with and the research itself discusses the precipitation patterns of the area.

4.1 MEASURES, THEIR APPLICATIONS AND IMPACTS

When looking for the different integrated flood and drought measures there are two key features that can be found back with the different studies. One is that a lot of measures are bound to concepts such as 'nature-based solutions', for example Ricart et al. (2022). In this following section the different measures and concepts found in the literature review will be discussed. An overview of the structural different measures and concepts can be found in Table 3. An more advanced overview can be found in figure 5. In this figure the concepts and measures are shown in relation to each other and depicted with the relevant articles.

Table 3: A quick overview of the found measures and concepts in the analysed articles (Author)

Measures	**Concepts**
Wetlands (reuse/store)	Resilience cities
Floodplains (store)	Nature-based solutions
Forests (store)	Ecosystem services
Dyke relocations (store)	Green infrastructure
Urban green(forest) (store)	Blue green development
- bioswale	Compact city
Retention (reuse/store)	Grey infrastructure
Wastewater treatment (reuse)	Sustainable Drainage urban Systems

Mukherjee et al. (2022) looked at how cities implemented different nature-based solutions for disaster reduction. Nature-based solutions (NbS) are connected to resilience cities among similar concepts such as green infrastructure (GI) and ecosystem services (ES). The studies looks at multiple measures which are implemented in different cities. Even though the measures are generally seen as successful, their impact is not assessed. The most relevant results come from the city of Gurugram and Colombo. Colombo is mainly facing floods, in order to mitigate these they restored the surrounding wetlands. The study seems to find this approach successful and discusses the additional functions that this brings. Such as strengthening of surrounding wetlands, overall increase in climate adaptations and a healthier urban life.
Escalante et al. (2019) also argues for the positive effects of wetlands, with the main argument being the natural treatment of water. This way the water can be used for secondary purposes. Which in order saves drink water and aids to the overall water provision which in crucial in the times of droughts.

In relation to droughts Mukherjee et al. (2022) summarizes a whole list of nature-based solution strategies used in Grugram, "blue-green development plans. Urban green, urban forests, bioswale and green boundary, construction of retention/detention ponds, and wastewater treatment and reuse were introduced primarily to enhance water security". Measures involving

green spaces often serve a combination between water retention and treatment likewise the wetlands. The measures targeted towards retention also serves as flood mitigation. Only wastewater treatment seems not directly related to flood adaptation.
Bernabé-Crespo et al., (2023) however shows that the way water is treated does indeed have an impact on flood mitigation. First of all, there is a difference between the treatment of sewage water and rainwater. If these circuits are separated the rainwater could be collected which not only allows for rain water collection but also prevents flooding of the sewage circuit, which can happen during heavy rainfalls in a combined system. This can be done by creating (storm) tanks, floodplain parks or by laminating ponds. The treatment of sewage water does only seem to have direct impacts on drought mitigation, such as relieve in drinking water sources and a certainty of flows.

Another integrated measure is the introduction of floodplains as argued by Tschikof et al. (2024). The floodplains decrease the impacts of drouths and helps to mitigate storm surges as they retain and store water.

These were all mainly structural measures, but the studies also included non-structural measures. Cacciotti et al. (2021) for example talks about a participatory and multidisciplinary project called ProteCHt2save which is focused on building resilience for cultural heritage against floods, droughts and fire hazards. These non-structural measures are focused on raising awareness, the identification of risks, education and training of the residents and the exchange of knowledge and experiences.

Escalante et al. (2019) takes a broader view at integrated water visions. Here it is not just about floods and drought but also about other impacts and more specific impacts of climate change such as the increase of evaporation or saltwater intrusion. Some interesting findings are that underground water storage also serves to decrease water evaporation caused by an average increase in temperature. They also talk about the concept of Sustainable Drainage urban Systems (SUDS) which is mainly targeted at combatting heat, but includes earlier discussions flood and drought integrated measures such as water storage and introduction of more green areas with permeable pavement. Furthermore, they go into detail surrounding water storage and the different infiltration systems such as punctual infiltration and gravity flow water distribution, but they also stress the importance of natural water infiltration by greenery. With the example of a forested watershed.

This broader approach can also be seen back in the research of Ricart et al. (2022) who looks at compact cities, and more importantly the lack of public spaces. They then argue how these spaces could be used to decrease multiple hazards. With their main message being that Blue-green infrastructure and nature-based solutions do not only mitigate flood and drought impacts, but also provide benefits to humans and ecosystem services.
Unlike previously mentioned articles they also go shortly into grey infrastructure and their importance in managing runoffs and flood risks. Kattel et al. (2023) also discusses grey infrastructure. They provide an overview of the benefits and drawbacks of large dams. With the main benefit being that it allows for flow regulation, and with this high discharges can be managed. However, the dam does rearrange the water flow throughout the whole river network. Which can lead to alternating sedimentation, intensified evaporation and reduced temporal runoff.

Overall structural measures are more central discussed in the articles as opposed to non-structural measures. However, this could be caused by the search strategy of the article. Next

to that a lot of measures are surrounding the concept of Nature-based solutions. This can also be seen back in figure 5. Furthermore, the analysis on the variety of measures seems to be limited. The studies do not often discuss what flood and drought types specifically are initiated nor is there a high emphasis on the interplay floods and droughts and how the measures address them. In addition to that, most of the articles focus singularly on the positive effects of the measures and concepts. And the negative impacts can hardly be found.

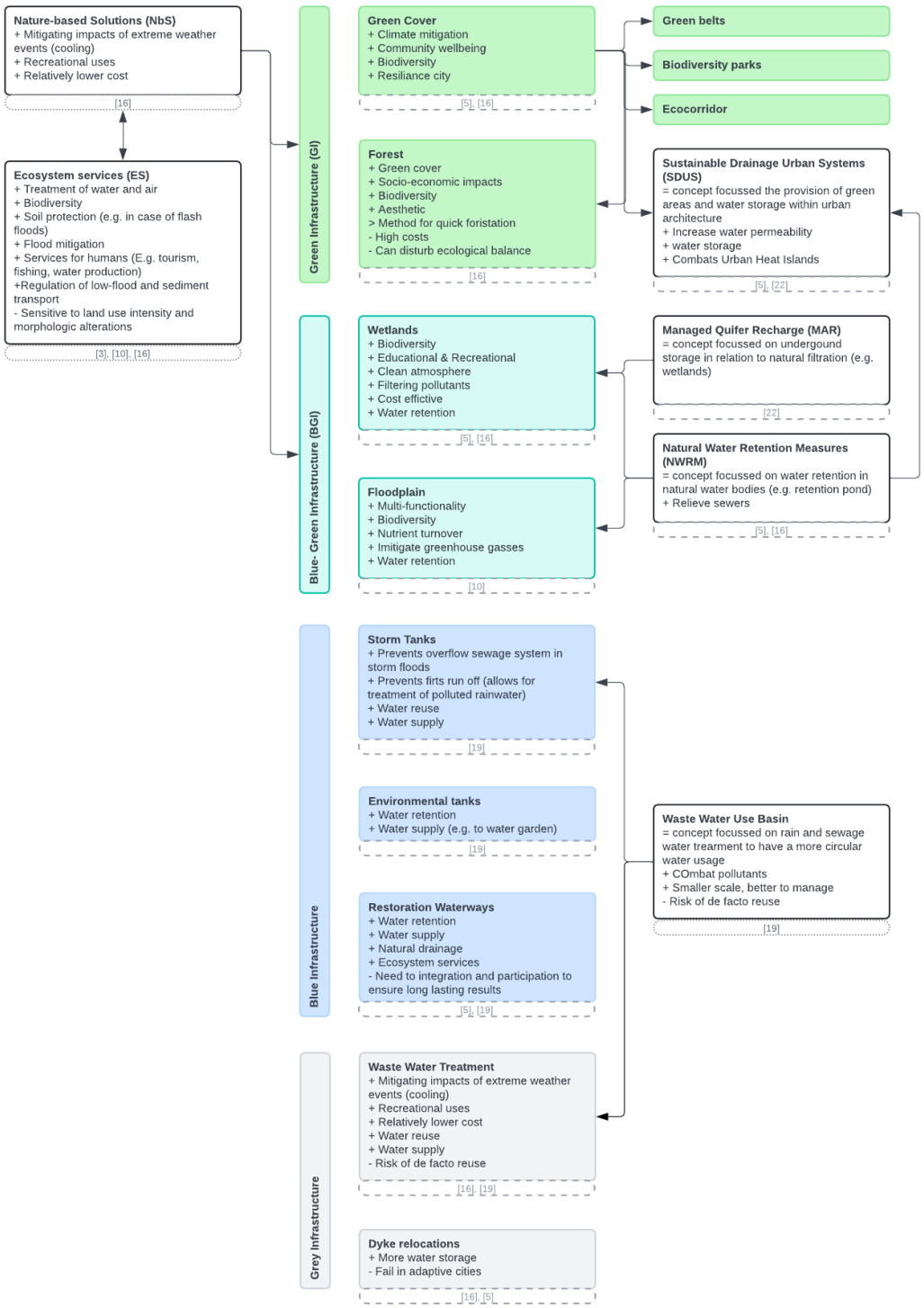

Figure 5: Combined overview of the measures, concepts, effects and related article (Author)

4.2 WHAT IS CONSIDERED THE IDEAL MEASURE

Looking at when measures are found to be efficient there can be seen a similar trend to the articles represented in the introduction of this research. There is a broad focus on the management itself. Where it is not as much about the found solutions (or the possibility there of), but rather the process itself and the required outcomes and values. As they often are not measures that directly influence flood and drought impacts, they do gibe insight into what is seen as an effective measure. Dikici & Aksel (2021) for example go into the meaning of risks management. However, it is only target at drought management, but it still gives to insights into what is found important in the management. As main key features of a good risks management they mention that it needs to be area specific, and with this also based on the legislation of the country, further more it should have integrity and the involvement of stakeholders is found as main importance.

Another study that focuses more on the approach itself is Kattel et al. (2023). Unlike Dikici & Aksel (2021), they do give attention to droughts and floods, however the focus seems to be mainly on flooding. Argues for the importance of resilience management which concludes that the water body should have homeostatic feedback. Meaning that the water body will return itself into balance when it finds itself in a situation above or below the ideal value. It should maintain its functions and lastly be capable to deal with transformations.

Lastly there is Roopnarine et al. (2021) who looks at disaster risks management (including flood and drought risks). As for the disaster risks management they argue that it is important that it is people-centred and should entail the values of the end users in the implementation as well as the development. This is further supported by their argument that cultural ideologies have knowledge on the environment and how to protect it. Thus, including them in the process could provide additional information about the area and the effects of different approaches. Furthermore, they also stress that physical interventions can lead to a forced cycle of disaster recovery and highlights the importance of soft approaches, participatory approaches and sustainable methods of management. This opinion is shared by Cacciotti et al. (2021) who finds that resilience strategies should allow non-expert stakeholders to actively engage in the disaster prevention.
Bernabé-Crespo et al. (2023) finds it most important that hydrological planning and management adapt water resources with anticompetition to future events caused by climate change.

As can be seen back in the theoretical framework, the importance of an integrated flood and drought approach and measures is found to surround participation and area specificness. Also other elements such as the measures needing to have value for its end users can be found back in the model of Alves et al. (2023). However, Aksel (2021) does give an new dimension that the measures should create self-sufficiency and robustness.

5 CONCLUSION

The central question this study aimed to answer was: “What are effective integrated flood and drought approaches?”. To answer the central question the following sub questions were drafted: “Which integrated flood and drought approaches exist?”, “Which integrated flood and drought measures have been put into practice?”, “When is an integrated flood and drought approach considered effective?”.

The literature provides a diversity in integrated flood and drought measures focusing more on sustainable and green measures. Nature-based solutions together with ecosystem services seems to be the overarching concept behind all the measure. In which the main mechanism behind the measures often come down to water retainment and reuse, although reuse is already more focussed on drought mitigation. As for the effects of the approach when put into practice the research is limited. The studies do often look at implemented measures in the form of case studies, but mainly focus on what the measures are. When looking at the effect of the specific measures, they are overlapping a lot. And thus far the articles have mainly discussed the positive effects of the measures. Negative impacts are rarely found.
What a measure should stive for is not precisely discussed within the analysed literature, the values and needs are projected rather generally and are more targeted towards the process rather than the end results. Overall, it has found to be important that the measures are beneficial to its end users and have a certain flexibility which allows the measures to adopt and survive in different circumstances. Next to that participation during the project by local and non-expert stakeholders is found to be very important. But as integrated flood and drought management is often more focussed on the quality of the process it is hard to find criteria for the measures themselves.

One of the potential weaknesses within this study is the broadness of the topic integrated flood and drought management. This term is often used as a concept and more focused on general water management and not so much on measures. Therefore, defining measures within this concept cannot be done in a concrete way. This could also be caused by the relatively newness of the field, and that it is still needs more time and additional research to lay down concrete foundation. As similar measures are found back in the analysed literature concepts are often named, structured, or divided differently. So are a lot of found concepts overlapping such as nature-based solutions and blue-green infrastructure or development. This study has made a start with categorizing these different concepts and measures.
And future research could look in more details to the different measures and what their particular effects are. This could in turn also be compares to the different types of drought or floods as explained in the theoretical framework. Such as meteorological hydrological, agricultural, and social economic drought.. As these definitions were prominent in the theoretical framework, they have not been found back with in the analysed literate. In addition to that the current articles mainly focus on the benefits of the measures and concepts. So future research could also investigate the different drawbacks.

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7 APPENDICES

Table 1: Overview of all the articles found for the systematic qualitative literature review (Author)

	Author	Year	Title
1	Yu Lu a, Xiaohua Yang, Dehui Bian , Yajing Chen , Yan Li , Zixing Yuan, Kaiwen Wang	2023	A novel approach for quantifying water resource spatial equilibrium based on the regional evaluation, spatiotemporal heterogeneity and geodetector analysis integrated model
2	Ashish Kumar, RAAJ Ramsankaran, Luca Brocca and Francisco Munoz-Arriola	2019	A Machine Learning Approach for Improving Near-Real-Time Satellite-Based Rainfall Estimates by Integrating Soil Moisture
3	Laura Piedelobo , Andrea Taramelli , Emma Schiavon, Emiliana Valentini, José-Luis Molina, Alessandra Nguyen Xuan and Diego González-Aguilera 1	2019	Assessment of Green Infrastructure in Riparian Zones Using Copernicus Programme
4	Guizhen Guo, Lulu Liu , Yuqing Li , Jiangbo Gao, Sen Lin and Shaohong Wu	2021	A Vulnerability Curve Method to Assess Risks of Climate-Related Hazards at County Level
5	Ronald Roopnarine, Ph.D, Lecturer , Gaius Eudoxie, Ph.D, Senior Lecturer, Mark N. Wuddivira, Ph.D, Dean, Sharmayne Saunders, Ph.D, Head, UWI Open Campus,Belize , Simone Lewis, Ruth Spencer, Cheryl Jeffers, Tasheka Haynes-Bobb , Charlene Roberts	2021	Capacity building in participatory approaches for hydro-climatic Disaster Risk Management in the Caribbean
6	Marzuki Marzuki, Ravidho Ramadhan, Helmi Yusnaini, Mutya Vonnisa, Ramadani Safitri and Elsa Yanfatriani	2023	Changes in Extreme Rainfall in New Capital of Indonesia (IKN) Based on 20 Years of GPM-IMERG Data
7	Dorcas N. Kalele, William O. Ogara, Christopher Oludhe, Joshua O. Onono	2021	Climate change impacts and relevance of smallholder farmers' response in arid and semi-arid lands in Kenya
8	Riccardo Cacciotti, Anna Kaiser, Alessandro Sardella, Paola De Nuntiis, Milo˘s Drdacký ,Christian Hanus, Alessandra Bonazza	2021	Climate change-induced disasters and cultural heritage: Optimizing management strategies in Central Europe
9	Majed ALOTAIBI	2023	Climate change, its impact on crop production, challenges, and possible solutions
10	Martin Tschikof, Barbara Stammel, Gabriele Weigelhofer, Elisabeth Bondar-Kunze, Gabriela Costea, Martin Pusch, Zorica Srdevi, Pavel Benka, David Bela Vizi, Tim Borgs, Thomas Hein	2024	Cross-scale and integrative prioritization of multi-functionality in large river floodplains

11	Muhammad Tayyab Sohail, Eslam B. Elkaeed, Muhammad Irfan, Ángel Acevedo-Duque and Sohaib Mustafa	2022	Determining Farmers' Awareness About Climate Change Mitigation and Wastewater Irrigation: A Pathway Toward Green and Sustainable Development
12	Danneille A. Townsend, Janez Sušnik and Pieter van der Zaag	2020	Domestic Water Supply Vulnerability to Climate Change and the Role of Alternative Water Sources in Kingston, Jamaica
13	Mehmet DIKICI Murat AKSEL	2021	Evaluation of Two Vegetation Indices (NDVI and VCI) Over Asi Basin in Turkey*
14	Jiangbo Gao, Lulu Liu & Shaohong Wu	2020	Hazards of extreme events in China under different global warming targets
15	Mariza Pereira de Oliveira Roza, Roberto Avelino Cecílio, Sidney Sara Zanetti, Marcel Carvalho Abreu, Gustavo Bastos Lyra, Guilherme Barbosa Reis	2023	Natural disasters related to rainfall trends in Espírito Santo, southeastern Brazil
16	Mahua Mukherjee, Deepthi Wickramasinghe, Imon Chowdhooree, Chimi Chimi, Shobha Poudel, Bhogendra Mishra, Zainab Faruqui Ali and Rajib Shaw	2022	Nature-Based Resilience: Experiences of Five Cities from South Asia
17	ZUZANA BOUKALOVÁ, JAN TĚŠITEL& BINOD DAS GURUNG	2020	NATURE-BASED WATER TREATMENT SOLUTIONS AND THEIR SUCCESSFUL IMPLEMENTATION IN KATHMANDU VALLEY, NEPAL
18	Veysel Coban & Ezgi Guler & Taner Kilic & Suheyla Yerel Kandemir	2021	Precipitation forecasting in Marmara region of Turkey
19	Miguel B. Bernabé-Crespo, Jorge Olcina Cantos and Antonio Oliva Cañizares	2023	Proposal of the "Wastewater Use Basin" Concept as an Integrated Sewage and Rainwater Management Unit in Semiarid Regions—A Case Study in the Southeast of the Iberian Peninsula
20	Nirupama Agrawal, Mark Elliott and Slobodan P Simonovic	2020	Risk and Resilience: A Case of Perception versus Reality in Flood Management
21	Nengwang Chen, Huasheng Hong, Xinjuan Gao	2021	Securing drinking water resources for a coastal city under global change: Scientific and institutional perspectives
22	Enrique Fernández Escalante, Jon San Sebastián Sauto and Rodrigo Calero Gil	2019	Mitigate Climate Change Effects in Spain

23	Wilmar L. Cerón, Mary T. Kayano, Camilo Ocampo-Marulanda, Teresita Canchala, Irma Ayes Rivera, Alvaro Avila-Diaz , Rita V. Andreoli and Itamara Parente de Souza	2021	Spatio-Temporal Variability of Hydroclimatology in the Upper Cauca River Basin in Southwestern Colombia: Pre- and Post-Salvajina Dam Perspective
24	Teresa Fidelis, Carla Rodrigues	2019	The integration of land use and climate change risks in the Programmes of Measures of River Basin Plans – assessing the influence of the Water Framework Directive in Portugal
25	Sandra Ricart, Carlo Berizzi, David Saurí and Gaia Nerea Terlicher	2022	The Social, Political, and Environmental Dimensions in Designing Urban Public Space from a Water Management Perspective: Testing European Experiences
26	Francisco Fabbro Neto, María Belén Gómez-Martín	2020	Water safety plan integrated to the land use and occupation measures: Proposals for Caraguatatuba-SP, Brazil
27	Giri R. Kattel, Amelie Paszkowski, Yadu Pokhrel, Wenyan Wu,Dongfeng Li, Mukund P. Rao	2023	How resilient are waterways of the Asian Himalayas? Finding adaptive measures for future sustainability